CITY OF DELRAY BEACH, FL

WATER TREATMENT PLANT 4 LOG, CHEMICAL SYSTEM AND SCADA IMPROVEMENTS

TECHNICAL SPECIFICATIONS

BID SET

VOLUME 1 OF 1

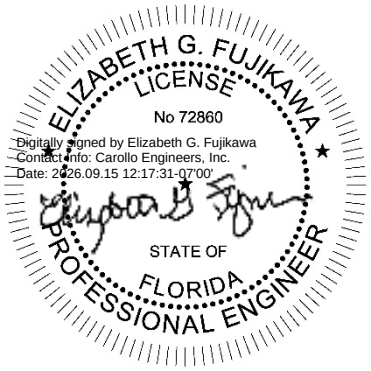
JULY 2026

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CITY OF DELRAY BEACH, FL

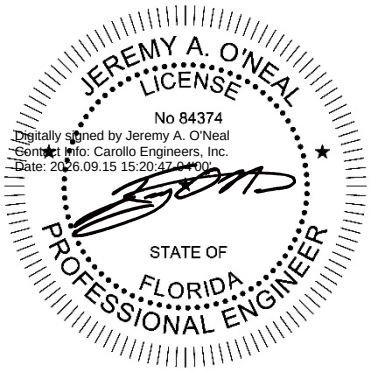
WATER TREATMENT PLANT 4 LOG, CHEMICAL SYSTEM AND SCADA IMPROVEMENTS



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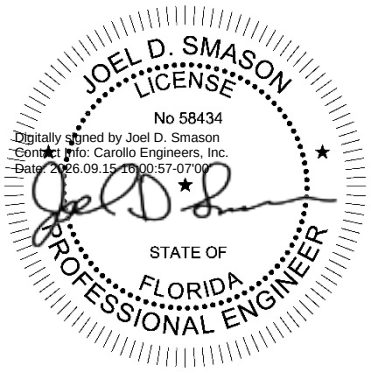
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This item has been digitally signed and sealed by Jeremy A. O'Neal. on the date adjacent to the seal.

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This item has been digitally signed and sealed by Keith R. Dinnen on the date adjacent to the seal.

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CITY OF DELRAY BEACH

WATER TREATMENT PLANT 4 LOG, CHEMICAL SYSTEM AND SCADA IMPROVEMENTS

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SECTION 01110

SUMMARY OF WORK

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Detailed description of the Work.

1.02 THE WORK

A. The Work consists of:
   1. Adherence to construction sequence described in Section 01140 Work Restrictions.
   2. Demolition of existing electrical, instrumentation, structural and mechanical systems and equipment shown on the Drawings.
   3. The baffle wall construction will be conducted with the Clearwells in operation. As a result, work shall be completed by divers. It shall be assumed that the water level in the Clearwells can fluctuate between any elevation of 4 to 7 feet from the clearwell floor slab.
   4. Provision and installation of new baffle walls in the East and West Clearwells.
   5. Provision and installation of new chemical feed lines and one sample line within the West Clearwell.
   6. Provision and installation of four new ferric chloride feed lines between the ferric chloride metering pump skid in the chemical building and each of the influents to clarifiers 1 through 4.
   7. Provision and installation of four new phosphate feed lines between the phosphate metering pump skid in the WTP chemical building and each of the effluents from clarifiers 1 through 4.
   8. Provision and installation of new transfer pump control panel LCP-050-500-02.
   9. Provision and installation of two new ferric chloride transfer pumps, ferric chloride day tank, associated transfer valve controls, radar level transmitter, high-high level/overflow switch, containment leak alarm, pressure indicators, signal wiring, conduit, surge protection, PLC I/O, HMI/SCADA configuration, alarms, trends, control logic, mechanical and electrical systems and equipment, and concrete equipment pads shown on the Drawings, described in the specifications, and required for a complete, working ferric chloride storage and transfer system.
   10. Provision and installation of two new phosphate transfer pumps, phosphate bulk storage tank, phosphate day tank, associated transfer valve controls, radar level transmitters, high-high level/overflow switch, pressure indicators, signal wiring, conduit, surge protection, PLC I/O, HMI/SCADA configuration, alarms, trends, control logic, mechanical and electrical systems and equipment, and concrete equipment pads shown on the Drawings, described in the specifications, and required for a complete, working phosphate storage and transfer system.

11. Provision and installation of a new Contractor-furnished triplex sodium hypochlorite metering pump skid and associated storage and feed system instrumentation and controls shown on the Drawings, including existing storage tank radar level instrumentation, containment leak alarm, metering pump skid control and monitoring signals, local control panels, pressure indicators, signal wiring, conduit, surge protection, PLC I/O, HMI/SCADA configuration, alarms, trends, control logic, testing, commissioning, and associated electrical modifications required for a complete and operational sodium hypochlorite storage and feed system.
12. Provision of all PCIS system hardware and software licenses as described in Division 17.
13. Field verification of all PCM panel enclosure dimensions and proposed locations, notifying Engineer in writing regarding any conflicts with panel size or installed location prior to shop drawing submittal.
14. Provision and installation of temporary control hardware and associated electrical work and materials for CO^2 System and Clarifier Sludge Blowdown Pumps to maintain automatic operation of each System from Owner's SCADA system.
15. Provision and installation of temporary network panel, associated hardware and electrical work and materials for CO^2 System to maintain communication of clarifier influent flow meter signals (F-050-145-11, F-050-145-21,F-050-145-31, F-050-145-41) and filter pH analyzer signals (AI-050-185-11 and AI-050-185-21) with Owner's SCADA system maintaining existing automatic control of CO^2 and chemical feed system until new PCMs are in full operation.
16. Demolition of the following: Chemical System Control Panel, Clarifier Sludge Blowdown Control Panel (existing conduit and wire to remain), and CO^2 System wall mounted RTU and PLC equipment.
17. Provision and installation of 4-Log Sample Panel, SP-050-225-21 and all associated instruments, analyzers, enclosures, equipment, and accessories. Analyzers shall be connected to the LAN switch in PCM-050-220-01 via Ethernet/IP communications.
18. Provision and installation of the following control panels: West Clearwell Sampling/Sludge Blowdown Control Panel (PCM-050-220-01), CO2 (Carbon Dioxide) System Control Panel (PCM-050-550-01), Chemical Storage & Feed System Control Panel(PCM-050-500-01), Clarifiers 1&2 RIO Panel (PCM-050-145-11), Clarifiers 3&4 RIO Panel(PCM-050-145-31), and Filter Gallery RIO Panel (PCM-050-185-01),.
19. Installation, including termination, of new and existing signal wiring in the new PCM panels as shown on the P&IDs and listed in the I/O list.
20. Provision and installation of all conduits, wiring and electrical modifications show on the Drawings.
21. Demolish Clarifier 1,2,3,4 insertion mag meter flow indicating transmitter 4-20mA output signal wiring. Install new conduit and wiring between Clarifier 1&2 insertion mag meter flow indicating transmitters and Clarifiers 1&2 RIO Panel. Install new conduit and wiring between Clarifier 3&4 insertion mag meter flow indicating transmitters and Clarifiers 3&4 RIO panel.
22. Demolish 4-20mA output signal wiring from existing Filter pH analyzers, AIT-050-185-11 and AIT-050-185-21. Install new conduit and wiring between pH analyzers and Filter Gallery RIO Panel, PCM-050-185-01.

23. Provision and installation of a fiber optic self-healing ring network for Ethernet/IP communications between the WTP SCADA System and the control panels installed under this Contract.
24. Provision and installation of a new SCADA Network Rack, SNR-050-901-01, with virtualized, redundant SCADA servers and SCADA network equipment in the WTP Admin Building Server Room.
25. Provision and installation of outdoor antennas for 4G/5G cellular and GPS time synchronization devices in SNR-050-901-01.
26. Provision and installation of CAT6 network cable and conduit between WTP Admin Building Electrical Room 112 and SNR-050-901-01 copper patch panel.
27. Programmer shall convert existing SCADA HMI workstation PC based servers to SCADA thick and thin clients, as shown on the Instrumentation drawings.
28. Programmer shall provide new SCADA HMI screens, new PLC logic, SCADA network configuration, and all associated testing and startup requirements.
29. Programmer shall provide temporary PLC logic, SCADA network configuration, and all associated temporary monitoring and control hardware testing and startup requirements.
30. Provision for hardware and software for secure remote access to the SCADA system.
31. Programmer shall configure SCADA system hardware and software for secure remote access by Owner designated staff to have read only access to the VTScada HMI screens.
32. Provision for hardware and software for text message (sms) based alarms send from the SCADA system.
33. Programmer shall configure the SCADA system to generate process alarms that are sent to Owner designated staff via text message.
34. All other materials and incidentals to complete the Work.
35. All materials must be NSF 61 certified.
36. Contractor shall provide detailed loop drawings that meet or exceed the requirements described in Section 17050-1.01-B-5.

B. See Section 01140 - Work Restrictions for construction constraints and protection of treatment plant processes during construction.

C. Obtain Building Permit from the City of Delray Beach. A construction or operating permit from the Florida Department of Health has been obtained.

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

1.03 LOCATION OF PROJECT

A. The Work is located at the City of Delray Beach Water Treatment Plant, 434 South Swinton Avenue, Delray Beach, FL 33444.

1.04 COORDINATION MEETINGS

A. Contractor shall attend the following meetings:
   1. Construction kickoff meeting.
   2. Monthly progress meetings.
   3. Other meetings as specified.

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

1.05 ACTIVITIES BY OTHERS

A. Activities by others which may affect performance of work include:
   1. Ongoing activities for the Water Treatment Plant may include other Contractors.

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 scheduling the Work.
   2. Access to the plant.
   3. Work restrictions and coordination between construction operations and plant operations.

1.02 GENERAL CONSTRAINTS ON WORK AND SCHEDULING OF WORK

A. Parking for Contractor shall be in a location as designated by the City.

B. Working hours and holidays:
   1. Work shall be conducted between the hours of 7 a.m. to 4 p.m. on Monday through Friday. Work outside these hours is prohibited unless approved by the Owner. The Owner will only consider requests from Contractor to work outside the hours of designated hours if the request is made in writing and at minimum 48 hours before the requested work period.
   2. The Contractor is required to adhere to the City's holiday schedule and any work on City holidays must be pre-approved in writing.

C. Prior to mobilization, submit to Owner and Engineer a drawing indicating proposed area to store materials, equipment, portable restroom, and contractor vehicles. Storage areas shall not disrupt continuous 24 hour per day, 7 days per week operation of the Water Treatment Plant. The Owner reserves the right to request reduction of onsite areas used by the Contractor for stored materials and equipment.

D. Stored materials:
   1. Long term storage of materials on-site is prohibited. Materials shall be installed within 30 days of arrival onsite.

E. General:
   1. The Water Treatment Plant is the Owner's sole source of drinking water.
   2. The installation of the baffles, chemical feed lines and sample line shall be done when the clearwells are in operation.
   3. All materials and personnel gear entering the clearwell shall be disinfected. Disinfection of any materials, tools and personnel shall be conducted just prior to entering the clearwells.
   4. Access to the clearwells shall be through the hatches as indicated on the Drawings.

5. Contractor shall inform and receive approval from Owner and Engineer, in writing, of any planned system cutovers or modifications that result in system downtime of any duration prior to commencing the work.
6. 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. Do not impair the operational capabilities of essential elements of the treatment process or reduce treatment capacity.
7. Conduct activities in a manner that will not impair capabilities of essential elements of the treatment process or reduce treatment capacity below levels sufficient to meet demands for water throughout the contract time.
8. Protect existing plant processes, equipment and utilities at all times from damage or disruption of service.
9. Contractor shall demonstrate to and receive approval by Engineer and Owner witnessed clean water testing for all chemical systems, prior to adding chemical to the chemical storage and day tanks.

F. Temporary process control hardware and software:
1. Contractor, through the ICSC, shall provide temporary process monitoring and control hardware and software licenses, and all associated electrical modifications, for the purpose of continuous automatic operation of existing process control systems modified under this Contract, including, but not limited to the CO^2 feed system, all chemical feed systems and the clarifier sludge blow down pumps.
2. Programmer shall provide network device configuration, develop, and deploy temporary automatic process control and monitoring programs for temporary process monitoring and control hardware and software provided by the Contractor and existing WTP monitoring and control hardware and software, including but not limited to the existing DFS SCADA HMI system software and DFS RTU software. Refer to Section 17050 - Common Work Results for Process Control and Instrumentation Systems for definition of “Programmer.”

G. Engineer’s proposed construction sequence:
1. The following is the Engineer’s proposed construction sequence. Contractor may submit in writing all modifications to the Engineer’s proposed construction sequence for Engineer's approval. The individual tasks listed below may occur concurrently with other tasks with written approval from Engineer.
    a. Submit Construction and Shop Drawing Submittal Schedule and receive approval from Owner and Engineer.
    b. Submit all shop drawings and receive approval from Engineer.
    c. Coordinate with Owner to plan all demolition and new construction work at the WTP.
    d. Conduct clearwell baffle wall upgrades.
    e. Programmer, in coordination with the Contractor and ICSC, shall conduct all software workshops listed in Division 17 and receive written approval from Engineer and Owner for all HMI graphic screens and PLC logic modified or created under this contract.

f. Contractor, through the ICSC, and in coordination with the Programmer shall provide a Pre-Factory Acceptance Test and Witnessed Factory Acceptance Test of all new equipment shown on the Instrumentation Drawings in accordance with Section 17950 - Commissioning for Instrumentation and Controls, including, but not limited to the equipment shown on the Network Connection Diagrams.
g. Install new SCADA Network Rack SNR-050-901-01 in the location shown on the drawings.
h. Install CAT6 cables between SNR-050-901-01 the Owner's LAN switch in WTP Admin Building Electrical Room 102.
i. Programmer shall establish communications between the SNR-050-901-01 servers and Owner's existing SCADA network, including but not limited to the existing VTScada SCADA system and DFS SCADA system.
j. Contractor shall install compact remote I/O panels PCM-050-145-11, PCM-050-145-31, and PCM-050-185-01.
k. Contractor shall install temporary clarifier sludge blowdown pump controls that automatically starts the manually selected lead pump based on an operator adjustable time delay for an adjustable duration, initially set at 4 hours.
l. Programmer shall perform all required network hardware and software configuration in preparation to connect SNR-050-901-01 with the new Clarifier Sludge Blowdown/4-Log Sampling control panel (PCM-050-220-01), all compact remote I/O panels (PCM-050-145-11, PCM-050-145-31, and PCM-050-185-01) and all SCADA workstation HMI client computers.
m. Programmer shall perform all required firewall configuration required to support communications between SNR-050-901-01, the Owner's existing SCADA network, the Owner's LAN, and all new PLC, remote I/O, SCADA server, and SCADA workstation equipment provided under this Contract. Firewall configuration shall be coordinated with the Owner and shall be completed prior to placing the affected equipment into service.
n. Programmer shall perform all required remote access configuration for the new SCADA system, including coordination with the Owner for approved access methods, user authentication, access permissions, and cybersecurity requirements. Remote access configuration shall be tested and confirmed with the Owner prior to placing the affected SCADA equipment into service.
o. Contractor, in coordination with the Owner and Programmer, shall remove the existing clarifier sludge blowdown control panel, protecting and preserving the existing control wiring, and shall install Clarifier Sludge Blowdown/4-Log Sampling control panel (PCM-050-220-01). Contractor shall install a housekeeping pad, followed by PCM-050-220-01, terminating and labeling the existing signal wiring in the new panel and neatly coiling all unused wires inside the panel. Contractor shall trace out and identify existing signal wiring as required to provide signals shown on the P&IDs and listed in the I/O list.
p. Contractor shall install fiber optic conduit and cable between PCM-050-220-01 and compact remote I/O panels: PCM-050-145, PCM-050-145-31 and PCM-050-185-01. Contractor shall install fiber optic conduit and cable between PCM-050-220-01 and SNR-050-901-01 in the Admin Building Server Room.

q. Programmer, in coordination with Contractor, shall disable temporary controls and test clarifier sludge blowdown pumps PLC logic in PCM-050-220-01 and new SCADA HMI screens, one pump at time. Once all pumps have been migrated to the new PLC logic and tested to be working in manual and automatic modes from both the SCADA HMI and local touch screen, all temporary pump controls shall be disabled. The temporary pump controls shall remain if normal pump manual and automatic operation from SCADA, local touch screen or local operators is not affected, otherwise the Contractor is to remove all temporary clarifier sludge blowdown pump controls.

r. Contractor, in coordination with Programmer, shall disconnect existing clarifier influent flow meter 4-20mA flow output signal wiring and run new signal wiring from the flow meter to PCM-050-185-01. Contractor, in coordination with Programmer, shall disconnect existing filter pH transmitter 4-20mA pH output signal wiring and run new signal wiring from the flow meter to PCM-050-145 and PCM-050-145-31. To maintain continuity of chemical feed system monitoring and control, Programmer, in coordination with Contractor, shall make available to be read, over the Ethernet/IP network, by both the new SCADA HMI/PLC system and the existing DFS system, the clarifier influent flow signal values and filter pH values. Programmer shall test and confirm that all existing chemical feed system control strategies in DFS are able to read the flow and pH signals and maintain the existing DFS control strategy.

s. Contractor shall install 4-Log Sample Panel, SP-050-225-21, and all power, communications, and signal wiring between PCM-050-220-01 and SP-050-225-21.

t. Programmer, in close coordination with Contractor, shall test and confirm proper operation of all sample panel signals from the SCADA HMI and PCM-050-220-01 touch screen.

u. Contractor shall install Chemical Storage and Feed System Control Panel (PCM-050-500-01) in the Chemical Building Electrical Room.

v. Contractor shall install fiber optic communications conduit and cable between PCM-050-500-01 and SNR-050-901-01.

w. Programmer shall perform all required network hardware and software configuration in preparation to connect SNR-050-901-01 with PCM-050-500-01.

x. Programmer shall test and confirm that chemical storage and feed system SCADA HMI screens are communicating and functioning properly from the SCADA workstations.

y. In close coordination with the Programmer, Contractor shall install conduit and wire between PCM-050-500-01 and the chemical metering skids, chemical storage tanks, containment sump level devices and all other devices associated with the chemical storage and feed system. Contractor shall cut over one metering pump and storage tank at a time from the existing DFS HyperSCADA and RTU to the new VTScada chemical storage and feed system SCADA HMI screens and PLC-050-500-01.

z. Programmer, in coordination with Contractor, shall test monitoring and control functionality of each chemical metering pump, chemical transfer pump, chemical bulk storage tank and day tank radar level transmitter, day tank overflow alarm level switch and containment level alarm switch. All testing shall be conducted during a clean water test provided by the Contractor, prior to filling the new storage and day tanks with chemicals. For the Ferric Chloride clean water test, a temporary water tank and temporary piping shall be provided by the contractor for transfer pump testing.

aa. Programmer, in coordination with the Contractor, shall test and confirm that the complete chemical storage and feed monitoring and control system is fully operational from VTScada and meets all monitoring and control requirements described in Division 17.

bb. Contractor shall install fiber optic communications conduit and cable between PCM-220-050-01 and a temporary communications panel near the existing CO^2 system PLC in the Lime Building CO^2 Room. The temporary communications panel hardware shall include but is not limited to the following components: patch panels, patch cables, LAN switches, media converters, protocol gateways, or any other hardware required to provide for CO^2 PLC logic to read between PCM-050-220-01 and the existing CO^2 system PLCs.

cc. Contractor shall install temporary network and monitoring/control hardware. Programmer shall modify existing PLC logic to maintain CO^2 feed system operation during the installation of the new CO^2 system control panel PCM-050-550-01. The existing Allen-Bradley MicroLogix PLCs shall be configured to read the filter pH and clarifier influent flow values over the Ethernet/IP network and control the CO^2 feed system output with a feedforward flow to CO^2 ratio and a pH feedback trim control strategy, in accordance with Section 17101A - Specific Control Strategies.

dd. Programmer, in coordination with Contractor, shall confirm proper operation of the temporary CO^2 feed system controls from the VTScada HMI screens.

ee. Contractor, in coordination with Programmer, shall install PCM-050-550-01, terminating all existing and new signals cables inside the new enclosure. Contractor shall remove the temporary network panel and terminate the fiber optic cable inside the fiber optic patch panel in PCM-050-550-01. One PLC-050-550-01 is controlling the CO^2 feed system in both remote manual and automatic mode from VTScada, the Contractor and Programmer shall work together to remove the temporary CO^2 feed system control hardware and temporary network panel.

ff. Programmer shall test and confirm that the CO^2 feed system (and other equipment connected to the PLC) SCADA HMI screens are communicating and functioning properly from the SCADA workstations (VTScada HMI screens).

gg. Contractor shall install fiber optic communications conduit and cable between PCM-050-550-01 and PCM-050-500-01.

hh. Programmer, in coordination with Contractor, shall test and verify proper operation of each segment of the Ethernet/IP fiber optic ring network.

ii. Contractor, in coordination with the Programmer, shall test and confirm that all instrument and equipment I/O points and associated monitoring and controls, shown on the P&IDs described in Division 17, are fully operational from the SCADA workstations (VTScada HMI screens).

1.03 SHUTDOWN AND CONSTRUCTION CONSTRAINTS

A. General shutdown constraints:
   1. Execute the Work while the existing facility is in operation.
   2. Owner maintains the ability to abort the work on the day of the scheduled work.
   3. Provide for health, safety, and wellbeing of plant staff at all times.

B. Chemical system constraints:
   1. Contractor shall submit a sequence of construction that meets all of the plant operation restrictions outlined below.
   2. The ferric chloride storage and feed system shall be operational at all times. For switchover to temporary and permanent systems a maximum downtime of 1 hours may be allowed. Coordinate switchover and downtime with Owner and Engineer including providing contingency plan for restarting system.
   3. The phosphate storage and feed system shall be operational at all times.
   4. The sodium hypochlorite system shall be operational at all times. Coordinate switchover to new sodium hypochlorite metering pump skid and injection location with Owner and Engineer.

1.04 CHEMICAL SYSTEMS SEQUENCE OF CONSTRUCTION

A. An example sequence of construction is provided below for the ferric chloride and phosphate storage and feed systems. Contractor is responsible for preparing and executing the sequence of construction that meets the requirements of this Section.
   1. Ferric Chloride Feed Pump System:
      a. Install new ferric chloride discharge piping to all four injection points.
      b. Install Owner-furnished ferric chloride skid at the interim location and make preparations for the following:
         1) To provide temporary discharge piping that will connect to new permanent piping that feeds new injection points at Clarifiers No.1,2,3,4.
         2) Provide temporary piping that will connect to the existing ferric chloride storage tank to the interim skid location.
         3) Provide temporary electrical power to the ferric chloride skid.
      c. Install temporary systems outlined above and switch operation of ferric chloride over to the new skid and take the existing skid out of service.
      d. Remove existing skid, associated piping, equipment and electrical equipment and conduits.
      e. Prepare permanent piping, day tank, transfer pumps and electrical connections for the permanent location of the new ferric chloride skid.
      f. Relocate ferric chloride skid from the temporary location to the permanent location and make all necessary piping and electrical connection.
      g. Startup and commission new ferric chloride skid, day tank and transfer pumps.

h. Remove any temporary piping or electrical systems used or install or the transition and commission that is not required for the final installation.

2. Ferric Chloride Storage:
   a. Improvements to the ferric chloride storage tank can be made at any time as it does not require any chemical systems to be shut down.
3. Phosphate Storage and Feed Pump System:
   a. Install new phosphate storage tank.
   b. Install new phosphate discharge piping to all four injection points.
   c. Install new phosphate skid in a temporary location and make preparations for the following:
      1) Provide temporary discharge piping that will connect to the injection points.
      2) Provide temporary piping that will connect to the phosphate storage tank.
      3) To provide temporary electrical power to the phosphate skid.
   d. Install temporary systems outlined above and switch operation of phosphate over to the new skid and take the existing skid and tanks out of service.
   e. Remove existing phosphate skid, associated piping, tanks, equipment, and demolish the existing equipment pad and platforms.
   f. Prepare permanent piping, day tank, transfer pumps and electrical connections for the permanent location of the new phosphate skid.
   g. Startup and commission new phosphate skid, day tank and transfer pumps.
   h. Remove any temporary piping or electrical systems.

1.05 METHOD OF PROCEDURE (MOP)

A. MOP Instructions: See Appendix A.

B. Prepare MOP for the following conditions:
   1. Disinfection activities.
   2. Installation of fiber optic network.
   3. VTScada SCADA system hardware and software installation.
   4. PLC control panel installation.
   5. Existing DFS SCADA RTU and HMI system hardware and software modifications.
   6. All SCADA system installation or modification activities that have potential to disrupt operations for any duration.

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

1.06 REQUIREMENTS FOR OPERATION OF PLANT AND MAINTAINING CONTINUOUS OPERATION OF EXISTING FACILITIES

A. Do not disrupt operations of, or access to, the Water Treatment Plant and its clearwells, chemical systems, SCADA system.

B. The jobsite must be kept clean at all times and free from loose trash. All construction waste and trash generated by Contractor should be placed in a dumpster. The dumpster should be kept in a neat and tidy manner and hauled away from the site in a timely manner.

C. Dumpster:
   1. Contractor shall maintain an on-site dumpster. The location of the dumpster shall be coordinated with Owner prior to delivery. Contractor is prohibited from using City dumpsters at all times throughout the contract.

1.07 OPERATIONS AND MAINTENANCE ACCESS

A. Provide safe, continuous access to process control equipment and plant processes for Plant Staff.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

APPENDIX A
"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. Submits MOP.	No later than 21 days prior to work
Owner	2. Reviews MOP.	
Owner	3. MOP finalized.	No later than 7 days prior to work
Contractor	4. Complete Work.	

MOP Process Detail

STEP 1. Submit MOP.

Contractor completes the MOP Form and submit 3 copies for approval.

STEP 2. Review of MOP.

Owner and Engineer 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 3. 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 4. Complete work.

Contractor completes work.

METHOD OF PROCEDURE (MOP) FORM

Owner: _____ **Date:** _____

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

Project Name: _____ **Submittal No.:** _____

Submittal Title: _____ **Spec/Dwg. Reference:** _____

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

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

REQUESTOR:

PRIMARY POINT OF CONTACT: PHONE/PAGER:

SECONDARY POINT OF CONTACT: PHONE/PAGER:

NOTIFY ☐ Control Room, Phone ☐ Security, Phone

BUILDING: LOCATION OF WORK FLOOR/LEVEL:

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

Task Summary: _____

Processes Affected: _____

Trades Affected: _____

WORK PLAN:

Work Sequencing: _____

Process Isolation: _____

Spill Prevention Plan: _____

Contingency Plans: _____

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

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

EXISTING SERVICE(S) AT RISK:

☐	Breathing Air	☐	Elect Normal	☐	Process Access	☐	Telephones
☐	Chemical Distribution	☐	Fire Protection	☐	Safety Showers	☐	UPS
☐	City Water	☐	HVAC	☐	SCADA	☐	VAX/DATA
☐	Communication	☐	Inert Gas	☐	Security	☐	
☐	Domestic Drain	☐	Instrument - Air	☐	Solvent Drain	☐	

☐	Elect-Bus Duct	☐	Life Safety System	☐	Specialty Gases	☐	
☐	Elect Emergency	☐	Natural Gas	☐	Storm Drain	☐	
REVIEWER'S INSTRUCTIONS / COMMENTS:							
☐	PREJOB BRIEFING MUST BE COMPLETED PRIOR TO COMMENCING WORK:						

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

SECTION 01220

MEASUREMENT AND PAYMENT

PART 1 GENERAL

1.01 SUMMARY

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

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 operations.
         2) Installing temporary construction power, wiring, and lighting facilities.
         3) Establish and submit safety program.
         4) 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.
         5) Arranging for and erection of Contractor's work and storage yard.
         6) Provide required insurance certificates and bonds.
         7) Obtaining required permits, licenses, and fees.
         8) Provide preliminary schedule of values of the Work.
         9) Provide preliminary schedule and develop baseline schedule.
         10) Provide Schedule of Submittals.
         11) Post OSHA, Department of Labor, state, and other required notices.
         12) Provide pre-construction photographs.
         13) Provide pre-construction videos.
         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 3 percent of Contract Price.
      d. Lump sum.

B. Item 2: Furnish, Deliver and Install Baffle Walls:
   1. Measurement:
      a. Deliver Baffle Wall Material for onsite storage as specified.
      b. Install and disinfect Baffle Walls as specified.
   2. Payment:
      a. Lump sum.

C. Item 3: Provide and install new 4 log chemical feed lines, 4 log sample lines and submersible mixers.
   1. Measurement:
      a. Provide materials and install lines and mixers as specified and shown on the Drawings.
   2. Payment:
      a. Lump Sum.

D. Item 4: Provide and install new SCADA system and fiber optic network.
   1. Measurement:
      a. Provide a complete SCADA HMI and PLC system with fiber-optic network, as specified and shown on the Drawings, successfully completing all final acceptance tests.
   2. Payment:
      a. Lump Sum.

E. Item 5: Chemical Feed Systems
   1. Measurement:
      a. Furnish and Install Ferric Chloride, Phosphate and Hydrofluorosilicic Acid storage and feed system modifications, including interim operations and completing final acceptance testing, as specified and shown in the Contract Documents.
   2. Payment:
      a. Lump Sum

F. Item 6: Balance of Work:
   1. Measurement:
      a. Remainder of the Work to complete the project.
   2. Payment:
      a. Lump sum.

G. Item 7: Demobilization:
   1. Measurement:
      a. Cleanup and restore entire job site to the satisfaction of the Owner.
      b. Removal of temporary facilities as specified in Section 01500 - Temporary Facilities and Controls.
      c. Completion of closeout submittals as specified in Section 01770 - Closeout Procedures.
   2. Payment:
      a. Shall not be less than 3 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: 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.

C. Prepare Schedule of Values identifying costs of Major Items of Work and other costs shown in sample included at end of this Section.

D. Divide the work into the following Major Items of Work:
   1. Mobilization.
   2. Furnish and Install Baffle Walls.
   3. Furnish and Install 4-Log Chemical Feed Lines, 4-Log Sample Lines and submersible mixers.
   4. Furnish and Install New SCADA System and Fiber Optic Network.
   5. Furnish and Install Ferric Chloride, Phosphate and Hydrofluorosilicic Acid storage and feed system modifications, including interim operations and completing final acceptance testing
   6. Balance of Work
   7. Demobilization.

1.03 SUBMITTALS

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

1.04 SAMPLE SCHEDULE OF VALUES

A. Following is an acceptable form for Schedule of Values:

(SAMPLE ONLY) SCHEDULE OF VALUES		
NO.	**DESCRIPTION OF ITEM**	**LUMP SUM COST**
1	Mobilization	
2	Furnish, Deliver and Install Baffle Walls	
3	Provide and Install 4 log Chemical Feed Lines, 4--Log Sample Lines and Submersible Mixers.	
4	Provide and install new SCADA system and fiber optic network	
5	Furnish and Install Ferric Chloride, Phosphate and Hydrofluorosilicic Acid storage and feed system modifications, including interim operations and completing final acceptance testing	
6	Balance of Work	
7	Demobilization	
	TOTAL LUMP COST	

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 with cover letter 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 5 copies of Application for Payment and Substantiating Data with cover letter.

1.05 PAYMENT REQUESTS

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

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

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

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

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

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

1.06 COST SUMMARIES

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

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

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

SECTION 01312

PROJECT MEETINGS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Requirements for conducting conferences and meetings for the purposes of addressing issues related to the Work, reviewing and coordinating progress of the Work and other matters of common interest, and includes the following:
      a. Qualifications of Meeting Participants.
      b. Basic Meeting Requirements.
      c. Pre-construction Conference.
      d. Pre-construction Safety Conference.
      e. Pre-submittal Conference.
      f. Web Based Construction Document Management Software Training.
      g. Progress Meetings.
      h. Schedule Update Meetings.
      i. Quality Control Meetings.
      j. Pre-Installation Meetings.
      k. Maintenance of Plant Operations (MOPO) Meetings.
      l. Commissioning Coordination Meetings.
      m. Instrumentation and Control Coordination Meetings.
      n. Close-out Meeting.
      o. Post Construction Meeting.

1.02 QUALIFICATIONS OF MEETING PARTICIPANTS

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

1.03 BASIC MEETING REQUIREMENTS

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

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

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

D. Agenda:
   1. Meeting leader shall prepare copies of the agenda for participants and distribute at the meeting.

2. Minimum requirements:
    a. Meeting purpose.
    b. Review minutes of previous meeting.
    c. Safety and security.
    d. Discuss issues.
    e. Action items.
    f. Next meeting.

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

1.04 PRE-CONSTRUCTION CONFERENCE

A. Construction manager leads the meeting.

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

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

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

11. Temporary utilities.
12. Safety and first aid procedures.
13. Security procedures.
14. Housekeeping procedures.
15. Safety and security.
16. Review proposed photographer Submittal.
17. Action items.
18. Next meeting.

1.05 PRE-CONSTRUCTION SCHEDULING MEETING

A. Construction manager leads the meeting.

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

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

D. Agenda minimum requirements:
   1. Meeting purpose:
      a. To establish the format and features of the Construction Schedule.
   2. Schedule preparation.
   3. Reporting requirements.
   4. Updates and revision procedures.
   5. Schedule delay analysis procedures.
   6. Schedule methodology.
   7. Planned sequence of operations.
   8. Cost and labor loading methodology.
   9. Proposed activity coding structure as specified in Section 01321 - Schedules and Reports.
   10. Naming convention: Name schedule files with the year, month and day of the data date, revision identifier, and a description of the schedule.
      a. Example 1: 2021_07_30 rev 1 draft baseline schedule.xer.
      b. Example 2: 2021_09_30 rev 2 sep final update.xer.
   11. Action items.
   12. Next meeting.

1.06 PRE-SUBMITTAL CONFERENCE

A. Construction manager leads the meeting.

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

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

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

1.07 PROGRESS MEETINGS

A. Construction manager will lead the meeting.

B. Timing:
    1. Hold meetings throughout progress of the Work at maximum weekly intervals.

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

D. Agenda minimum requirements:
    1. Meeting purpose:
        a. Provide the status of the Work.
    2. Review minutes of previous meeting.
    3. Safety and security.
    4. Construction schedule summary.
    5. Review of 6 weeks schedule.
        a. Contractor shall provide printed hard copies for each attendee.
    6. Review of off-site fabrication and delivery schedules.
    7. Review of Submittals schedule and status of Submittals.
    8. Request for information (RFI's) status.
    9. MOP's/shutdown coordination.
    10. Change order management status.
    11. Maintenance of quality standards (QA/QC).
    12. Field observations, problems, and conflicts.
    13. Commissioning.
    14. Partnering recognition status (optional).

15. General items.
16. Action items.
17. Next meeting.

1.08 SCHEDULE UPDATE MEETINGS

A. Contractor leads the meeting.

B. Timing:
   1. Hold meetings throughout progress of the Work at maximum monthly intervals.

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

D. Agenda minimum requirements:
   1. Meeting purpose:
      a. Identify and troubleshoot scheduling issues in a collaborative environment.
      b. Provide further detail on Work status.
   2. Review minutes of previous meeting.
   3. Review Monthly Schedule, (Actual Progress and Variance).
      a. "Activities Started/Completed" this period.
      b. "Activities Started/Completed" "Variance" Baseline vs. current.
      c. "Added/Deleted Activities".
      d. "Revised Activity Descriptions".
      e. Any significant Proposed Logic Changes.
   4. Review milestone "Substantial Completion" Schedule:
      a. "Critical" Activities - "Critical Area, Float and Vital Statistics".
   5. Review "Cumulative and Monthly Costs" graph.
   6. Review "Budgeted Cost" indicating the Current Project Budgeted Cost.
   7. Safety and security.
   8. Action items.
   9. Next meeting.

1.09 PRE-INSTALLATION MEETINGS

A. Contractor leads the meeting.

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

C. Required attendees:
   1. Owner, Engineer, Contractor, Contractor's project manager, general superintendent, project scheduler, major subcontractors including electrical instrumentation, and suppliers as appropriate to the agenda topics for each meeting.

2. Additional invitees:
    a. Owner utility companies when the Work affects their interests and others necessary to the agenda.

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

1.10 PRE-SHUTDOWN MEETINGS

A. Contractor leads the meeting.

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

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

D. Agenda minimum requirements:
1. Meeting purpose:
    a. Review conditions of installation, preparation, and installation procedures.
    b. Review coordination with related work.
2. Review minutes of previous meeting.
3. Review accepted Construction Method of Procedure (MOP), as specified in Attachment A of Section 01140 - Work Restrictions, including conditions of shutdown, preparation, and installation procedures.
4. Review timelines and sequences.
5. Review responsibilities.
6. Review dry run plan and schedule, as necessary.
7. Review coordination with related work.
8. Safety and security.
9. Action items.
10. Next meeting.

1.11 QUALITY CONTROL MEETINGS

A. Contractor leads the meeting.

B. Timing:
1. Hold meetings throughout progress of the Work at maximum weekly intervals.

C. Required attendees:
   1. Engineer, Construction manager and staff, Contractor's quality control manager, and staff.

D. Agenda minimum requirements:
   1. Meeting purpose:
      a. Update Contractor's efforts to comply with quality requirements in the Contract Documents.
   2. Review minutes of previous meeting.
   3. Review of Work progress and schedule.
   4. Review of out-of-compliance inspection or test results.
   5. Field observations, problems, and decisions.
   6. Review of offsite fabrication and delivery schedules.
   7. Planned progress during succeeding work period.
   8. Coordination of required inspections and tests.
   9. Review 6-week schedule report with upcoming inspections and special tests.
   10. Maintenance of quality and work standards.
   11. Other business relating to Work.
   12. Safety and security.
   13. Action items.
   14. Next meeting.

1.12 COMMISSIONING COORDINATION MEETINGS

A. Contractor leads the meeting.

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

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

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

1.13 INSTRUMENTATION AND CONTROL COORDINATION MEETINGS

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

1.14 CLOSE-OUT MEETING

A. Construction manager leads the meeting.

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

C. Required attendees:
   1. Owner, Engineer, Contractor, Contractor's project manager, and superintendent.

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

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: Preparation, submittal, and maintenance of schedules and reports.

1.02 SUBMITTAL REQUIREMENTS

A. Submit preliminary and baseline schedule.

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

C. Submit final schedule update as specified.

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

E. Submit schedules in the media and number of copies as follows:
   1. Provide each submittal in PDF format and in other formats specified in this Section.

1.03 SCHEDULING FORMAT AND SOFTWARE

A. Schedule format: Utilize CPM format.

B. Prepare computerized schedule utilizing Primavera P6 Professional, SureTrak or Microsoft Project software, most current version.

C. Contractor and Engineer must agree on the format.

1.04 REVIEW AND ACCEPTANCE OF SCHEDULES

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

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

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

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

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

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

G. Engineer’s submittal review response:
   1. When schedule reflects Owner's and Contractor's agreement of project approach and sequence, schedule will be accepted by Owner.
   2. Engineer’s submittal review response for schedule submittal will be “Receipt Acknowledged - Filed for Record” including applicable comments.
   3. Acceptance of the schedules by the Owner is for general conformance with the Contract Documents and for Owner’s planning information, and does not relieve the Contractor of sole responsibility for planning, coordinating, and executing the Work within the contract completion dates. Omissions and errors in the accepted schedules shall not excuse performance less than that required by the Contract Documents. 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.

1.05 SCHEDULE UPDATES

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

B. Monthly updates:
   1. Submit written narrative report in conjunction with each Schedule Update including descriptions of the following:
      a. Activities added to or deleted from the schedule are to adhere to cost and other resource loading requirements.
         1) Identify added activities in manner distinctly different from original activity designations.
      b. Changes in sequence or estimated duration of activities.
      c. Current or anticipated problems and delays affecting progress, impact of these problems and delays and measures taken to mitigate impact.
      d. Assumptions made and activities affected by incorporating change order work into the schedule.

2. Submit updated schedule and materials specified under Submittal of Progress Schedules, 5 calendar days before the monthly schedule update meeting.
3. Since Monthly Schedule Update is required for the application for progress payment , submittal and acceptance of the monthly Schedule Update is a condition precedent to the making of any progress payments.

C. Monthly progress meeting:
1. Update the schedule prior to monthly progress meeting.
   a. Identify overall progress of each Major Item of Work in the Summary Schedule.
   b. If there are significant changes to the schedule, submit a written report at the weekly progress meeting.
2. Should monthly Schedule Update show project completion earlier than current Contract completion date, show early completion time as schedule activity, identified as “Project Float”.
3. Should monthly Schedule Update show project completion later than current Contract completion date, prepare and submit a Schedule Revision in accordance with the Revisions to Schedule.

1.06 REVISIONS TO SCHEDULE

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

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

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

1.07 ADJUSTMENT OF CONTRACT TIMES

A. Contract Time will be adjusted only for causes specified in Contract Documents.
1. Non-excusable delay:
   a. Non-excusable delays include actions or inactions of the Contractor, or events for which the Contractor has assumed contractual responsibility (including actions or inactions of subcontractors, suppliers, or material manufacturers at any tier) that would independently delay the completion of the Work beyond the current Contract completion date).

b. No time extensions will be granted for non-excusable delays.

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

B. If the Contractor believes that the Owner has impacted its work, such that the project completion date may be delayed, the Contractor must submit proof demonstrating the delay to the critical path in writing to Owner within 7 calendar days of the event that may have caused the delay.
   1. This proof, in the form of a Time Impact Analysis, may entitle the Contractor to an adjustment of Contract Time.

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

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

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

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

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

H. If completion of the project occurs within the specified Contract Time, the Contractor is not entitled to jobsite 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 with Contract Documents.
   2. In cases where the Contractor does not submit a request for Contract Time adjustment for a specific change order, delay, or Contractor request within the specified period of time, then it is mutually agreed that the particular change order, delay, or Contractor request has no time impact on the Contract completion date and no time extension is required.

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

1.08 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. Contractor's bid covers all costs associated with the execution of the Work in accordance with the Progress Schedule.

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

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

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

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

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

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

I. Imposed dates, hidden logic prohibited: Do not use imposed dates or hidden logic in preparation of schedule.

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

K. Contract float is for the mutual benefit of both Owner and Contractor.
   1. Changes to the project that can be accomplished within this available period of float may be made by Owner without extending the Contract Time, by utilizing float.

2. Time extensions will not be granted nor delay damages owed until Work extends beyond currently accepted Contract completion date.
3. Likewise, Contractor may utilize float to offset delays other than delays caused by Owner.
4. Mutual use of float can continue until all available float shown by schedule has been utilized by either Owner or Contractor, or both. At that time, extensions of the Contract Time will be granted by Owner for valid Owner-caused or third party-caused delays which affect the planned completion date and which have been properly documented and demonstrated by Contractor.
5. Non-sequestering of float: Pursuant to float sharing requirements of Contract, schedule submittals can be rejected for, use of float suppression techniques such as preferential sequencing or logic, special lead or lag logic restraints, extended activity durations or imposed dates.

L. 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?

M. 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.

N. 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 Engineer.

O. 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 updated Schedule of Values is accepted.

1.09 NETWORK DETAILS AND GRAPHICAL OUTPUT

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

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

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

D. Indicate the critical path for the project.

E. Delineate the specified contract duration and identify the planned completion of the Work as a milestone.
   1. Show the time period between the planned and Contract completion dates, if any, as an activity identified as project float unless a Change Order is issued to officially change the Contract completion date.

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

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

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

I. Identify the execution of the following:
   1. Mobilization.
   2. All required submittals and submittal review times showing 30 calendar day duration for such activities and equal amount of time for re-submittal reviews.
   3. Equipment and materials procurement/fabrication/delivery.
   4. Delivery of new Filter Media.
   5. For each filter:
      a. Removal of filter from operation.
      b. Removal and disposal of filter media.
      c. Installation of new filter media.

d. Bacteriological testing.
e. Placement of filter back into operation.
6. Substantial completion.
7. Punch list work.
8. Demobilization.

1.10 WEATHER DAY ALLOWANCE

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

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

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

1.11 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 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.

1.12 PRELIMINARY SCHEDULE AND PRELIMINARY SCHEDULE OF VALUES

A. Due date:
    1. Submit proposed preliminary schedule and 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 and Preliminary Schedule of Values to review and make necessary adjustments.
    3. Submit revised preliminary schedule and Preliminary Schedule of Values within 5 calendar days after meeting.
    4. Update Preliminary Schedule and Preliminary Schedule of Values monthly during first 90 calendar days after Notice to Proceed.
        a. Use Preliminary Schedule and Preliminary Schedule of Values as the payment application as specified in Section 01294 - Applications for Payment.

B. Format:
    1. Schedule of manpower and costs for all activities for first 90 calendar days of Work after receipt of Notice to Proceed.
        a. Provide realistic and level manpower and costs so as not to have unusual manpower requirements.
    2. Schedule of costs:
        a. Schedule of Values as specified in Section 01292 - Schedule of Values for first 90 calendar days of Work.
        b. Submittal and acceptance of Preliminary Schedule 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.
        c. Proceed with pay item Work after Preliminary Schedule and schedule of costs have been accepted by Owner.

C. Incorporate unchanged, the accepted Preliminary Schedule as first 90 calendar days of activity in Contractor’s Baseline Schedule.

1.13 SCHEDULE OF SUBMITTALS

A. Schedule of Submittals shall include submittals required in the Contract Documents but not limited to Commissioning 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 Owner.
   2. Format:
      a. Include submittals anticipated in the first 90 calendar days after Notice to Proceed using early start dates.
      b. Indicate week and month anticipated for each submittal.
      c. Indicate “Priority” submittals where review time can impact Contractor’s schedule.
         1) “Priority” indication will not alter review times specified in Section 01330 - Submittal Procedures.
         2) Engineer will endeavor to provide early review of “Priority” submittals where possible.
   3. Submittal of Preliminary Schedule of Submittals shall be a condition precedent to Owner making progress payments during the first 90 calendar days after Notice to Proceed.

C. Final Schedule of Submittals:
   1. Due date: 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 each submittal.
      d. Indicate “Priority” submittals where review time can impact Contractor’s schedule.
         1) “Priority” indication will not alter review times specified in Section 01330 - Submittal Procedures.
         2) 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.

1.14 BASELINE SCHEDULE AND BASELINE SCHEDULE OF VALUES

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

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

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

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: Requirements and procedures for submittals.

B. Submittals shall be made in both hard copy and electronic formats.

1.02 REFERENCES

A. NSF International:
   1. NSF 61 - Drinking Water System Components - Health Effects.

1.03 DEFINITIONS

A. Certificates: Describe certificates that document affirmations by the Contractor or other entity that the work is in accordance with the Contract Documents.

B. Extra stock materials: Describe extra stock materials to be provided for the Owner's use in facility operation and maintenance.

C. Maintenance material submittals: Use this article to categorize maintenance materials submittals requiring no Engineer action other than confirmation of receipt under an explanatory heading.

D. Manufacturer's instructions: Instructions, stipulations, directions, and recommendations issued in printed form by the manufacturer of a product addressing handling, installation, erection, and application of the product; manufacturer's instructions are not prepared especially for the Work.

E. Product data: Product data usually consists of manufacturers' data sheets or catalog pages illustrating the products to be incorporated into the project.

F. Samples: Samples are full-size actual products intended to illustrate the products to be incorporated into the project. Sample submittals are often necessary for such characteristics as colors, textures, and other appearance issues.

G. Spare parts: Describe spare parts necessary for the Owner's use in facility operation and maintenance; identify the type and quantity here, but include the actual characteristics of the spare parts in Product as part of the specification of the product.

H. Shop drawings: Shop drawings are prepared specifically for the project to illustrate details, dimensions, and other data necessary for satisfactory fabrication or construction that are not shown in the contract documents. Shop drawings could include graphic line-type drawings, single-line diagrams, or schedules and lists of products and their application.

I. Submittals: Submittals are samples, product data, shop drawings, and others that demonstrate how Contractor intends to conform with the Contract Documents.

J. Tools: Tools are generally defined as items such as special wrenches, gauges, circuit setters, and other similar devices required for the proper operation or maintenance of a system that would not normally be in the Owner's tool kit.

1.04 GENERAL INSTRUCTIONS

A. Certification: Contractor is responsible to determine and verify all 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 all Contract requirements.

B. Provide submittals that are specified or reasonably required for construction, operation, and maintenance of the Work.

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

D. Edit submittals so that the submittal specifically applies to only the equipment furnished.

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

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

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

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

I. Minimum page size will be 8 1/2 inches by 11 inches:
   1. Maximum page size will be 11 inches by 17 inches.

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

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

L. Indicate project designated equipment tag numbers from P&IDs for submittal of devices, equipment, and assemblies.

1.05 SUBMITTAL ORGANIZATION

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

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

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

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

E. Thumbnails optimized for fast web viewing.

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

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

c. Provide field dimensions and relationship to adjacent or critical features of the Work or materials.

H. Contractor: Prepare submittal information in sufficient detail to show compliance with specified requirements.
   1. Determine and verify quantities, field dimensions, product dimensions, specified design and performance criteria, materials, catalog numbers, and similar data.
   2. Coordinate submittal with other submittals and with the requirements of the Contract Documents.
   3. Check, verify, and revise submittals as necessary to bring them into conformance with Contract Documents and actual field conditions.

1.06 SUBMITTAL METHOD AND FORMAT

A. Submittal identification numbering:
   1. Number each submittal using the format defined below:

	Spec Section Number	**Dash**	**Initial Submittal - Sequential Number**	**Decimal Point**	**Subsequent Submittal Revisions Sequential Number**
Example 1 Description	*Cast-In-Place Concrete*		*8th initial submittal*		
	03300	-	0008		
Example 2 Description	*Cast-In-Place Concrete*		*8th initial submittal*		*First revision to the 8th initial submittal*
	03300	-	0008	.	1

B. Submittals in electronic media format:
   1. General: Provide all information in PC-compatible format using Windows® operating system as utilized by the Owner and Engineer.
   2. Text: Provide text documents and manufacturer's literature in Portable Document Format (PDF).
   3. Graphics: Provide graphic submittals (drawings, diagrams, figures, etc.) utilizing Portable Document Format (PDF).

C. In addition to electronic submittals, send hardcopy submittal to Engineer:
   1. Provide number of copies of submittal as below:
      a. Total: 2 copies minimum except where noted.
      b. Owner: 1 copy.
      c. Engineer: 1 copy.

1.07 SUBMITTAL PROCEDURE

A. Engineer: Review submittal and provide response:
   1. Review description:
      a. Engineer will be entitled to rely upon the accuracy or completeness of designs, calculations, or certifications made by licensed professionals accompanying a particular submittal whether or not a stamp or seal is required by Contract Documents or Laws and Regulations.
      b. Engineer's review of submittals shall not release Contractor from Contractor's responsibility for performance of requirements of Contract Documents. Neither shall Engineer's review release Contractor from fulfilling purpose of installation nor from Contractor's liability to replace defective work.
      c. Engineer's review of shop drawings, samples, or test procedures will be only for conformance with design concepts and for compliance with information given in Contract Documents.
      d. Engineer's review does not extend to:
         1) Accuracy of dimensions, quantities, or performance of equipment and systems designed by Contractor.
         2) Contractor's means, methods, techniques, sequences, or procedures except when specified, indicated on the Drawings, or required by Contract Documents.
         3) Safety precautions or programs related to safety which shall remain the sole responsibility of the Contractor.
      e. Engineer can Approve or Not Approve any exception at their sole discretion.
   2. Review timeframe:
      a. Except as may be provided in technical specifications, a submittal will be returned within 21 days.
      b. When a submittal cannot be returned within the specified period, Engineer will, within a reasonable time after receipt of the submittal, give notice of the date by which that submittal will be returned.
      c. Engineer’s acceptance of progress schedule containing submittal review times less than those specified or agreed to in writing by Engineer will not constitute Engineer’s acceptance of review times.
      d. Critical submittals:
         1) Contractor will notify Engineer in writing that timely review of a submittal is critical to the progress of Work.
   3. Schedule delays:
      a. No adjustment of Contract Times or Contract Price will be allowed due to Engineer’s review of submittals, unless all of the following criteria are met:
         1) Engineer has failed to review and return first submission within the agreed upon time frame.
         2) Contractor demonstrates that delay in progress of Work is directly attributable to Engineer’s failure to return submittal within time indicated and accepted by Engineer.

4. Review response will be returned to Contractor with one of the following dispositions:
    a. Approved:
        1) No Exceptions:
            a) There are no notations or comments on the submittal and the Contractor may release the equipment for production.
        2) Make Corrections Noted - See Comments:
            a) The Contractor may proceed with the work, however, all notations and comments must be incorporated into the final product.
            b) Resubmittal not required.
        3) Make Corrections Noted - Confirm:
            a) The Contractor may proceed with the work, however, all notations and comments must be incorporated into the final product.
            b) Submit confirmation specifically addressing each notation or comment to the Engineer within 15 calendar days of the date of the Engineer's transmittal requiring the confirmation.
    b. Not approved:
        1) Correct and resubmit:
            a) Contractor may not proceed with the work described in the submittal.
            b) Contractor assumes responsibility for proceeding without approval.
            c) Resubmittal of complete submittal package is required within 30 calendar days of the date of the Engineer's submittal review response.
        2) Rejected - See Remarks:
            a) Contractor may not proceed with the work described in the submittal.
            b) The submittal does not meet the intent of the Contract Documents. Resubmittal of complete submittal package is required with materials, equipment, methods, etc. that meet the requirements of the Contract Documents.
    c. Receipt acknowledged - Filed for record:
        1) This is used in acknowledging receipt of informational submittals that address means and methods of construction such as schedules and work plans, conformance test reports, health and safety plans, etc.
    d. Receipt acknowledged with comments - Resubmit:
        1) This is used in acknowledging receipt of informational submittals that address means and methods of construction such as schedules and work plans, conformance test reports, health and safety plans, etc. Feedback regarding missing information, conflicting information, or other information that makes it incomplete can be made with comments.

B. Contractor: Prepare resubmittal, if applicable:
    1. Clearly identify each correction or change made.

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

1.08 PRODUCT DATA

A. Details:
    1. Supplier name and address.
    2. Subcontractor name and address.

B. Include:
    1. Catalog cuts.
    2. Bulletins.
    3. Brochures.

4. Manufacturer's Certificate of Compliance: Signed by product manufacturer along with supporting reference data, affidavits, and tests, as appropriate.
5. Manufacturer's printed recommendations for installation of equipment.
6. Quality photocopies of applicable pages from manufacturer's documents.

C. Test reports including the following information:
1. Test description.
2. List of equipment used.
3. Name of the person conducting the test.
4. Date and time the test was conducted.
5. Ambient temperature and weather conditions.
6. All raw data collected.
7. Calculated results.
8. Clear statement if the test passed or failed the requirements stated in Contract Documents.
9. Signature of the person responsible for the test.

D. Certificates:
1. As specified in technical sections.
2. For products that will be in contact with potable water, or products that will be in contact with potable water treatment chemicals, submit evidence from a nationally recognized laboratory that the products comply with the requirements of the NSF 61 standard.

1.09 O&M MANUAL

A. Two O&M manuals, 1 for the baffle materials and 1 for the SCADA system upgrades shall be provided in a hardbound 3-ring binder. Binder shall be appropriately labeled on cover and spine. Sections shall contain final copy of submittals.

1.10 SAMPLES

A. Details:
1. Submit labeled samples.
2. Samples will not be returned.

B. Field samples:
1. As specified in technical sections.

1.11 SCHEDULES AND REPORTS

A. As specified in Section 01321 - Schedules and Reports.

1.12 REQUESTS FOR INFORMATION (RFI)

A. As needed.

1.13 CONTRACTOR'S PROFESSIONAL ENGINEER (P.E.) CERTIFICATION FORM

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

1.14 CLOSEOUT SUBMITTALS

A. Provide closeout submittals as specified in Section 01770 - Closeout Procedures.

B. Operation and Maintenance Manuals: final documents shall be submitted as specified.

C. Extra materials, spare parts, etc.: Submittal forms shall indicate when actual materials are submitted.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

ATTACHMENT A

CONTRACTOR'S P.E. CERTIFICATION FORM

DOCUMENT 01330
CONTRACTOR'S P.E. CERTIFICATION FORM

Owner:	Click here to enter text.	**Date:**	MM/DD/YYYY.
Contractor:	Click here to enter text.	**Registration State:**	Click here to enter text.
Project Name:	Click here to enter text.	**Project No.:**	00000.00
Responsibilities:	Click here to enter text.		
Spec Section:	Click here to enter text.		

Statement of Certification

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

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

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

Click here to enter text.

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

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

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

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

Printed Name: _____

ATTACHMENT B

CONTRACTOR SUBMITTAL TRANSMITTAL FORM

DOCUMENT 01330
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 01357

DELEGATED DESIGN PROCEDURES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Delegated Design procedures.

1.02 GENERAL

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

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

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

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

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

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

1.03 CONTRACTOR'S PROFESSIONAL ENGINEER

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

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

C. Insurance:
   1. Provide Contractor's Professional Engineer's Professional Liability Insurance as specified in Section 00800 - Supplementary Conditions.

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

1.04 SUBMITTALS

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

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

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

1.05 ENGINEER RESPONSE TO DELEGATED DESIGN SUBMITTALS

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

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

SECTION 01410

REGULATORY REQUIREMENTS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Regulatory authorities and codes.

1.02 AUTHORITIES HAVING JURISDICTION

A. Building Department.

B. 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, 6th Edition.

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. Supervision:
   1. The Contractor shall have a foreman/supervisor on the jobsite at all times when work is being performed, including work being performed by subcontractors.
   2. At the Owner's request, the Contractor shall provide credentials on each workers experience relative to working on active water treatment plant. The City reserves the right to have the Contractor replace unqualified personnel.

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

C. Comply with manufacturers' instructions.

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

E. 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.

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

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

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

I. 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.

J. 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 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.

1.07 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.

1.08 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.

1.09 CONTRACTOR'S RESPONSIBILITIES

A. Secure and deliver to laboratory adequate quantities of representative samples of materials proposed to be used and which require testing.

B. Furnish electronically and 5 hard copies of product test reports.

C. 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, temporary controls, field office and sheds, and removal after construction.
   2. Furnishing a preconstruction video and photographs.

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 USE OF CITY FACILITIES

A. Contractor shall not enter City facilities unless access is required for the Work.

1.05 TEMPORARY UTILITIES

A. Temporary electrical power:
   1. The City will provide electrical power (energy cost) for use during construction.
   2. If temporary power during construction is needed, Contractor shall provide all material and equipment. The Owner will designate where on-site power can be connected so as not to interfere with WTP operations.
   3. 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. Contractor shall coordinate with Owner on where to access temporary water. If more than incidental water is needed, e.g., water is needed to conduct the Work, prior to Contractor having access to water, Contractor shall request a temporary meter from the City and pay all fees associated with water usage.
   2. A certified backflow prevention device shall be utilized at all times.

D. Temporary sanitary facilities:
   1. Provide and maintain 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 sufficient fire protection required to protect stored materials 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.

1.06 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. Devices shall conform to 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.

1.07 SECURITY

A. The Water Treatment Plant is a secure site, and all safety and security protocols shall be followed at all times.

B. Prior to the Contractor mobilizing to the site, Contractor shall supply for approval a list with full names of all personnel, including sub-contractors that are assigned to the project.

C. Contractor's personnel shall sign-in upon arriving, each day, and prior to beginning to perform work.

D. Make adequate provision for protection of the work area against fire, theft, and vandalism, and for protection of plant staff against exposure to injury.

1.08 TEMPORARY CONTROLS

A. Dust and Debris control:
   1. Prevent dust nuisance caused by operations, or other activities.
   2. Protect existing plant processes from dust and debris.

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.

1.09 CONTRACTOR FIELD OFFICE 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.

1.10 PRECONSTRUCTION VIDEO AND PHOTOGRAPHS

A. At a minimum of 30 days prior to mobilization, Contractor shall prepare a video and take photographs to document the existing conditions of all storage and work areas.

B. Video to be narrated to document location and observations.

C. Submit video and photographs on a portable drive to Owner for approval. Approval shall be received prior to mobilization.

1.11 MAINTENANCE OF STORAGE AND LAYDOWN AREAS

A. Contractor shall be responsible for maintaining storage and laydown areas. Grass shall be cut weekly, areas to be kept neat and free from weeds, insects, and debris.

1.12 SITE RESTORATION

A. Restore disturbed areas of the site.

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

1.13 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 01738

SELECTIVE ALTERATIONS AND DEMOLITION

PART 1 GENERAL

1.01 SUMMARY

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

1.02 REFERENCES

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

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

1.03 DEFINITIONS

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

B. Concrete breaker: A hand-operated electrical or pneumatic demolition device for removal of hardened concrete or masonry materials having a weight greater or impact frequency less than the limits defined for a chipping hammer.

C. Coring equipment: Non-impact rotary drill with diamond cutting edges.

D. Heavy abrasive blast: Cleaning procedure by which various abrasives materials, or steel shot, are forcibly propelled by high pressure against a surface to remove loose material and produce a concrete surface roughened to ICRI Surface Profile CSP-7, or higher, as specified in ICRI 301.3R.

E. Salvage material: Materials removed from existing facilities and stored for Owner's future reuse.

1.04 DESCRIPTION OF WORK

A. The work includes partial demolition, cutting, and modifying of existing facilities, utilities, and/or structures.

B. These facilities may be occupied and/or operational. Satisfactory completion of the work will require that the Contractor plan activities carefully to work around unavoidable obstacles and to maintain overall stability of structures and structural elements. It will further require restoration of existing facilities, utilities, and structures that are to remain in place and that are damaged by demolition or removal operations.

1.05 SUBMITTALS

A. General:
   1. Submit specified in Section 01330 - Submittal Procedures.

B. Shop drawings: Include:
   1. The location of all embedded items shall be documented using diagrams and/or other media that clearly show dimensions and locations of existing structural elements, existing embedded items and any new embedded items and their relationship to each other.

C. Submittals for information only:
   1. Permits and notices authorizing demolition.
   2. Certificates of severance of utility services.
   3. Permit for transport and disposal of debris.
   4. Selective Demolition Plan.
   5. Pipe Abandonment Plan.

D. Quality assurance submittals:
   1. Qualifications of non-destructive testing agency/agencies.

E. Project record documents.

F. Drawings and/or other media documenting locations of service lines and capped utilities.

1.06 QUALITY ASSURANCE

A. Qualifications:
   1. Assign relocation, removal, cutting, coring and patching to trades and workers qualified to perform the Work in manner that causes the least damage and that provides means of returning surfaces to an appearance at least equal to that of the surrounding areas unaffected by the Work.
   2. Non-destructive testing agencies: Minimum of 5 years' experience performing non-destructive testing for location of steel reinforcement in existing concrete under conditions similar to that required for this Work.

1.07 SEQUENCING

A. Perform Work in sequences and within times specified in Section 01140 - Work Restrictions.

B. If the facility or utility to be modified cannot be removed from service, perform the Work while the facility is in operation using procedures and equipment that do not jeopardize operation or materially reduce the efficiency of that facility.

C. Coordinate the Work with operation of the facility:
   1. Do not begin alterations of designated portions of the Work until specific permission for activities in each area has been granted by Owner in writing.
   2. Complete Work as quickly and with as little delay as possible.

D. Operational functions of the facility that are required to be performed to facilitate the Work will be performed by facility personnel only.

E. Owner will cooperate to assist in expediting the Work.

F. When necessary for the proper operation or maintenance of portions of the facility, reschedule operations so the Work will not conflict with required operations or maintenance.

1.08 REGULATORY REQUIREMENTS

A. Dispose of debris in accordance with governing regulatory agencies.

B. Comply with applicable air pollution control regulations.

C. Obtain permits for building demolition, transportation of debris to disposal site and dust control.

1.09 PREPARATION

A. Non-destructive evaluation of existing concrete and masonry:
   1. Prior to cutting, drilling, coring, and/or any other procedure that penetrates existing concrete or masonry, retain and pay for the services of a qualified non-destructive testing agency to perform investigations to determine the location of existing steel reinforcement, plumbing, conduit, and/or other embedments in the concrete.
   2. Submit documentation of the investigations to the Engineer for review and approval as specified in Section 01330 - Submittal Procedures, before any work involving penetration of existing concrete is initiated.

1.10 PROJECT CONDITIONS

A. Do not interfere with use of adjacent structures and elements of the facility not subject to the Work described in this Section. Maintain free and safe passage to and from such facilities.

B. Provide, erect, and maintain barricades, lighting, guardrails, and protective devices as required to protect building occupants, general public, workers, and adjoining property:
   1. Do not close or obstruct roadways without permits.
   2. Conduct operations with minimum interference to public or private roadways.

C. Prevent movement, settlement, or collapse of structures adjacent services, sidewalks, driveways and trees:
   1. Provide and place bracing or shoring.
   2. Cease operations and notify Engineer immediately when safety of structures appears to be endangered. Take precautions to properly support structure. Do not resume operations until safety is restored.
   3. Assume liability for movement, settlement, or collapse. Promptly repair damage.

D. Arrange and pay for capping and plugging utility services. Disconnect and stub off.
   1. Notify affected utility company in advance and obtain approval before starting demolition.
   2. Place markers to indicate location of disconnected services.

E. Unknown conditions:
   1. The drawings may not represent all conditions at the site and adjoining areas. Compare actual conditions with drawings before commencement of Work.
   2. Existing utilities and drainage systems below grade are located from existing documents and from surface facilities such as manholes, valve boxes, area drains, and other surface fixtures.
   3. If existing active services encountered are not indicated or otherwise made known to the Contractor and interfere with the permanent facilities under construction, notify the Engineer in writing, requesting instructions on their disposition. Take immediate steps to ensure that the service provided is not interrupted, and do not proceed with the Work until written instructions are received from the Engineer.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION

A. Prior to beginning selective demolition operations, perform a thorough inspection of the facility and site.
   1. Report to the Engineer defects, structural damage, and deterioration of existing construction to remain in place.

B. Examine areas affected by the Work and verify the following conditions prior to commencing demolition:
   1. Disconnection of utilities as required.
   2. Verify that utilities serving occupied or active portions of surrounding facilities will not be disturbed, except as otherwise indicated.

C. If unsatisfactory conditions exist, notify the Engineer, and do not begin demolition operations until such conditions have been corrected.

3.02 PREPARATION

A. Plan and organize Work to minimize inconvenience to adjacent buildings and to plant operations.

B. Selective Demolition Plan:
   1. Prepare and submit a comprehensive selective demolition plan for the Work including the following elements, at a minimum:
      a. Proposed sequence, methods, temporary support, and equipment for demolition, removal, and disposal of portions of structure(s).
      b. Provisions and procedures for salvage and delivery to Owner of salvaged items, if required.
   2. Submit plan a minimum 4 weeks before demolition is scheduled to begin.

C. Pipe Abandonment Plan:
   1. Prepare and submit a comprehensive Pipe Abandonment Plan for the Work.
      a. Include provisions to demonstrate and verify with camera inspection that all solids have been removed and that pipe is free of residuals.
   2. At a minimum, define the following elements:
      a. Proposed sequence, methods, cleaning procedures, or demolition, removal, and disposal of contents of the piping.
      b. Method of verification of final pipe condition.
      c. Detailed drawings showing treatment of pipe ends**.**
   3. Submit plan a minimum 4 weeks before abandonment is scheduled to begin.

D. Protection:
   1. Erect weatherproof closures to protect the interior of facilities and elements or equipment that are not designed for exposure to the weather.
   2. Provide temporary heat, cooling, and humidity control as necessary to prevent damage to existing and new equipment and construction.
   3. Maintain existing exiting paths and/or provide new paths in compliance with Building Code requirements.
   4. Erect and maintain dustproof partitions as required to prevent spread of dust, to other parts of building. Maintain negative pressure in the area where the Work is being performed to prevent the accidental spread of dust and to minimize the spread of fumes related to the Work.
   5. Upon completion of Work, remove weatherproof closures and dustproof partitions.
   6. Repair damaged surfaces to match adjacent surfaces.
   7. Provide and maintain protective devices to prevent injury from falling objects.
   8. Locate guardrails in stairwells and around open shafts to protect workers. Post clearly visible warning signs.
   9. Protect the following from damage or displacement during Work.
      a. Benchmarks and survey points.
      b. Existing construction that will remain in place.
      c. Trees and landscaping designated to remain in place.
   10. Carefully remove designated materials and equipment to be salvaged by Owner or reinstalled.
   11. Store and protect materials and equipment to be reinstalled.

E. Layout:
   1. The limits of selective demolition are indicated on the Drawings. Confine demolition operations within the limits indicated on the Drawings.
   2. Lay out demolition and removal work at the site and coordinate with related Work for which demolition and removal is required.
   3. Clearly mark the extent of structural elements to be removed on the actual surfaces that will be removed.
   4. Arrange for Engineer's inspection of the lay out extents.
   5. Do not begin demolition/removal operations until the lay out markings have been reviewed by the Engineer.

3.03 DEMOLITION

A. General:
   1. Perform demolition work in accordance with ANSI A10.6.
   2. Demolish designated portions of structures and appurtenances in orderly and careful manner in accordance with the Selective Demolition Plan.
   3. Conduct demolition and removal work in a manner that will minimize dust and flying particles.
      a. Use water or dust palliative when necessary to prevent airborne dust.
      b. Provide and maintain hoses and connections to water main or hydrant.
   4. Remove materials carefully, to the extent indicated and as required.
      a. Provide neat and orderly junctions between existing and new materials.
      b. Use methods that terminate surfaces in straight lines at natural points of division.
   5. Do not remove anything beyond the limits of Work indicated without prior written authorization from the Engineer.
      a. If in doubt about whether to remove an item, obtain written authorization from the Engineer prior to proceeding.
   6. Perform work so as to provide the least interference and most protection to existing facilities to remain.
   7. Demolished materials:
      a. Assume possession of materials unless otherwise indicated on the Drawings or specified.
      b. Remove demolished materials from site at least daily and dispose of them in accordance with Laws and Regulations.
      c. Do not burn or bury materials on site.

B. Demolition of concrete and masonry:
   1. Demolish concrete and masonry in small sections.
      a. Perform demolition with small tools as much as possible.
      b. Blasting with explosive charges is not permitted.
   2. Sawcut concrete to establish the edges of demolition, wherever possible.
      a. Do not use a concrete breaker within 6 inches of reinforcing or structural metals that are designated to remain in place.
      b. At edges that are not sawcut, remove the final 6 inches of material with a chipping hammer as defined herein. At surfaces where material is removed with a chipping hammer, follow with a heavy abrasive blast to remove all loose material and microcracking.

c. Alternate techniques to remove concrete may be used if acceptable to the Engineer; however, techniques other than those deemed by ICRI Guideline No. 310.2R to provide a low risk of introducing microcracking will require a subsequent procedure to remove loose material and microcracked.

3. At locations indicated on the Drawings where the existing reinforcing is to be preserved, remove concrete using methods that do not damage the reinforcing. Use one of the following techniques:
   a. Hydrodemolition techniques as outlined in ICRI Guideline No. 310.3R.
   b. Chipping hammer, as defined herein, followed by heavy abrasive blast to remove all loose material and microcracking at remaining surfaces impacted by the chipping hammer.
   c. Alternate methods may be used, only when accepted in advance by the Engineer.
   d. For all methods, provide a small completed area for Engineer's review and acceptance. If the proposed method, in the opinion of the Engineer, damages the reinforcing, revise the removal method to remove the concrete with a less aggressive technique to protect the reinforcing.

C. Sizing of openings in existing concrete or masonry:
   1. Make openings large enough to permit final alignment of pipe and fittings without deflections, but without oversizing.
   2. Allow adequate space for packing around pipes and conduit to ensure watertightness.
   3. If the Engineer deems the opening to be insufficient in size to accomplish this criteria, remove additional material using the procedures outlined in this Section.

D. Cutting openings in existing concrete or masonry:
   1. Do not allow saw cuts to extend beyond limits of openings.
   2. Create openings by the following method or other means acceptable to the Engineer that prevents over-cutting of member at corners:
      a. Core-drill through slab or wall at corners, being careful not to damage materials beyond the area to be removed.
      b. Saw cut completely through the member, between the core holes at the corners.
      c. As an alternate to saw cutting through the member, score the edges of the opening with a saw to a 1-inch depth.
         1) Provide score on both surfaces (when accessible).
         2) Remove concrete or masonry to within 6 inches of material to remain with a concrete breaker.
         3) Remove the remaining material with a chipping hammer.
      d. Remove the remaining material at the corners left by the core-drilling with a chipping hammer.
   2. Prevent debris from falling into adjacent tanks or channels in service or from damaging existing equipment and other facilities.

E. In-place Abandonment of Pipe:
   1. Abandoned pipe in-place as indicated on the Drawings.
   2. Clean buried or exposed solids service piping to a condition free of residual.
      a. Solids service piping includes: raw wastewater (RAW WW), primary sludge or scum (PS), mixed liquor (ML), return activated sludge (RAS), waste active sludge (WAS), surface waste activated sludge (SWAS), thickened waste activated sludge (TWAS), digested sludge (DS), centrate, or other similar solids service subject to biological degradation, etc.
   3. Provide closure of abandoned pipe cut ends as using one of the following methods:
      a. Install cap.

F. Immediately upon discovery, remove and dispose of contaminated, vermin-infested, or dangerous materials using safe means that will not endanger health of workers and public.

G. Backfill open pits and holes caused by demolition as specified in Section 02300 - Earthwork.

H. Rough grade areas affected by demolition.

I. Remove demolished materials, tools, and equipment upon completion of demolition.

3.04 RESTORATION

A. General:
   1. Repair damage caused by demolition to conditions equal to those that existed prior to beginning of demolition.
      a. Patch and replace portions of existing finished surfaces that are damaged, lifted, and discolored. Refinish patched portion surfaces in a manner which produces uniform color and texture to entire surface, and that matches color and texture of adjacent surfaces.
      b. When existing finish cannot be matched, refinish entire surface to nearest change of plane where angle of change exceeds 45 degrees.
   2. The cost of repairs shall be at the Contractor’s expense at no increase in the Contract Price.
   3. When new construction abuts or finishes flush with existing construction, make smooth transitions. Match finish of existing construction.
   4. Where partitions are removed, patch floors, walls, and ceilings with finish materials that match existing materials.
   5. Where removal of partitions results in adjacent spaces becoming one, rework floors, walls, and ceilings to provide smooth planes without breaks, steps, or bulkheads.
      a. Where change of plane between adjacent surfaces exceeds 2 inches, request and obtain instructions for making transition from Engineer.
         1) Refinish door surfaces and edges as necessary.
   6. Trim existing doors as necessary to clear new floors.
   7. Match patched construction with adjacent construction in texture and appearance so that patch or transition is invisible at 5-foot distance.

8. When finished surfaces are cut so that smooth transition is impossible, terminate existing surface in neat manner along straight line at natural line of division and provide appropriate trim.

B. Restore existing concrete reinforcement as follows:
   1. Where existing reinforcement is to be incorporated into the new Work, protect, clean, and extend into new concrete.
   2. Where existing reinforcement is not to be retained, cut off as follows:
      a. Where new concrete joins existing concrete at the removal line, cut reinforcement flush with concrete surface at the removal line.
      b. Where concrete surface at the removal line will become the finished surface, cut reinforcement 2 inches below the surface, paint ends with epoxy, and patch holes with dry pack mortar.

C. Restore areas affected by removal of existing equipment, equipment pads and bases, piping, supports, electrical panels, electric devices, conduits, and fasteners so little or no evidence of the previous installation remains:
   1. After removal of piping, conduit, fasteners, and other construction, fill areas in existing concrete and masonry floors, walls, and ceilings with non-shrink grout and finish smooth.
   2. Remove concrete bases for equipment and supports by:
      a. Saw cutting clean, straight lines with a depth equal to the concrete cover over reinforcement minus 1/2 inch below finished surface.
         1) Do not cut existing reinforcement in slab.
      b. Chip concrete within scored lines.
      c. Cut exposed reinforcing steel and anchor bolts that will project above the repaired surface.
      d. Patch with non-shrink grout to match adjacent grade and finish.
   3. Terminate abandoned piping and conduits with blind flanges, caps, or plugs.
   4. Where existing fasteners are not to be retained, cut off as follows:
      a. Where new concrete joins existing concrete at the removal line, cut fasteners flush with concrete surface at the removal line.
      b. Where concrete surface at the removal line will become the finished surface, cut fasteners 1 inch below the surface, paint ends with epoxy, and patch holes with epoxy grout.

3.05 FIELD QUALITY CONTROL

A. Do not proceed with demolition without Engineer's inspection of lay out.

B. Do not deviate from the submitted demolition plan without notifying the Engineer prior to Work.

END OF SECTION

SECTION 01756

COMMISSIONING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Commissioning.

1.02 DEFINITIONS

A. Commissioning: The process of planning for, testing of, and start-up of systems, subsystems, equipment, components, and devices of the Work to demonstrate, through documented verification, that the Work has successfully met the Contract Documents. It includes training the Owner's staff on operation and maintenance of the installed Work.

B. Commissioning Phases: The activities of commissioning are grouped into the phases defined in the following table.
   1. Table 1 - Commissioning Phases.

TABLE 1 - COMMISSIONING PHASES		
Planning Phase	**Testing and Training Phase**	**Start-Up Phase**
Draft Test Plans	Source Testing: • Documentation	Start-Up: • Documentation • Owner Training
	Installation Verification: • Documentation • Owner Training	
	Functional Testing: • Documentation • Owner Training	

   2. Attachment A provides Commissioning Flowcharts.

C. Component: A part of a system that does not have an electrical connection or internal electronics. Examples: Piping and pressure gauges.

D. Device: A part of a system that has electrical connections or internal electronics. Examples: Level transmitter or pressure transmitter.

E. Electrical Energization Plan: A plan to manage how and when power is applied to electrical equipment.

F. Equipment: A factory or field assembled apparatus that performs an identifiable function. Examples: Pumps, motors, VFDs, MCCs.

G. Functional Testing: Testing performed on a completed subsystem or system to demonstrate that the system meets the specified requirements. Example systems: Backwash system, dewatering system.

H. Installation Verification: Testing to demonstrate that equipment or system and associated components or devices have been properly installed. Example equipment: Pumps, meters, and blowers with associated piping.

I. Manufacturer's Certificate of Functional Compliance: The form completed by the manufacturer to confirm that testing of the installed equipment or system has been performed and the results conform to the specified performance. The form is provided in Attachment D provided at the end of this Section.

J. Manufacturer's Certificate of Installation Verification: The form completed by the manufacturer to confirm that the equipment or system is installed in conformance with the Contract. The form is provided in Attachment C at the end of this Section.

K. Manufacturer's Certificate of Source Testing: The form completed by the manufacturer to confirm that the specified source tests have been performed and the results conform to the specified requirements. The form is provided in Attachment B at the end of this Section.

L. Owner Training: The Owner's staff is trained by the Contractor, with assistance from manufacturer, to operate and maintain the completed Work. This is sometimes referred to as Vendor Specific Training.

M. Process Stream: A series of liquid or solids flow processes that are designed to improve water quality to meet regulatory permit requirements.

N. Source Testing: Test equipment or products for performance at point of manufacture or assembly for the requirements specified in the Contract Documents. Also referred to as factory testing and factory acceptance testing (FAT).

O. Start-Up: Operating the Work with process water to verify the Work meets the Contract Documents.

P. Start-Up Phase: The phase when Start-Up occurs.

Q. Subsystem: A grouping of equipment, components, and devices that is a part of a larger system and that perform a single definable function. Examples: Sand filters, filter backwash.

R. System: A grouping of equipment, components, and devices that perform a single definable function. If a system is a part of a larger system, it is referred to as a subsystem.
   1. Examples: Flocculation and sedimentation, filtration.

S. System Testing: Testing of a completed system for an extended time period. Examples: Headworks, filtration.

T. Water Management Plan: A plan to manage the test water used for commissioning from source to disposal. The test water may be clean water, potable water, nonpotable water, or process water (e.g., raw water, plant water, sludge). The plan demonstrates how water will be produced, conveyed, treated, disposed of as directed by the plant manager, and/or recycled.

1.03 SUBMITTALS

A. Project Commissioning:
   1. Commissioning Coordinator's qualifications.
      a. Submit to Engineer no later than 30 days after Notice to Proceed.
      b. Describe previous similar experience on similar projects with a list of references including phone numbers.
      c. Provide names and qualifications of commissioning assistants, if applicable.
   2. Schedules:
      a. Commissioning Schedule containing all commissioning activities.
      b. Owner Training Schedule.
   3. Test Plans:
      a. Submit draft Test Plan outlined in the Planning Phase, unless specified otherwise.
         1) Engineer approval of draft Test Plans required for successful completion of Planning Phase.
      b. Submit final Test Plan a maximum of 45 calendar days prior to testing.
      c. Engineer approval of final Test Plan required prior to start of testing.
   4. Test Reports:
      a. Submit draft Test Reports outline in the Planning Phase, unless specified otherwise.
         1) Engineer approval of draft Test Reports outline required for successful completion of Planning Phase.
      b. Submit final Test Report a maximum of 30 calendar days after testing.

B. Technical Sections Commissioning:
   1. Manufacturer's representative's qualifications.
      a. Submit to Engineer no later than 30 days in advance of required services.
      b. Representative's name, phone, and e-mail address:
         1) May use 2 representatives: 1 for field testing and 1 for Owner Training.
         2) Provide resume stating instructor's technical expertise and instructional technology skills and experience.
   2. Test Plans:
      a. Submit draft Test Plan outlined in the Planning Phase, unless specified otherwise.
         1) Engineer approval of draft Test Plans required for successful completion of Planning Phase.
      b. Submit final Test Plan a maximum of 30 calendar days prior to testing.
      c. Engineer approval of final Test Plan required prior to start of testing.
   3. Test Reports:
      a. Submit draft Test Reports outline in the Planning Phase, unless specified otherwise.
         1) Engineer approval of draft Test Reports outline required for successful completion of Planning Phase.

b. Submit final Test Report a maximum of 30 calendar days after testing.
4. Manufacturer's representatives field notes and data.
5. Owner Training:
   a. Prior to the training session:
      1) Training instructor qualifications.
      2) Training course materials: Due 30 calendar days prior to initial training session.
         a) If Owner requires, Continuing Education Units (CEUs), submit training materials to state regulatory agency in sufficient time to obtain approval for training prior to the training.
         b) Drafts of training agenda, lesson plan, presentation, handouts, and list of audio-visual aids.
         c) Format: 1 electronic copy in the format specified by the Owner and 3 hard copies organized in notebooks.
   b. Post training session:
      1) Training course materials: Due 14 calendar days after class completion.
         a) Recordings.
         b) Class attendance sheet.
         c) Final version of training agenda, final lesson plan, presentation, handouts, and audio-visual aids.
         d) Format: 1 electronic copy in the format specified by the Owner and 3 hard copies organized in notebooks.
      2) Provide materials for all sessions of the class in a single transmittal.
      3) If the Owner requires training CEUs, issue training CEU certificates approved by the state regulatory agency to Owner's staff who successfully completed the training.

1.04 COMMISSIONING COORDINATOR (CC)

A. Responsibilities include the following:
   1. Part-time person.
   2. Become thoroughly familiar with Contract Commissioning requirements.
   3. Provide the primary interface with Engineer and Owner for Commissioning efforts.
   4. Lead Commissioning efforts - all phases and tasks.
   5. Coordinate training efforts.
   6. Meetings:
      a. CC is responsible for setting Commissioning coordination meeting dates and times, as well as preparing the agendas and meeting minutes.
      b. CC shall conduct Commissioning progress meetings throughout construction, to plan, scope, coordinate, and schedule future activities, resolve problems, etc.
      c. Frequency: Monthly minimum. Increase frequency as needed based on complexity and quantity of Commissioning activities.

B. CC on-site:
   1. Notice to Proceed to 30 percent milestone: 2 hours per week.
   2. 30-percent milestone to 70-percent milestone: 1 day per week.
   3. Testing and Training Phase: Full-time.
   4. Start-Up Phase: Full-time.

1.05 MANUFACTURER'S REPRESENTATIVES

A. Qualifications: As specified below and in the Technical Sections:
   1. For Installation and Functional Testing:
      a. Factory trained and experienced in the technical applications, installation, operation, and maintenance of respective equipment/system with full authority by the equipment/system manufacturer to issue the certifications required of the manufacturer.
   2. Training instructor qualifications:
      a. Provide resume stating instructor's technical preparation and instructional technology skills and experience.
      b. If CEUs are required, the operator training instructors must comply with state regulatory.
      c. Knowledgeable in the equipment/system for which they are training.
      d. Experienced in conducting classes.
      e. Sales representatives are not qualified instructors unless they possess the detailed operating and maintenance knowledge required for proper class instruction.
   3. Representatives to be approved by Owner and Engineer.
   4. No substitute representatives without written approval by Owner and Engineer.

B. Duties:
   1. Determine if additional time and/or trips (beyond those specified in the Technical Sections) is required to perform the specified services.
   2. Coordinate services in accordance with the Contractor's project schedule up to and including making multiple trips to the project site when there are separate milestones associated with installation of each occurrence of manufacturer's equipment.
   3. Perform on-site services as specified in the Technical Sections.
   4. Provide weekly copies of manufacturer's representatives field notes and data to Contractor.

1.06 PLANNING PHASE

A. Overview of Planning Phase:
   1. Define approach and timing for Commissioning.
   2. Obtain Engineer approval of draft Test Plans.

B. Test Plans.
   1. Define approach and timing for:
      a. Testing and Training Phases.
         1) Major systems, with separate plans for each system.
      b. Start-Up Phase.
   2. Centralized Commissioning database:
      a. Provide system to manage information.
         1) Detailed steps.
         2) Dependencies and other relationships of steps.
      b. Update the database within 24 hours of task completion.
   3. Source Test (Factory Acceptance Test) and Functional Test Plans:
      a. As specified in this Section and other Technical Sections.
      b. Based on approved Shop Drawings.

c. Prepared by the Contractor.
d. Include the following items for each test:
    1) Purpose of the test.
    2) Identification of each item of equipment/system to be tested, including system designation, location, tag number, control loop identifier, etc.
    3) Description of the pass/fail criteria that will be used.
    4) Listing of pertinent reference documents (Contract and industry standards or sections applicable to the testing).
        a) Credentials of test personnel.
    5) Test equipment:
        a) Include Product Data for the test equipment.
        b) Appropriate calibration records.
            (1) Drawings or photographs of test stands and/or test apparatus.
    6) Duration: Determine test durations with Owner's input.
    7) Detailed step-by-step test procedures.
        a) Level of detail shall be sufficient for the witness to follow the steps.
e. Define for Functional Testing:
    1) Required temporary systems (pumps, piping, etc.).
    2) Shutdown requirements for existing systems.
f. Furnish labor, power, tools, equipment, instruments, and services required for and incidental to testing activities.

4. Test forms minimum requirements:
    a. Name of product to be tested.
    b. Test date.
    c. Names of persons conducting the test.
    d. Names of persons witnessing the test, where applicable.
    e. Test data.
    f. Applicable project requirements as specified in the Technical Sections.
    g. Check offs for each completed test or test step.
    h. Place for signature of person conducting tests and for the witnessing person, as applicable.
5. Owner responsibilities:
    a. Owner will schedule staff within the constraints of their workloads.
        1) Those who will participate in this test have existing full-time work assignments, and testing is an additional assigned work task, therefore, scheduling is imperative.
        2) Treatment facilities are typically operated on an around-the-clock basis and are staffed in work shifts.
        1) Maximum hours per day available for commissioning activities: 4.
        2) Days available for commissioning activities: Monday to Thursday.
        3) Scheduling coordination with the CC.
6. CC is responsible for the following:
    a. Coordinate schedule with the Owner's personnel and manufacturer's representatives (instructors).

C. Test Reports:
    1. Minimum requirements:
        a. Title.
        b. Abstract.
        c. Equipment.
        d. Procedures.
        e. Results.
            1) Complete disclosure of the calculation methodologies.
        f. Conclusions.
        g. Signature by an authorized party.
        h. Appendices.
            1) Completed test forms signed by witnesses.
    2. Water Management Plan:
        a. Requirements:
            1) Demonstrate how water will be produced, conveyed, treated, recycled, and or disposed until testing verifies specified requirements.
    3. Commissioning Schedule:
        a. Content:
            1) Comply with Attachment G - Functional Testing Requirements and provide activities organized by system and subsystem.
            2) Include:
                a) Source Testing when required.
                b) Functional Testing.
                c) Owner Training.
            3) Comply with Attachment F - Commissioning Roles and Responsibilities Matrix.
        b. Procedures:
            1) Submit Commissioning Schedule as specified in Section 01321 - Schedules and Reports.

1.07 TESTING AND TRAINING PHASE

A. Overview of Testing and Training Phase:
    1. General:
        a. Contractor tests the Work to verify it meets the Contract requirements.
        b. Contractor trains the Owner to operate and maintain the Work.
    2. Contractor responsibilities:
        a. Furnish labor, tools, equipment, instruments, and services required for and incidental to completing Commissioning activities in accordance with the approved Commissioning Plans.
    3. Owner responsibilities:
        a. Furnish labor, and services required for and incidental to completing Commissioning activities in accordance with the approved Commissioning Plans.
        b. Owner provided services, equipment, and/or materials to be as specified in Section 01110 - Summary of Work.

B. Source Testing:
    1. As specified in the Technical Section.
    2. Source Test Plan:
        a. Engineer approval of Source Test Plan required prior to testing.

3. Witnessed in person:
    a. As specified in the Technical Section.
    b. Contractor is responsible for trip costs associated with Owner's and Engineer's representatives.
        1) Transportation:
            a) Commercial airline costs to and from Project site airport, including related fees.
            b) Rental car to and from arrival airport, hotel, and test site including related fees.
        2) Hotel/Meals:
            a) Hotel with an American Automobile Association 3 Diamond rating or higher equivalent for single occupancy room per person per day.
            b) Meal allowance based on state government per diem guidelines per test site location.
4. Virtual witness testing:
    a. As specified in the Technical Sections.
    b. Contractor is responsible for costs associated with virtual witness.
    c. Provide the following:
        1) An agenda detailing start time of each major phase in the procedure defined in the approved Test Plan.
        2) A dedicated operator (separate from the test technician) to operate the camera, provide commentary throughout test, and inspect devices at the request of the attendees.
    d. Online meeting platform: Microsoft Teams.
    e. Share video through a high-definition camera.
    f. Establish methods to communicate, convey, and record information clearly even in environments with loud background noise.
        1) Electronic feed for screen sharing of the control panel, HMI, or other screens used throughout testing.
        2) Provide recording of virtual sharing within 1 day after testing.
    g. Test run of virtual sharing a minimum of 1 week prior to the test:
        1) Use current record documents in PDF format.
        2) Provide recording of virtual sharing within 1 day after the test run.
        3) Engineer approval of test run virtual sharing is required before Source Testing.
5. If the Source Test is not ready on the scheduled date or if the Source Test fails:
    a. Contractor is responsible for associated costs:
        1) First test costs that are non-refundable, if applicable.
        2) Repeat test costs:
            a) Trip costs, if applicable.
        3) Virtual witness costs, if applicable.
            a) Witness labor costs:
                (1) Travel time and witness time are included, if applicable.
                (2) The greater of $200 per hour or $1,600 per day.
6. Source Testing is complete after successful testing, submittal of test report, and Manufacturer's Certificate of Source Testing.
7. Engineer approval of Source Testing Report is required.

C. Installation Verification:
    1. Overview:
        a. Verifying the installation of equipment to be in accordance with Manufacturer's Instructions.
    2. Prerequisite:
        a. Engineer approval of Source Testing Report.
    3. Perform checks:
        a. Structural anchorage check.
        b. Electrical energization check.
            1) As specified in the flowchart shown in Attachment A.
        c. Health and safety check.
    4. Submit Manufacturer's Certificate of Installation Verification.
    5. Engineer approval of Manufacturer's Certificate of Installation Verification is required.

D. Functional Testing:
    1. Overview:
        a. Testing the function of a system or subsystem.
    2. Prerequisites:
        a. Engineer approval of Manufacturer's Certificate of Installation Verification.
        b. Engineer approval of Functional Test Plan required prior to testing.
        c. Draft Operations and Maintenance Manual as specified in Section 01782 - Operations and Maintenance Manual.
        d. Completed pipe, valve, and gate labeling of system or subsystem.
            1) As specified in Section 15076 - Pipe Identification prior to the start of Functional Testing.
    3. Witnessed.
    4. Discipline checks:
        a. Verify support systems function properly, such as seal water, pipes, valves, etc.
        b. As specified in the individual Technical Sections.
    5. Consecutive Day Test:
        a. Operate the Work as specified in Attachment G - Functional Testing Requirements and as specified in the individual Technical Sections.
            1) Successful completion of subsystem testing required prior to system testing.
        b. Failure response time:
            1) Be equipped and ready to provide emergency repairs, adjustments, and corrections to comply with the "Significant Interruption Duration" requirements as specified in Attachment G - Functional Testing Requirements.
        c. Duration:
            1) As specified in Attachment G - Functional Testing Requirements.
            2) Restart the consecutive day test when the system performance failures exceed the "Significant Interruption Duration" time period specified in Attachment G - Functional Testing Requirements.
                a) Individual equipment/system failures that are corrected within the "Significant Interruption Duration" time specified in Attachment G - Functional Testing Requirements shall not require the consecutive day test to be restarted unless the failure recurs.

b) Engineer has the authority to reject the consecutive day test if individual equipment/system failures are repetitive.

6. Instrumentation and controls tests.
   a. Loop Validation Tests.
   b. Complete End-to-End Testing (CEET):
      1) Signal are tested from the field device through the PLC program, the network, and all the way to the operator's HMI graphic screens.
7. Restore to condition prior to testing:
   a. Remove, clean, and replace permanent and temporary filters and strainers in pipeline systems.
   b. Dewater and clean sumps.
   c. Dewater process units, where required by test plan.
8. Submit Manufacturer's Certificate of Functional Compliance.
9. Engineer approval of Manufacturer's Certificate of Functional Compliance is required.

E. Documentation:
   1. Provide records generated during Commissioning Phase of Project, including, but not limited to:
      a. Training documentation.
      b. Manufacturer's Certificate of Source Testing.
      c. Manufacturer's Certificate of Installation Verification.
      d. Manufacturer's Certificate of Functionality Compliance.
      e. Daily logs of equipment/system testing identifying tests conducted and outcome.
      f. Test forms and documentation.
      g. Functional Testing results.
      h. Logs of time spent by manufacturer's representatives performing services on the job site.
      i. Equipment lubrication records.
      j. Electrical phase, voltage, and amperage measurements.
      k. Insulation resistance measurements.
      l. Bearing temperature measurements.
      m. Data sheets of control loop testing including testing and calibration of instrumentation devices and setpoints.
      n. Provide: 1 electronic copy in format specified by Owner and 3 hard copies organized in notebooks.
      o. Store the data within 24 hours of the test or document creation in the project SharePoint site file system.
      p. Due date: Within 14 calendar days of Substantial Completion.
   2. Engineer approval of documentation is required.

F. Owner Training:
   1. Train Owner's staff on the operation and maintenance of the equipment/system.
      a. Provide Owner staff with state regulatory agency approved training CEUs.
   2. Train on each topic of the approved Operation and Maintenance Manual.
      a. Include classroom instruction and field demonstration with all necessary tools and test equipment.
   3. Training tailored to the skills and job classifications of the staff attending the classes (e.g., plant superintendent, treatment plant operator, maintenance technician, electrician, etc.).

4. Training outcomes:
    a. Owner's staff can safely operate, maintain, and repair the equipment/systems provided as recommended by the manufacturer.
5. Training plan:
    a. CC shall meet with Engineer and Owner's designated training coordinator to develop list of personnel to be trained and to establish expected training outcomes and objectives at least 60 calendar days prior to commissioning of equipment/system.
    b. Coordinate and arrange for manufacturer's representatives to provide both classroom-based learning and field (hands-on) training, based on training module content and stated learning objectives.
    c. Conduct classroom training at location designated by Owner.
    d. Scope and sequence:
        1) Plan and schedule training in the correct sequence to provide prerequisite knowledge and skills to trainees.
            a) Describe recommended procedures to check/test equipment/system following a corrective maintenance repair.
        2) If multiple classes are needed to meet the training objectives, they shall be included in the training plan.
6. Owner Training Schedule:
    a. Schedule Owner's staff training within the constraints of their workloads.
        1) Those who will participate in this training have existing full-time work assignments, and training is an additional assigned work task, therefore, scheduling is imperative.
        2) Owner staff work schedules regularly shift, as treatment facilities are typically operated on an around-the-clock basis.
        3) Maximum training hours per week: 16.
        4) Days available for training:
            a) Monday to Thursday.
    b. Training scheduling coordination:
        1) CC is responsible for the following:
            a) Coordinate schedule for training periods with the Owner's personnel and manufacturer's representatives (instructors).
        2) Complete Owner Training no sooner than 15 calendar days prior to Functional Testing of each system.
    c. Class logistics:
        1) Delivery time minimum: 2 hours.
        2) Delivery time maximum: 4 hours.
        3) Class agenda:
            a) Refreshment break: One 15-minute break.
            b) Meal break: One 1-hour break, unless otherwise specified.
            c) Schedule refreshment breaks and meal breaks to meet the class needs and Owner work rules.
        4) Schedule specific sessions:
            a) Minimum of 30 days in advance to allow Owner staffing arrangements to take place.
            b) At the times requested by the Owner, within the period 7 a.m. to 7 p.m. Monday through Friday.
                (1) Times scheduled will be at Owner's discretion.
            c) Owner approval and confirmation required for session schedules.

d) Provide minimum of 2 sessions for each class unless otherwise noted.
(1) The purpose of having multiple sessions on each class is to accommodate the attendance of as many Owner personnel working different shifts as possible.
e) A maximum of 1 session per day for each class.

d. Number of students:
1) Estimated class size maximum: 10 staff.
2) Engineer will confirm the headcount 1 week prior to the class so that the instructor can provide the correct number of training aids for students.

7. Submittals:
a. Submit Training Plan Schedule 30 calendar days before the first scheduled training session, including, but not limited to, lesson plans, participant materials, instructor's resumes, and training delivery schedules.
b. Submit training documentation including the following:
1) Training plan:
a) Training modules.
b) Scope and sequence statement.
c) Contact information for manufacturer's instructors including name, phone, and e-mail address.
d) Instructor qualifications.
2) Training program schedule:
a) Format: Bar chart:
(1) Include in the Project Progress Schedule.
b) Contents:
(1) Training modules and classes.

8. Lesson plans:
a. Divide training into discrete modules appropriate for the equipment and trades.
b. State performance-based learning objectives in terms of what the trainees will be able to do at the end of the lesson.
c. Define student conditions of performance and criteria for evaluating instructional success.
d. Minimum requirements:
1) Hands-on demonstrations planned for the instructions.
2) Cross-reference training aids.
3) Planned training strategies such as whiteboard work, instructor questions, and discussion points or other planned classroom or field strategies.
4) Attach handouts cross-referenced by section or topic in the lesson plan.
5) Indicate duration of outlined training segments.
e. Provide instruction lesson plans for each trade:
1) Detailed component description:
a) Identify each component function and describe in detail.
b) Identify equipment's mechanical, electrical, and electronic components and features.

c) Where applicable, group relative components into subsystems.
d) Identify and describe in detail equipment safety features, permissive and controls interlocks.

2) Equipment operation:
a) Describe equipment's operating (process) function and system theory.
b) Describe equipment's fundamental operating principles and dynamics.
c) Identify support equipment associated with the operation of subject equipment.
d) Detail the relationship of each piece of equipment or component to the subsystems, systems, and process.
e) Cite hazards associated with the operations, exposure to chemicals associated with the component, or the waste stream handled by the component.
f) Specify appropriate safety precautions, equipment, and procedures to eliminate, reduce, or overcome hazards.

3) Define Preventative Maintenance (PM) inspection procedures required on equipment in operation, spot potential trouble symptoms (anticipate breakdowns), and forecast maintenance requirements (predictive maintenance).
a) Review preventive maintenance frequency and task analysis table.

4) Define equipment Corrective Maintenance (CM) troubleshooting:
a) Describe recommended equipment preparation requirements as they relate to specific craft problems.
b) Identify and describe the use of any special tools required for maintenance of the equipment as they relate to specific craft problems.
c) Provide component specific troubleshooting checklists as they relate to specific craft problems.
d) Describe component removal/installation and disassembly/assembly procedures for specific craft repairs.
e) Perform at least 2 hands-on demonstrations of common corrective maintenance repairs.

5) Describe recommended measuring instruments and procedures, and provide instruction on interpreting alignment measurements, as appropriate.

9. Training instruction format:
a. Training for operations personnel shall be provided separately from the maintenance personnel.
1) Training for maintenance personnel shall be further subdivided into the following 4 trade groups.
a) Mechanical maintenance.
b) Electrical maintenance.
c) Instrumentation and controls maintenance.
d) Process Controls Network (PCN) maintenance.
b. Instructors shall apply adult education best practices, emphasizing learner participation and activity.
c. Lecturing should be less than 30 percent of class time.

d. Training delivery may include problem solving, question/answer, hands-on instruction, practice, evaluation/feedback tools, and lecture to support training objectives.
e. Conduct hands-on instruction according to the following descriptions:
    1) Present hands-on demonstrations of at least the following tasks:
        a) Proper start-up, shutdown, and normal and alternative operating strategies.
        b) Common corrective maintenance repairs for each group.
        c) Recommended procedures to check/test equipment/system following a corrective maintenance repair.
        d) Preventative maintenance points.
        e) Calibration, if applicable.
    2) Use tools and equipment provided by manufacturer to conduct the demonstrations.
        a) Submit requests for supplemental assistance and facilities with the Contractor's proposed lesson plans.
    3) Contractor remains responsible for equipment disassembly or assembly during hands-on training situations involving equipment disassembly or assembly by Owner's personnel.
f. Training aids:
    1) Instructors shall provide needed audio-visual devices such equipment (televisions, video recorder/player, computer, projectors, screens, easels, etc.), models, charts, etc., for each class.
    2) Instructor to confirm with Engineer in advance of each class that the classroom will be appropriate for the types of audiovisual equipment to be employed.

10. Training sessions:
    a. Provide training sessions for equipment/system as specified in the individual equipment/system section.
    b. Include the following information in the agenda:
        1) Instructor name.
        2) Listing of subjects to be discussed.
        3) Time estimated for each subject.
        4) Allocation of time for Owner staff to ask questions and discuss the subject matter.
        5) List of documentation to be used or provided to support training.
    c. Owner may request that particular subjects be emphasized, and the agenda be adjusted to accommodate these requests.
    d. Digitally record audio and video of each training session.
        1) Include classroom and field instruction with question and answering periods.
        2) Engineer approval required for producer of video materials from one of the following options:
            a) Qualified, professional video production company or individual.
        3) Record in digital format and recording shall become property of the Owner with exclusive rights.
            a) No video recording agreements will be entered into by the Owner.
        4) Media:
            a) Video quality shall be 720p HD or greater in MPG, AVCHD, AVI, or MP4 format.
            b) Digital color video format.

c) Provide audio portion of the composite CD sufficiently free from electrical interference and background noise to provide complete intelligibility of oral report.
d) Identification: On each copy provide a label with the following information:
(1) Name of training.
(2) Date video was recorded.
e) Display continuous running time.
f) At start of each video recording, record training class name, date, instructor's name.
g) Provide audio quality that is not degraded during the recording of the field sessions due to background noise, space, distance or other factors.
5) Contractor shall provide a written release from all claims to the recorded training material produced, if required.
e. Distribute copies of the agenda to each student at the beginning of each training class.
f. Trainees will keep training materials and documentation after the session.
g. Distribute Training Evaluation Form following each training session.
1) Training Evaluation Form is included in this Section.
2) Return completed Training Evaluation Forms to Owner's designated training coordinator immediately after session is completed.
3) Revise training sessions judged "Unsatisfactory" by a majority of attendees.
a) Conduct training sessions again until a satisfactory rating is achieved.
11. Engineer approval of Owner Training is required.

1.08 START-UP PHASE

A. Overview of Start-Up Phase:
1. General:
a. Confirm reliability requirements.
b. Confirm regulatory compliance.
1) Turbidity: Maximum 1 NTU.

B. Start-Up Period:
1. Contractor responsibilities:
a. Support Owner to operate the Work.
2. Owner responsibilities:
a. Owner to operate the Work.
b. Owner-provided services, equipment, and/or materials to be as specified in Section 01110 - Summary of Work.
c. Furnish labor, tools, equipment, instruments, and services required for and incidental to completing commissioning activities in accordance with the approved Commissioning Plans.
3. Prerequisites:
a. Engineer approval of Testing and Training Phase.
4. Witnessed.

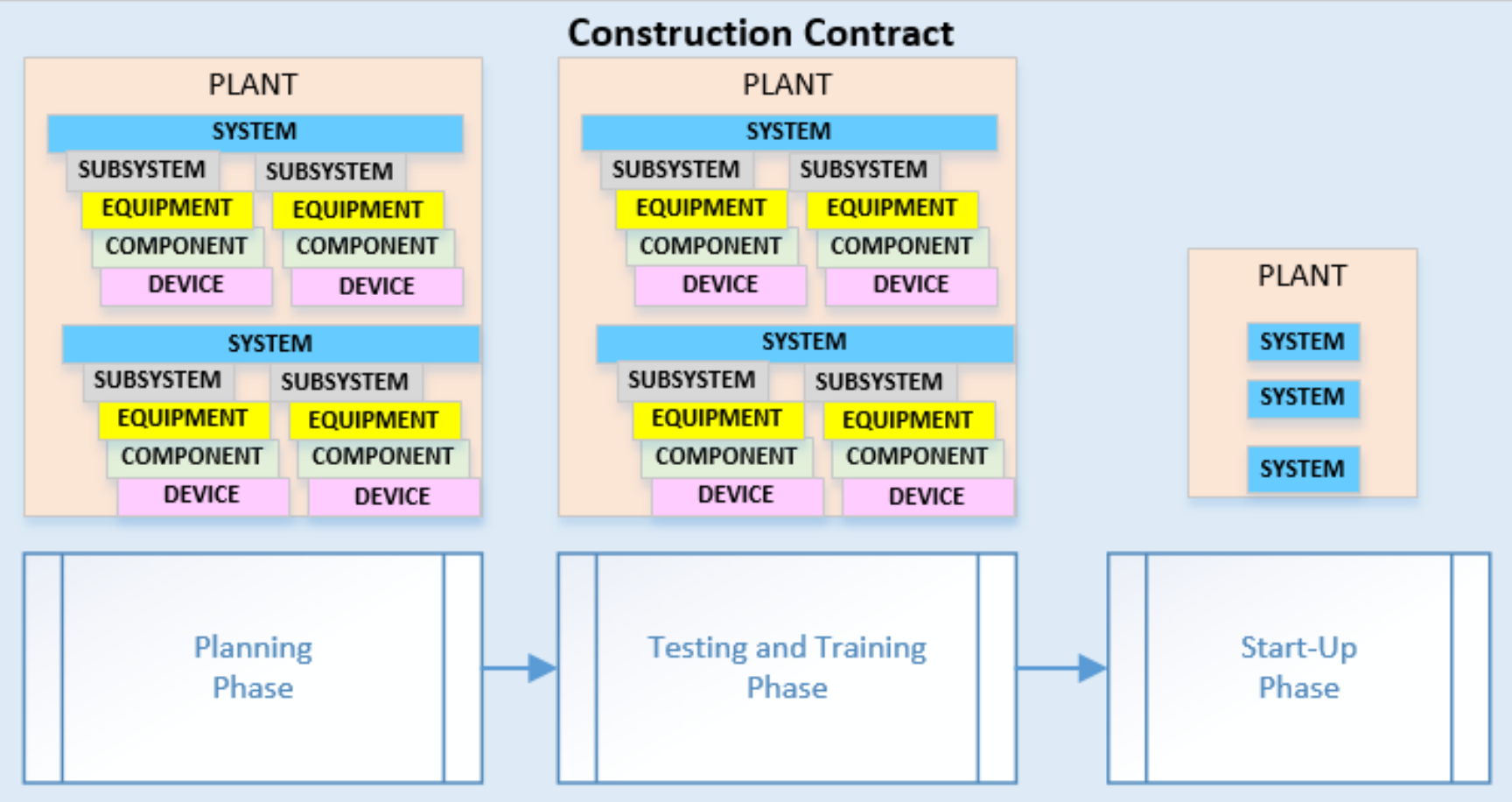
5. Duration: 7 days.
6. Engineer approval of Start-Up Period is required to achieve substantial completion.

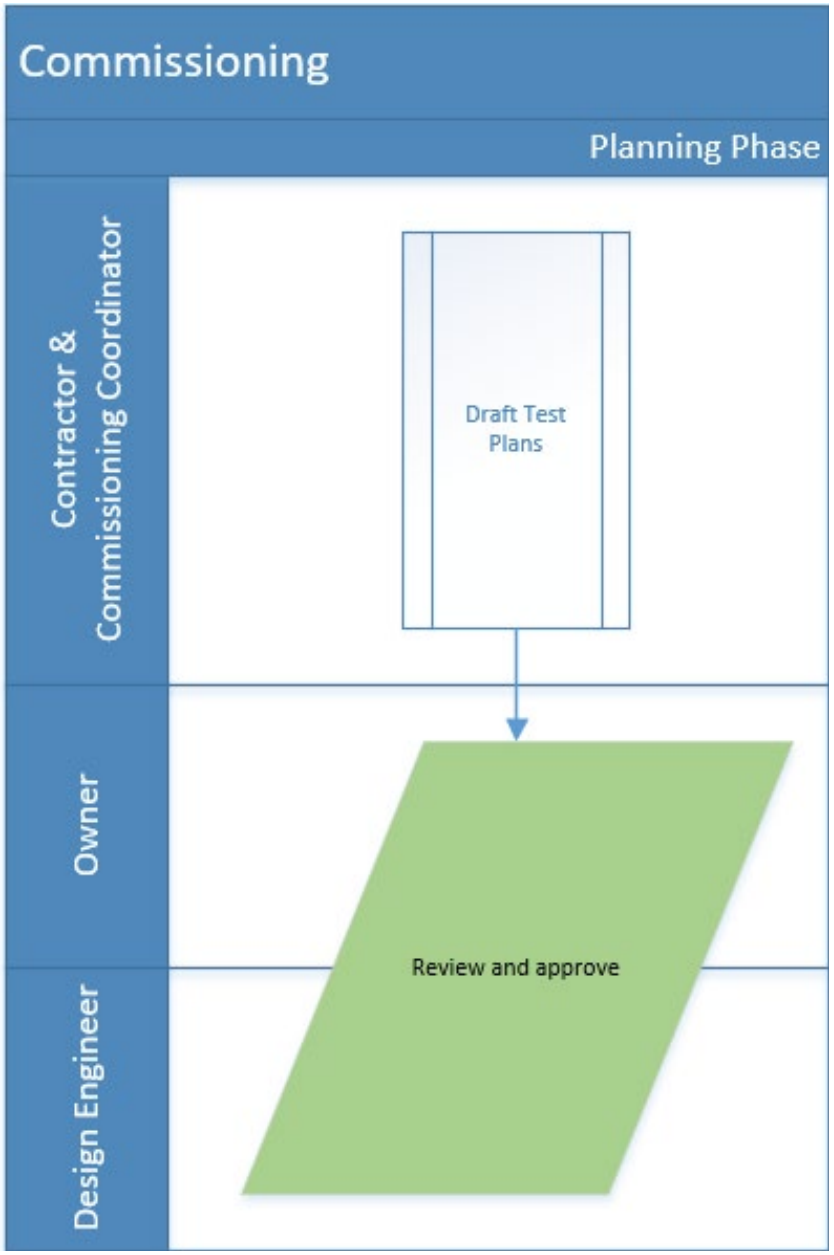
PART 2 PRODUCTS (NOT USED)

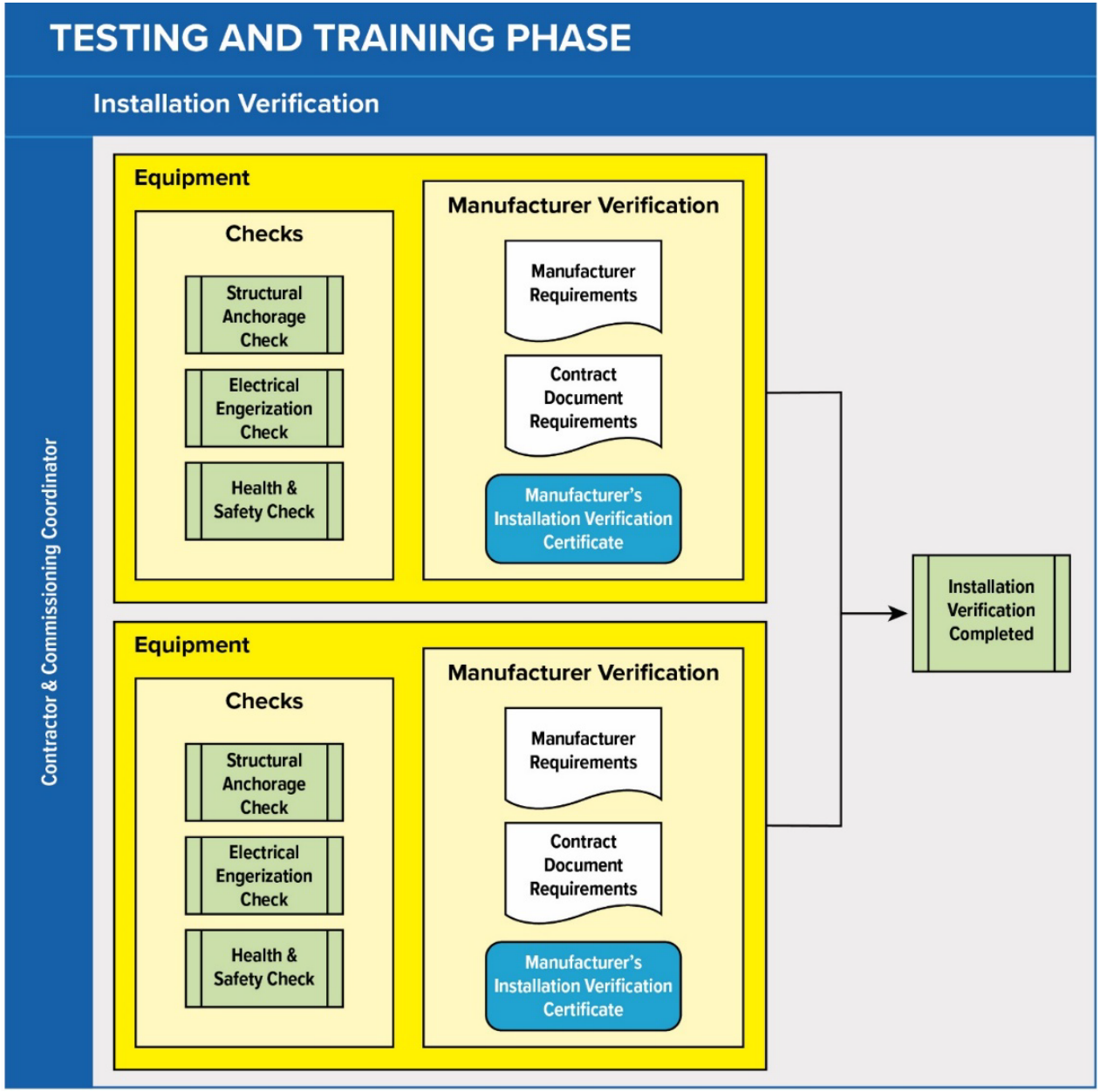
PART 3 EXECUTION (NOT USED)

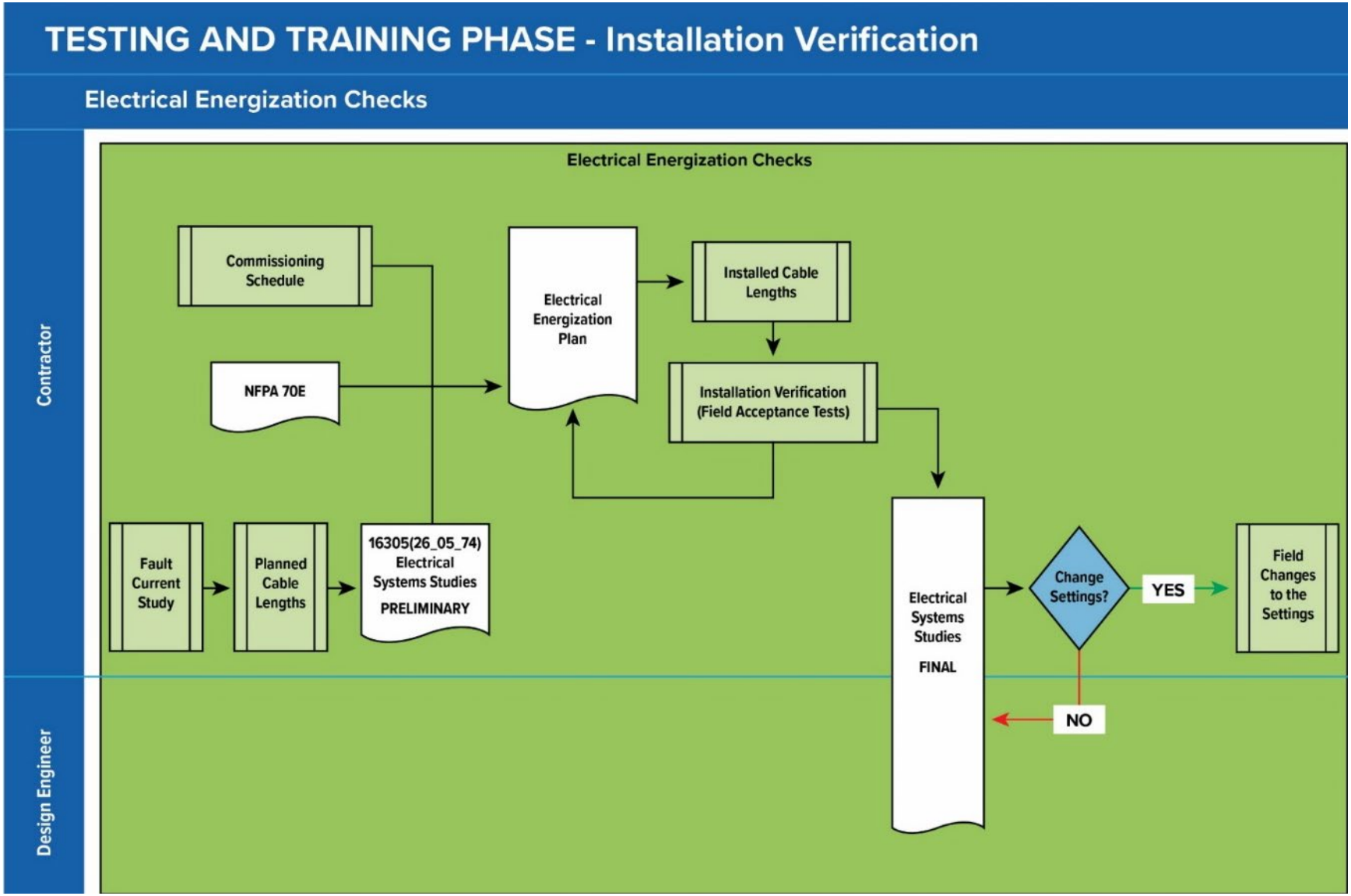
END OF SECTION

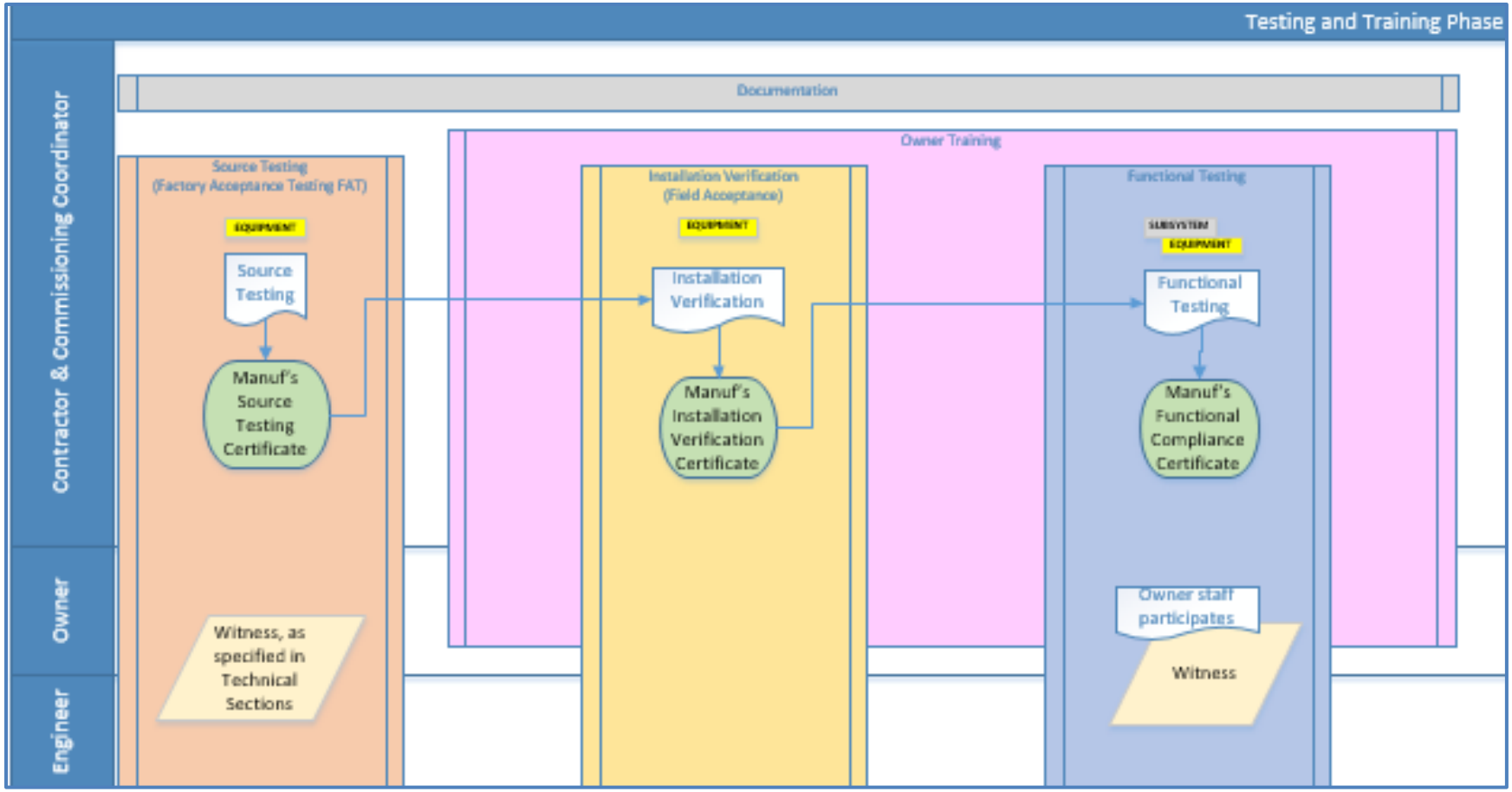
ATTACHMENT A - COMMISSIONING FLOWCHARTS

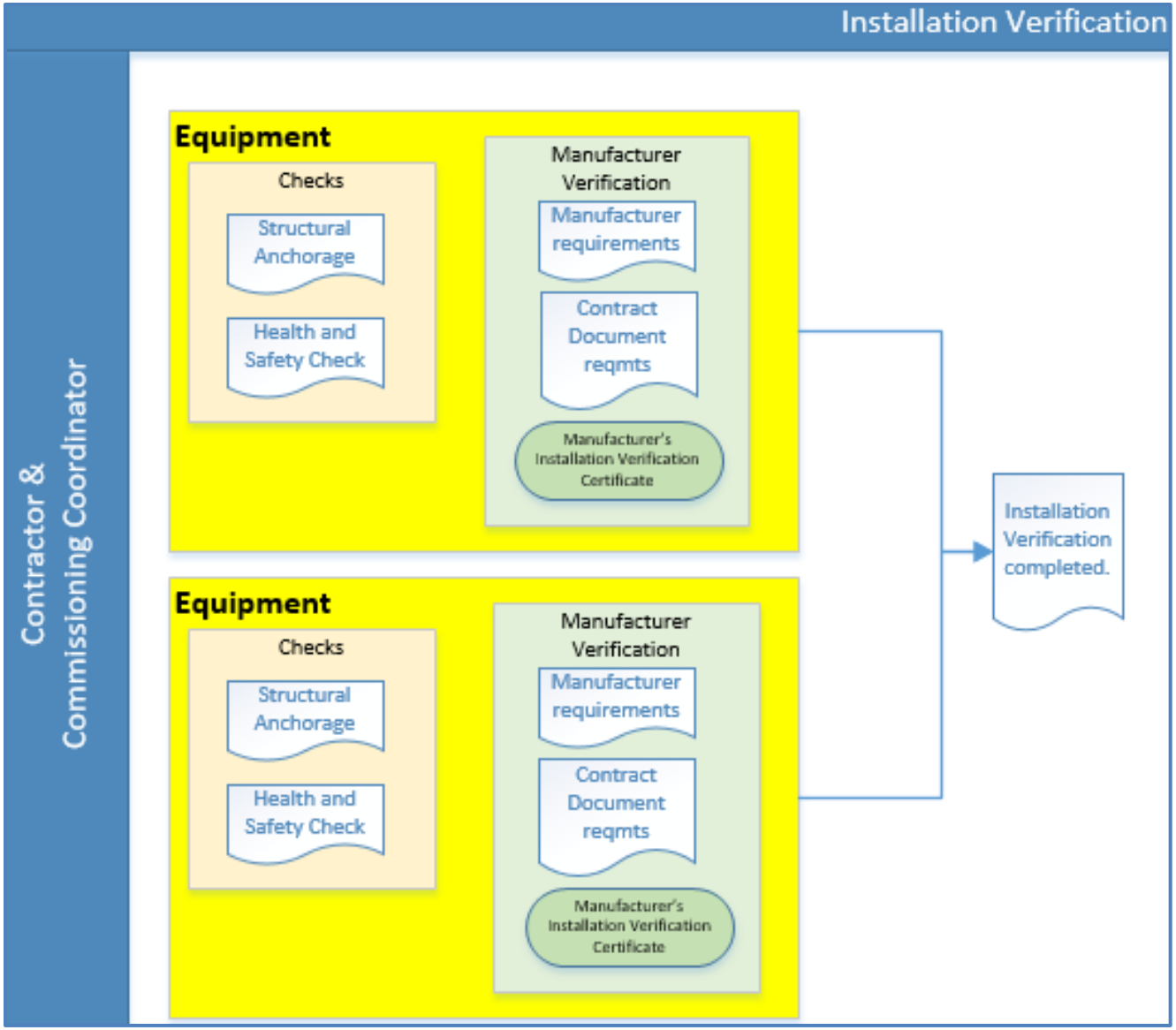

Construction Contract
PLANT
SYSTEM
SUBSYSTEM
SUBSYSTEM
EQUIPMENT
EQUIPMENT
COMPONENT
COMPONENT
DEVICE
DEVICE
SYSTEM
SUBSYSTEM
SUBSYSTEM
EQUIPMENT
EQUIPMENT
COMPONENT
COMPONENT
DEVICE
DEVICE
PLANT
SYSTEM
SUBSYSTEM
SUBSYSTEM
EQUIPMENT
EQUIPMENT
COMPONENT
COMPONENT
DEVICE
DEVICE
SYSTEM
SUBSYSTEM
SUBSYSTEM
EQUIPMENT
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COMPONENT
COMPONENT
DEVICE
DEVICE
PLANT
SYSTEM
SYSTEM
SYSTEM
Planning Phase
Testing and Training Phase
Start-Up Phase

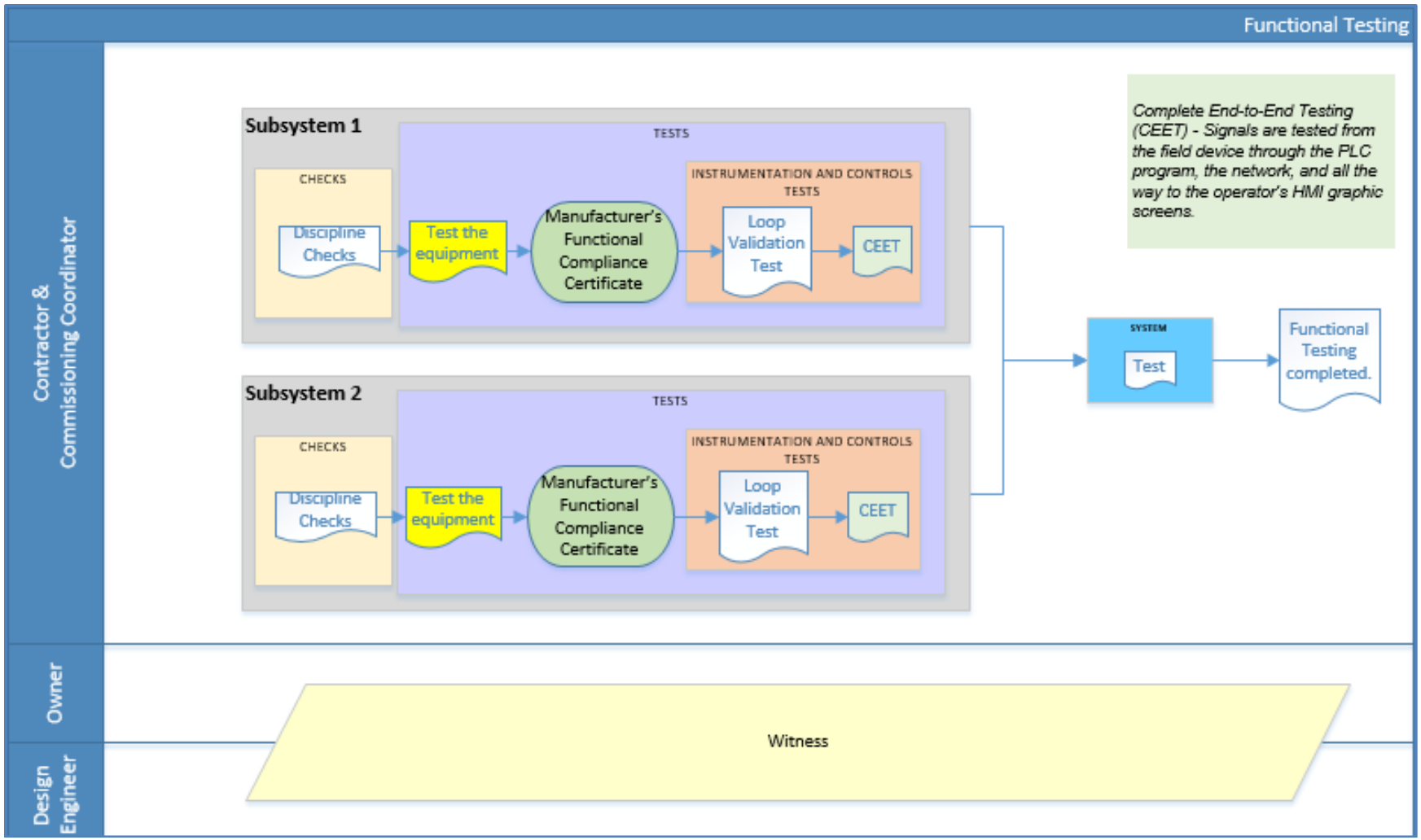

Commissioning
Planning Phase
Contractor & Commissioning Coordinator
Draft Test Plans
Owner
Review and approve
Design Engineer

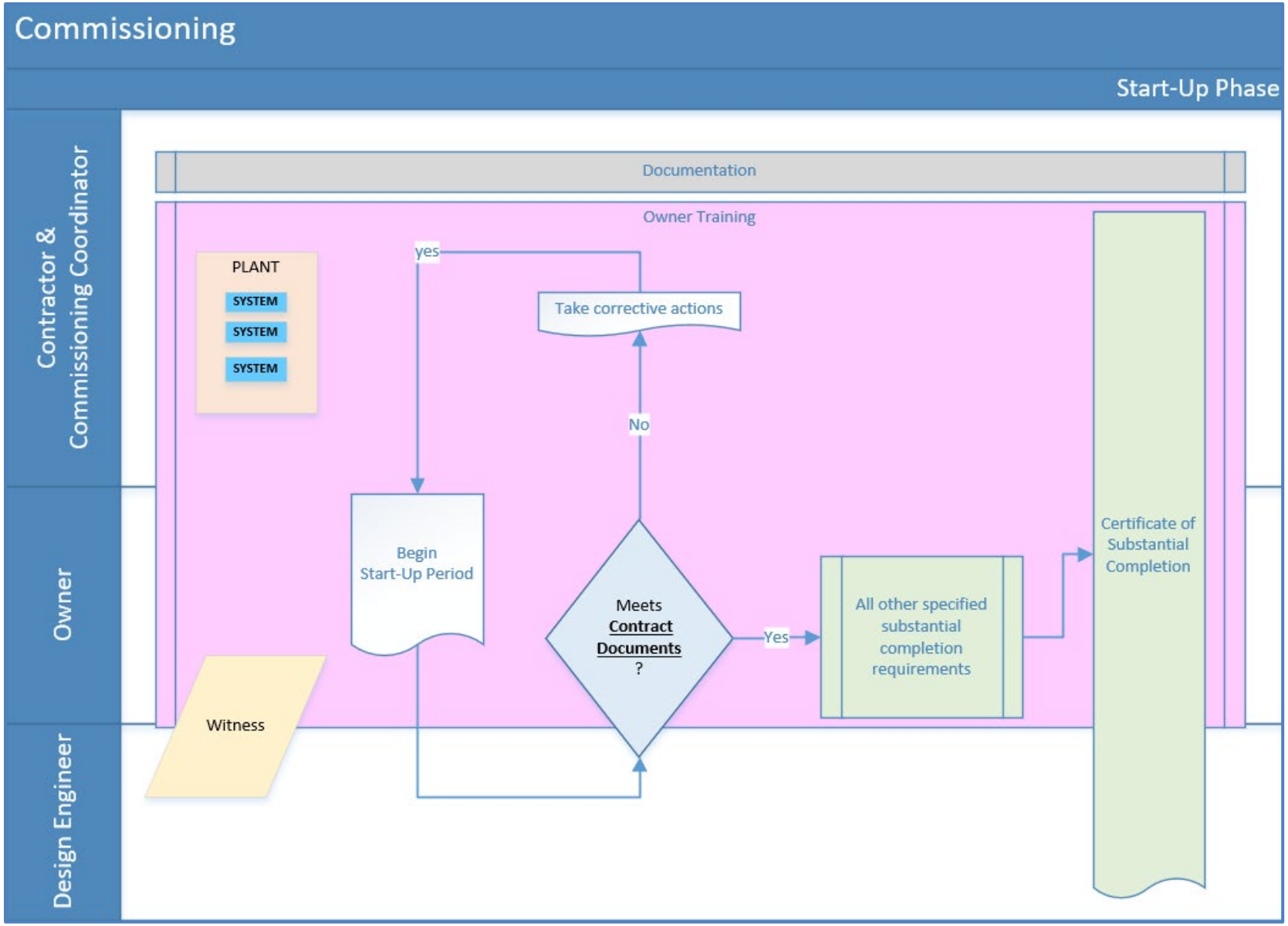

TESTING AND TRAINING PHASE
Installation Verification
Contractor & Commissioning Coordinator
Equipment
Checks
Structural Anchorage Check
Electrical Engerization Check
Health & Safety Check
Manufacturer Verification
Manufacturer Requirements
Contract Document Requirements
Manufacturer's Installation Verification Certificate
Equipment
Checks
Structural Anchorage Check
Electrical Engerization Check
Health & Safety Check
Manufacturer Verification
Manufacturer Requirements
Contract Document Requirements
Manufacturer's Installation Verification Certificate
Installation Verification Completed


TESTING AND TRAINING PHASE - Installation Verification
Electrical Energization Checks
Contractor
Design Engineer
Electrical Energization Checks
Commissioning Schedule
NFPA 70E
Electrical Energization Plan
Installed Cable Lengths
Installation Verification (Field Acceptance Tests)
Fault Current Study
Planned Cable Lengths
16305(26_05_74) Electrical Systems Studies PRELIMINARY
Electrical Systems Studies FINAL
Change Settings?
YES
NO
Field Changes to the Settings


Testing and Training Phase
Contractor & Commissioning Coordinator
Owner
Engineer
Documentation
Source Testing
(Factory Acceptance Testing FAT)
EQUIPMENT
Source Testing
Manuf's Source Testing Certificate
Witness, as specified in Technical Sections
Owner Training
Installation Verification
(Field Acceptance)
EQUIPMENT
Installation Verification
Manuf's Installation Verification Certificate
Functional Testing
SUBSYSTEM
EQUIPMENT
Functional Testing
Manuf's Functional Compliance Certificate
Owner staff participates
Witness


Installation Verification
Contractor & Commissioning Coordinator
Equipment
Checks
Structural Anchorage
Health and Safety Check
Manufacturer Verification
Manufacturer requirements
Contract Document reqmts
Manufacturer's Installation Verification Certificate
Equipment
Checks
Structural Anchorage
Health and Safety Check
Manufacturer Verification
Manufacturer requirements
Contract Document reqmts
Manufacturer's Installation Verification Certificate
Installation Verification completed.


Functional Testing
Contractor & Commissioning Coordinator
Owner
Design Engineer
Subsystem 1
TESTS
CHECKS
Discipline Checks
Test the equipment
Manufacturer's Functional Compliance Certificate
INSTRUMENTATION AND CONTROLS TESTS
Loop Validation Test
CEET
Subsystem 2
TESTS
CHECKS
Discipline Checks
Test the equipment
Manufacturer's Functional Compliance Certificate
INSTRUMENTATION AND CONTROLS TESTS
Loop Validation Test
CEET
Complete End-to-End Testing (CEET) - Signals are tested from the field device through the PLC program, the network, and all the way to the operator's HMI graphic screens.
SYSTEM
Test
Functional Testing completed.
Witness


Commissioning
Start-Up Phase
Contractor & Commissioning Coordinator
Owner
Design Engineer
Documentation
Owner Training
PLANT
SYSTEM
SYSTEM
SYSTEM
yes
Take corrective actions
No
Begin Start-Up Period
Meets Contract Documents ?
Yes
All other specified substantial completion requirements
Certificate of Substantial Completion
Witness

ATTACHMENT B - MANUFACTURER'S CERTIFICATE OF SOURCE TESTING

MANUFACTURER'S CERTIFICATE OF SOURCE TESTING

OWNER _____ EQPT/SYSTEM _____

PROJECT NAME _____ EQPT TAG NO. _____

PROJECT NO. _____ EQPT SERIAL NO. _____

SPECIFICATION NO. _____

SPECIFICATION TITLE _____

Comments: _____

_____

_____

_____

_____

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

Date of Execution: _____, 20 _____

Manufacturer: _____

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

_____

(Authorized Signature)

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

_____

(Witness Signature)

ATTACHMENT C - MANUFACTURER'S CERTIFICATE OF INSTALLATION VERIFICATION

MANUFACTURER'S CERTIFICATE OF INSTALLATION VERIFICATION

OWNER _____ EQPT/SYSTEM _____

PROJECT NAME _____ EQPT TAG NO. _____

PROJECT NO. _____ EQPT SERIAL NO. _____

SPECIFICATION NO. _____

SPECIFICATION TITLE _____

I hereby certify the installation of the above-referenced equipment/system as defined in the Contract Documents.

NOTES:

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

Comments: _____

_____

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

Date: _____

Manufacturer: _____

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

By Manufacturer's Authorized Representative: _____

(Authorized Signature)

ATTACHMENT D - MANUFACTURER'S CERTIFICATE OF FUNCTIONAL COMPLIANCE

MANUFACTURER'S CERTIFICATE OF FUNCTIONAL COMPLIANCE

OWNER _____ EQPT/SYSTEM _____

PROJECT NAME _____ EQPT TAG NO. _____

PROJECT NO. _____ EQPT SERIAL NO. _____

SPECIFICATION NO. _____

SPECIFICATION TITLE _____

I hereby certify the Functional Testing of the above-referenced equipment/system as defined in the Contract Documents.

NOTES:

1. Attach test results with collected data and test report.
2. Attach written certification report prepared by and signed by the electrical and/or instrumentation subcontractor.

Comments: _____

_____

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

Date: _____

Manufacturer: _____

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

By Manufacturer's Authorized Representative: _____

(Authorized Signature)

WITNESSES:

By Owner's Authorized Representative: _____

(Authorized Signature)

By Engineer's Authorized Representative: _____

(Authorized Signature)

ATTACHMENT E - TRAINING EVALUATION FORM

TRAINING EVALUATION FORM

EQUIPMENT/SYSTEM ITEM: _____

VENDOR/MANUFACTURER: _____

DATE: _____ NAME OF REPRESENTATIVE: _____

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

Note:

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

ATTACHMENT F- COMMISSIONING ROLES AND RESPONSIBILITIES MATRIX

COMMISSIONING ROLES AND RESPONSIBILITIES MATRIX

NO.	TASK	OWNER	CONTRACTOR	ENGINEER
Testing and Training Phase				
Source Testing				
	Source Testing	Witness	Lead	Witness, Review
	Manufacturer's Certificate of Source Testing	No Action	Lead	Review
Installation Verification				
	Structural Anchorage Check	Witness	Lead	Review
	Health and Safety Check	Witness	Lead	Review
	Manufacturer Requirements Verification	No Action	Lead	Review
	Contract Documents Verification	No Action	Lead	Review
	Manufacturer's Certificate of Installation Verification	No Action	Lead	Review
Functional Testing				
	Checks	Witness	Lead	Witness, Review
	Tests	Witness	Lead	Witness, Review
	Manufacturer's Certificate of Functional Compliance	No Action	Lead	Witness, Review
System Testing				
	System Testing	Witness	Lead	Witness, Review
Start-Up Phase				
	Start-Up	Lead	Support	Witness, Review

Legend:

Lead: Primarily responsible for organization, coordination, and execution of task work product or result.
Support: Assist the lead with organization, coordination, and execution of task work product or result.
Witness: Observe and document completion of task work product or result.
No Action: Limited or no involvement.
Review: Approve for compliance with Contract Documents or reject.

ATTACHMENT G - FUNCTIONAL TESTING REQUIREMENTS

FUNCTIONAL TESTING REQUIREMENTS

System	Subsystem	Consecutive Day Test Duration (Days)	Significant Interruption Duration (Hours)	Test Liquid	System Operated By
Clearwell	Baffle Wall System	2	4	Water	Contractor
Clarifier	Rakes and Turbines	1	4	N/A	Owner
Clarifier	Sludge Blowdown Pumps	2	4	N/A	Owner
4-Log Sample Panel		2	4		Contractor
Ferric Chloride Storage and Feed System	Metering Pumps	2	2	Ferric	Owner
Polymer Storage and Feed System	Metering Pumps	2	2	Polymer	Owner
Sodium Hypochlorite Storage and Feed System	Metering Pumps	3	1	Sodium Hypochlorite	Owner
Phosphate Storage and Feed System	Metering Pumps	1	2	Phosphate	Owner
Carbon Dioxide (CO^2) Storage and Feed System	Carbonators	1	2	Carbon Dioxide + water feed solution	Owner

Notes:

(1) As specified in Section 01110 - Summary of Work.
(2) As specified in Section 17101 - Specific Control Strategies.
(3) As specified in this Section under Functional Testing.
(4) As specified in this Section under Functional Testing.

A. Schedule delays:
   1. Changes in the dates for Source Testing less than 30 days of the date provided in the latest approved Commissioning Schedule are considered delays.
   2. Contractor is responsible for associated costs resulting from delays:
      a. In person and/or virtual witnessing.
      b. Travel costs and witness labor costs.
         1) Witness labor costs at $250 per hour.

B. Repeat test costs:
   1. Contractor is responsible for associated costs for repeat testing:
      a. In person and/or virtual witnessing.
      b. Travel costs and witness labor costs.
         1) Witness labor costs at $250 per hour.

SECTION 01770

CLOSEOUT PROCEDURES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes contract closeout requirements including:
   1. Final cleaning.
   2. Waste disposal.
   3. Touch-up and repair.
   4. Preparation and submittal of closeout documents.
   5. Certificate of Substantial Completion.

1.02 REFERENCES

A. American Water Works Association (AWWA).

1.03 FINAL CLEANING

A. The Contractor is required to leave the site in as good or better condition than before the Work. Prior to Owner making Final payment, the work site will be inspected by Owner and Engineer for specific areas of the site that need to be restored. The pre-construction video will be used to determine the condition prior to Contractor beginning to work.

B. Perform final cleaning prior to inspection for Substantial Completion.

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 dust, dirt, stains, and other foreign materials from sight exposed surfaces, including clearwell roof and hatches, handrails, instruments, and piping.

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. Remove non-permanent protection and labels.

1.04 WASTE DISPOSAL

A. Arrange for and dispose of surplus materials, waste products, and debris off-site.

B. Do not create unsightly or unsanitary nuisances during disposal operations.

C. Maintain disposal site in safe condition and good appearance.

D. Complete 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 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. Required Permit Approvals.
   3. Project Record Documents.
   4. Approved Operation and Maintenance Manual.
   5. Approved Warranties and Bonds.
   6. Completed contract requirements for commissioning and process start-up.

B. Submit 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.

C. 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.

Additions:	Red
Deletions:	Green
Comments	Blue
Dimensions:	Graphite

1.07 SUBSTANTIAL COMPLETION

A. Obtain Certificate of Substantial Completion.

1.08 FINAL COMPLETION

A. When Contractor considers the Work is complete, submit written certification that:
   1. Work has been completed in accordance with the Contract Document:
   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.

1.09 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.

1.10 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.

B. Contractor to fill-out and return to City PM Final Receipt once Contractor has received final payment.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

SECTION 01782

OPERATION AND MAINTENANCE MANUALS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Preparation and submittal of manual with requirements to operate and maintain the equipment.

1.02 PREPARATION

A. General requirements:
   1. Provide dimensions in English units.
   2. Assemble material, where possible, in the same order within each volume.
   3. Reduce drawings and diagrams to 8-1/2 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 PLC code, 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) Ensure that page numbers are included on every page of the document.
6) Searchable.
7) Scanned images are not acceptable.
8) Bookmarks:
a) 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.
9) 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 8 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. 7-22 - Minimum Design Loads and Associated Criteria for Buildings and Other Structures. (ASCE 7).

B. American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE):
   1. ASHRAE Fundamentals Handbook.

C. International Code Council (ICC):
   1. International Energy Conservation Code (IECC).
   2. International Plumbing Code (IPC).

D. Sheet Metal and Air Conditioning Contractor’s National Association (SMACNA):
   1. Seismic Restraint Manual: Guidelines for Mechanical Systems, 3rd edition 2008.

PART 2 PRODUCTS

2.01 DESIGN CRITERIA - SITE INFORMATION

A. Site name: City of Delray Beach Water Treatment Plant
   1. Street address: As specified in Section 01110 - Summary of Work.
      a. Coordinates (approximate): Latitude 26.452; Longitude -80.075 .
   2. Site elevation (approximate):
      a. 22 feet above mean sea level.

3. Groundwater elevation:
    a. Assume groundwater level at grade.

2.02 DESIGN CRITERIA - REGULATORY REQUIREMENTS

A. Requirements of authorities having jurisdiction over the Project are included in Section 01410 - Regulatory Requirements.

2.03 DESIGN CRITERIA - OPERATING ENVIRONMENT

A. Drawings and Technical Sections include additional criteria and requirements relevant to specific locations, materials, and equipment.

B. Outdoor conditions:
1. IECC: Climate Zone 2A, Hot-Humid.
2. ASHRAE site climatic data location: Palm Beach International Airport, approximately 15 miles from site, WMO PEGF1 Port Everglades, FL..
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	
Daily mean range:	14.1 degrees Fahrenheit.
Winter:	At or above this temperature 99.6 percent of the time: 44.6 degrees Fahrenheit dry-bulb.
Summer:	At or above this temperature 0.4 percent of the time: 91.8 degrees Fahrenheit dry-bulb.

4. Rainfall intensity:
    a. Reference: International Plumbing Code (IPC):
        1) 6 inches per hour (100-year, 1-hour rainfall).

2.04 DESIGN CRITERIA - STRUCTURAL

A. General:
1. Criteria for structural design of:
    a. Equipment at locations subject to seismic events.
    b. Equipment exposed to outdoor environments.
    c. Equipment supports and bracing, and anchorage of such items to building and non-building structures.
    d. Structures provided for the Work through Delegated Design.
    e. Manufactured and prefabricated structures, and anchorage of such structures to foundations or other supporting elements.
2. Structural design criteria used by the Engineer of record and required by the building code are included on the Contract Drawing titled “General Structural Notes.

B. Delegated Design:
1. As specified in Section 01357 - Delegated Design Procedures.
2. Structural engineering design shall be performed by a Civil Engineer licensed in the State of Florida.

C. 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.

D. Seismic loads:
   1. Seismic design parameters: Basic parameters - ASCE 7:
      a. Ground motion MCER, 5 percent damped:
         1) Short periods, Ss = 0.052 g.
         2) 1 second period, S_1 = 0.023 g.
      b. Peak ground acceleration, MCEG:
         1) Peak ground acceleration, PGA = 0.027 g.
      c. Mapped long-period transition period:
         1) TL = 8 seconds.
   2. Structures - General:
      a. Seismic Design Category (SDC): As indicated in the following Table: Project Structures - Risk Category and Seismic Design Information.

Table: Project Structures - Risk Category and Seismic Design Information

Description: Water Treatment Facility

Area	Description	Risk Category	Site Class	S_{DS}	S_{D1}	Seismic Design Category(1)
All		III	D	0.047	0.033	

Notes:

(1) Seismic Design Category for Delegated Design, and for seismic certification of electrical and mechanical equipment as required by ASCE 7.

      b. Structure response modification coefficient, R:
         1) In accordance with ASCE 7 and the requirements of the Technical Sections.
   3. Structures - Tanks and vessels.
      a. Includes: Tank structures, tank supports, and anchorage to structures or foundations.
      b. Liquid storage structures (e.g., basins and tanks).
         1) Include impulsive and convective (“sloshing”) effects.
         2) Component response modification factor - impulsive effects, Ri: In accordance with ASCE 7, Table 15.4-2.
         3) Component response modification factor - convective effects, Rc = 1.0.
      c. Dry material storage structures (e.g., silos, hoppers):
         1) Include effects of stored materials.
         2) Component response modification factor - impulsive effects, Ri: In accordance with ASCE 7, Table 15.4-2.
   4. Non-structural components - General:
      a. Includes:
         1) Mechanical and electrical equipment; anchorage of equipment to structures or supports; design of supports; and anchorage of supports to structures or foundations.

2) Distribution systems associated with mechanical and electrical equipment such as piping, ductwork, conduits, cable trays, raceways, bus ducts, and similar items; anchorage of such systems to supports and structures; and bracing or such systems.

b. Seismic design requirements for non-structural components are based on the Seismic Design Category (SDC) of the structure or facility where the equipment is installed.

c. Design components, component anchorage, and component connections to piping and utilities in accordance with the requirements of ASCE 7, Table 13.2-1.

d. Component amplification factor (ap), response factor (Rp), and overstrength factor for anchorage to concrete (Ωo):
   1) Mechanical and electrical components and systems: In accordance with ASCE 7, Table 13.6-1, unless otherwise indicated in the Technical Sections for these items.
   2) Architectural components and systems: In accordance with ASCE 7, Table 13.6-1, unless otherwise indicated in the Technical Sections for these items.

e. Component importance factor, I_p:
   1) In accordance with the following Table: Component Importance Factor for Seismic Design, I_p.
   2) For items not listed in Table: Component Importance Factor for Seismic Design, I_p, designate importance factor in accordance with the provisions of ASCE 7, Chapter 13, and submit to the Engineer for review prior to developing calculations and details related to that component.

Table: Component Importance Factor for Seismic Design, I_p

Structure Seismic Design Category	Components	I_p
All	Electrical: Items and distribution system components specified in Division 16 - Electrical.	1.0
All	Process Control and Instrumentation Systems: Components and distribution systems specified in Division 17 - Instrumentation and Controls.	1.0
All	Fire protection: Components and distribution systems specified in Section 10520 - Fire Protection Specialties.	1.0
All	Conveyance and distribution systems and supports for toxic, highly toxic, hazardous, or explosive substances as specified in Divisions 6 through 15.	1.0
All	Conveying equipment: Items specified in Division 14	1.0
All	Equipment and components specified in Divisions 11 through 15, except HVAC and plumbing components listed below.	1.0
All	Plumbing equipment:	1.0
All	HVAC equipment:	1.0

Table: Component Importance Factor for Seismic Design, I_p		
Structure Seismic Design Category	**Components**	**I_p**
All	Other equipment not listed above.	1.0

5. Non-structural components: HVAC ductwork.
    a. Component importance factor, I_p: Determine in accordance with ASCE 7, Section 15.4.1.1.
    b. Seismic design category:
        1) See Table: Component Importance Factor for Seismic Design, I_p (preceding).

E. 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) 181 miles per hour (33 feet, 3 second gust).
    b. Exposure category: C.
    c. Topographic factor, Kzt: 1.0.
    d. Wind pressure for design of “components and cladding”.
        1) “Components and cladding” includes doors, windows, siding panels, skylights, parapets and similar architectural elements.
        2) Minimum wind pressure for components and cladding, strength level:
            a) Wall elements: Minimum 102 pounds per square foot, pressure or vacuum.
            b) Roof elements: Minimum 241 pounds per square foot, pressure or vacuum.
            c) For “allowable stress level” pressures, multiply strength level pressures by 0.625.

F. Rainfall loads:
1. Determine rainfall loads using rainfall intensity specified in this Section and including effects of exposed surface slope, height above surface to discharge elevation, and deflection of ponded surfaces.

G. Operational loads:
1. Loads may include equipment vibration, torque, thermal effects, effects of internal contents (weight and sloshing), surge or “water hammer,” and other load conditions.
2. Design for loads indicated by the equipment manufacturer.
3. Design for loads indicated in the Technical Sections for equipment and appurtenances.

H. Serviceability considerations: ASCE 7-22, 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.

C. Where Owner-Delegated Design is required by the Specifications, prepare and submit designs as specified in Section 01357 - Delegated Design Procedures.

3.02 DELEGATED DESIGN

A. Where Delegated Design is required by the Technical Sections, prepare and submit designs as specified in Section 01357 - Delegated Design Procedures.

B. Calculations:
    1. Where submittal of calculations is required:
        a. Provide complete calculations, including sketches to illustrate the design concepts being evaluated, and details to fully describe proposed construction.
    2. Requirements for seismic design calculations will be waived for the following:
        a. Furniture and storage racks 6 feet in height or less.
        b. Moveable equipment.
        c. Mechanical and electrical equipment and components located in structures designated as Seismic Design Category A or B.
        d. Mechanical and electrical equipment and components located in structures designated as Seismic Design Category C and where the component importance factor, I_p, is equal to 1.0.
    3. Requirements for wind design calculations will be waived for the following:
        a. Equipment and components located inside structures, and away from the effects of wind loads.

C. Shop Drawings:
    1. Describing components and manufacturer’s requirements for connections.
        a. Include details for connections of components to structures and supports.
        b. Include details for anchoring bracing to structures where required.

3.03 DESIGN - ANCHORS FOR EQUIPMENT, COMPONENTS, AND BRACING

A. General:
   1. Engineer's approval of anchor designs is required before placement of construction that supports or provides bracing for anchored equipment and components.
      a. Prepare anchor designs after the Engineer's approval of the products and layout, and before placement of concrete or masonry that supports them.
   2. Adjust equipment pad sizes and add additional anchor confinement reinforcing to provide required strength at anchorage points between equipment and pad, and between pad and structure.
   3. Supports and bracing:
      a. Design and install braces and anchors to transfer forces from equipment and components to the lateral force resisting system of the surrounding structure.
      b. Anchor and brace piping, ductwork, and electrical distribution components so that lateral or vertical displacement does not result in damage to or failure of essential architectural, mechanical, or electrical equipment.
         1) Provide supplementary framing where required to transfer forces.
         2) Detail and locate braces and anchors to minimize differential movements between components and structure.

B. Preparation:
   1. Obtain manufacturer's information:
      a. Weight and dimensions of components.
      b. Layout and location of anchors that connect to equipment base plates, sole plates, skids, or pads.
      c. Sizes of holes for anchors that will be provided in equipment bases or support frames.

C. Analysis and design:
   1. Perform and submit calculations to determine anchor designs at locations where equipment and equipment supports are connected to the supporting structure.
      a. Indicate number, size, type, and material for anchors.
   2. In determining forces at locations where equipment is anchored to structures, include effects of:
      a. Equipment self-weight and operating weight.
      b. Location of equipment center of mass.
      c. Forces from equipment operation, including, but not limited to:
         1) Effects of internal contents, including weight and sloshing.
         2) Effects of thrust, surge, and water hammer where specified.
         3) Equipment reactions and operating torque.
         4) Equipment vibration.
         5) Thermal effects from equipment and from distribution systems connected to the equipment (piping, ducts, and electrical).
         6) Other load or displacement inducing conditions.
      d. Forces on equipment from loads specified in this Section.
         1) Include effects of wind, snow, and icing loads where applicable.
         2) Design for load combinations indicated in ASCE 7, unless otherwise specified or indicated on the Drawings.

3) Seismic and wind loads: For equipment and tanks with weight that varies based on the volume of contained material, determine anchor forces to accommodate the full range of filled, partially filled, and empty conditions.

3. Determine forces and overturning moments at equipment supports and at locations where supports are anchored to structures.
   a. Indicate shear force and associated axial force at each anchor.
4. Do not use friction to resist sliding resulting from seismic or wind forces.
   a. Resist sliding only by direct application of sliding loads to fasteners as bearing, shear, tension, or compression forces.
5. Using combined shears and axial forces at each anchor, design anchors and anchor groups for ductile failure.
   a. Ductile failure: Anchor yield before failure of base material, typically concrete or masonry, at the anchor.
6. Anchor selection:
   a. Provide anchors type indicated on the Drawings.
   b. Where anchors are not specifically indicated on the Drawings, select in accordance with the following:
      1) Anchors that resist seismic and wind forces:
         a) Cast-in-place forged hex-head anchor bolt.
      2) Anchors loaded in sustained tension:
         a) Cast-in-place forged hex-head anchor bolt.
      3) Anchors for reciprocating, vibrating, and rotating equipment:
         a) Cast-in-place forged hex-head anchor bolt.
   c. Do not use post-installed anchors, mechanical or adhesive, unless:
      1) Post-installed anchors are indicated on the Drawings, or
      2) Post-installed are approved by the Engineer prior to placement of the surrounding concrete or masonry.
   d. Anchor diameter:
      1) Select diameter so that hole in base plate is not greater than 125 percent of the nominal diameter of the anchor, nor greater than the diameter of the anchor plus 1/4 inch.
7. Determine number, size, layout, and minimum effective embedment for anchors.
   a. Layout includes anchor spacing and required distance(s) from anchor to edge(s) of supporting concrete or masonry.
   b. Anchors in concrete: Design based on minimum specified 28-day compressive strength, f'c, as follows, unless otherwise indicated on the Drawings for the Work area:
      1) Concrete placed for this Work: f'c = 4500 pounds per square inch.
      2) Existing concrete in place prior to this Work: f'c = 3500 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) Concrete masonry placed for this Work: f'm = 1500 pounds per square inch.
      2) Existing concrete masonry in place prior to this Work: f'm = 3500 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 02050

SOILS AND AGGREGATES FOR EARTHWORK

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Material requirements for soils and aggregates.

1.02 REFERENCES

A. American Association of State Highway and Transportation Officials (AASHTO):
   1. T 11 - Standard Method of Test for Materials Finer than 75µm (No. 200) Sieve in Mineral Aggregates by Washing.
   2. T 27 - Standard Method of Test for Sieve Analysis of Fine and Coarse Aggregates.
   3. T 89 - Standard Method of Test for Determining the Liquid Limit of Soils.
   4. T 90 - Standard Method of Test for Determining the Plastic Limit and Plasticity Index of Soils.
   5. T 96 - Standard Method of Test for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.
   6. T 104 - Standard Method of Test for Soundness of Aggregate by Use of Sodium Sulfate or Magnesium Sulfate.
   7. TP 95 - Standard Method of Test for Surface.

B. ASTM International (ASTM):
   1. C117 - Standard Test Method for Materials Finer than 75-µm (No. 200) Sieve in Mineral Aggregates by Washing.
   2. C131 - Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.
   3. C136 - Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
   4. D2419 - Standard Test Method for Sand Equivalent Value of Soils and Fine Aggregate.
   5. D2844 - Standard Test Method for Resistance R-Value and Expansion Pressure of Compacted Soils.
   6. D4318 - Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.
   7. D4829 - Standard Test Method for Expansion Index of Soils.
   8. D5821 - Standard Test Method for Determining the Percentage of Fractured Particles in Coarse Aggregate.

C. Florida Department of Transportation (FDOT):
   1. Standard Specifications for Road and Bridge Construction (Standard Specifications).

1.03 SUBMITTALS

A. Product data:
   1. Material source.
   2. Gradation.
   3. Testing data.

B. Quality control for aggregate base course:
   1. Test reports: As required by Sections of specifications.
   2. Certificates of compliance: As required by Sections of specifications.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Storage and protection: Protect from segregation and excessive moisture during delivery, storage, and handling.

B. Comply with specified storage requirements, if applicable.

PART 2 PRODUCTS

2.01 MATERIALS - GENERAL

A. Provide material having maximum particle size not exceeding 4 inches and that is free of trash, lumber, debris, leaves, grass, roots, stumps, and other organic matter.

B. Materials derived from processing demolished or removed asphalt concrete are not acceptable.

C. Comply with soil and aggregate material requirements in the specifications, unless specified otherwise.

2.02 AGGREGATE BASE COURSE

A. Material requirements:
   1. Graded aggregate base, Group 1 or 2, as specified in the Standard Specifications.
   2. Use graded aggregate material which yields a satisfactory mixture meeting the requirements of the Standard Specifications after it has been crushed and processed as a part of the mining operations.
   3. Contractor may furnish the material in 2 sizes of such gradation that, when combined in a central mix plant pugmill, the resultant mixture meets the required specifications.
   4. Use graded aggregate base material of uniform quality throughout, substantially free from vegetable matter, shale, lumps and clay balls, and having a Limerock Bearing Ratio (LBR) value of not less than 100.
   5. Use material retained on the No. 10 sieve composed of aggregate meeting the following requirements:
      a. Soundness loss, sodium, sulfate (AASHTO T 104): 15 percent.
      b. Percent wear (AASHTO T 96, Grading A):
         1) Group 1 aggregates: 45 percent.
         2) Group 2 aggregates: 65 percent.

c. Group 1: This group of aggregates is composed of limestone, marble, or dolomite.
d. Group 2: This group of aggregates is composed of granite, gneiss, or quartzite.

6. Use graded aggregate base material meeting the following gradation:

Sieve Sizes (Square Openings)	Percent by Weight Passing Sieve
2 inch	100
1 1/2 inch	95 - 100
3/4 inch	65 - 90
3/8 inch	45 - 75
No. 4	35 - 60
No. 10	25 - 45
No. 50	5 - 25
No. 200	0 - 10]

2.03 SAND

A. Clean, coarse, natural sand.

B. Non-plastic when tested in accordance with ASTM D4318.

C. Conforms to size and grade within the following limits when tested in accordance with ASTM C117 and ASTM C136:

Sieve Size (Square Openings)	Percent by Weight Passing Sieve
1/2 inch	100
No. 200	0 - 20

2.04 STABILIZATION MATERIAL

A. Material requirements:
1. Materials for subgrade stabilization shall meet the following minimum requirements:
a. Plasticity index (AASHTO T 90): Maximum 10.
b. Liquid limit (AASHTO T 89): Maximum 40.
c. Passing a 3-1/2-inch screen (AASHTO T 27): Minimum 97 percent.
d. Limerock Bearing Ratio (LBR): No requirement.
2. Commercial materials may be either limerock, shell rock, cemented coquina, or shell base sources.
3. Local materials used for stabilizing may be soils or recyclable materials such as crushed concrete, roof tiles and asphalt coated base, reclaimed asphalt pavement (RAP) or fossil fuel combustion products (FFCPs) provided the following limits for organic content are met.
a. Average organic content: Maximum 2.5 percent.
b. Individual organic content sample: Maximum 4 percent.

4. FFCPs may be used provided they meet the requirements of Florida Statute 403.7047, are not used outside the paved area, and are not less than 3 feet above the design high groundwater table.
5. Materials for stabilizing must meet applicable air or water quality standards or criteria in Florida Department of Environmental Protection (FDEP) rules.

2.05 SHELL ROCK

A. May be used as a base course for roadways, and for other applications as approved by the Engineer.

B. Material requirements:
   1. Shall consist of naturally occurring heterogeneous deposits of limestone with interbedded layers or lenses of loose and cemented shell, to include cemented sands (calcitic sandstone).
      a. Shall be mined and processed in a manner that will result in a reasonably homogenous finished product.
   2. Limerock Bearing Ratio (LBR):
      a. Average result per lot: 100, minimum.
      b. Individual results: 90, minimum.
   3. Liquid limit: Not to exceed 35.
   4. Plastic properties: Non-plastic.
   5. Percentage of carbonates (calcium and magnesium): 50 percent minimum.
   6. Gradation:
      a. A minimum of 97 percent shall pass a 3-1/2-inch sieve.
      b. A maximum of 70 percent shall pass a No. 4 sieve.
      c. A maximum of 20 percent shall pass a No. 200 sieve (washed)].

2.06 LIMEROCK

A. May be used as a base course for roadways, and for other applications as approved by the Engineer.

B. Material requirements:
   1. Shall consist of unconsolidated or partly consolidated limestone of marine origin.
   2. Limerock bearing ratio (LBR):
      a. Average result per lot: 100, minimum.
      b. Individual results: 90, minimum.
   3. Liquid limit: Not to exceed 35.
   4. Plastic properties:
      a. For base material: Non-plastic.
      b. For stabilized base: Plasticity not to exceed 10.
   5. Percentage of carbonates (calcium and magnesium): 70 percent minimum.
   6. Gradation:
      a. For base material: At least 97 percent shall pass a 3-1/2-inch sieve.
      b. For stabilized base: At least 97 percent shall pass a 1-1/2-inch sieve].]

PART 3 EXECUTION (NOT USED)

END OF SECTION

SECTION 02318

TRENCHING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Trench excavation and trench backfill for pipelines, manholes, vaults, and appurtenances.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. D698 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3).
   2. D6938 - Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).

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. Backfill: Material placed in trench above the pipe embedment zone.
   2. Bedding: Material placed under, around, and over pipes or ducts in trenches.
   3. Fine grading: Bedding material placed directly below pipes or ducts to provide support at the bottom of the trench and to bring those elements to required grades and elevations.
   4. Flexible pipe: Includes steel, ductile iron, thermoplastics such as polyvinyl chloride (PVC) and high-density polyethylene (HDPE), thermosetting plastics such as fiberglass-reinforced polymer (FRP), bar-wrapped concrete cylinder pipe, and corrugated steel pipes.
   5. Haunch zone: Material placed below and beside the pipe up to the pipe springline.
   6. Lift: A layer of soil or aggregate material, measured before compaction.
   7. Maximum density, Field Compaction: Soil density and water content when tested in accordance with ASTM D6938.
   8. Maximum density, Laboratory Compaction: Soil maximum density and optimum water content when tested in accordance with ASTM D698.
   9. Pavement section: Includes pavement plus underlying courses such as base course and subgrade.
   10. Pipe embedment zone: Includes bedding, fine grading, and haunch zone.
   11. Pipe foundation: Material placed at the bottom of trench to provide support.
   12. Pipe springline: A horizontal reference line located at mid-height, or halfway point, of a circular conduit, pipe, or tunnel. It is the maximum horizontal dimension or diameter of a circular conduit, pipe, or tunnel.

13. Rigid pipe: Includes reinforced non-cylinder concrete, reinforced concrete cylinder, prestressed concrete cylinder, vitrified clay, polymer concrete, cast iron, asbestos cement and cast-in-place pipes.

1.04 SUBMITTALS

A. As specified in Section 01330 - Submittal Procedures.

B. Product data on soils and aggregates.
   1. Material source.
   2. Gradation.
   3. Test data to demonstrate compliance with requirements as specified in this Section.

C. Samples:
   1. Provide 50-pound sample of materials when requested by the Engineer.

D. Confirmation testing:
   1. Certification of Contractor's testing laboratory.
   2. Record copy report for tests performed by the Contractor's testing laboratory.

PART 2 PRODUCTS

2.01 MATERIALS

A. As specified in Section 02050 - Soils and Aggregates for Earthwork.

B. Class C concrete: As specified in Section 03300 - Cast-in-Place Concrete.

PART 3 EXECUTION

3.01 PREPARATION

A. Stabilize excavations as specified in Section 02260 - Excavation Support and Protection.

B. Perform subsurface utility engineering (SUE) for utility locating and verification prior to any excavation work and as specified in Section 02280 - Subsurface Utility Engineering.

3.02 DEWATERING

A. As specified in Section 0224002241 - Dewatering.

3.03 TRENCH EXCAVATION

A. Excavate bottom of trench to depth indicated on the Drawings.

B. Areas of new fill or embankment:
   1. Prior to laying pipes or electrical service, place fill and compact as specified to not less than 2 feet above top of pipe, conduit, or duct bank.
   2. Excavate through fill for pipe trench.

C. Trench widths as specified in the following table:

Buried Pipe or Accessory	Minimum Trench Width	Maximum Trench Width
Nominal Pipe Diameter: 4-inch to 24-inch	OD + 18 inches	OD + 24 inches
Nominal Pipe Diameter: Greater than 24-inch	OD + 24 inches	OD + 36 inches
Manholes, vaults, valves, or other accessories	12 inches between outer surface and trench side or shoring	Not applicable

D. Potable water pipe and appurtenances:
   1. Lay in trenches separate from those used for sewers and recycled water.
   2. Unless otherwise specified or indicated on the Drawings, lay in trenches having cover of not less than 3 feet below surface of ground located at distance of not less than 10 feet clear horizontally from any parallel sewer and **1** foot clear vertically above any parallel sewer.

E. At road crossings or existing driveways:
   1. Provide notification, vehicular access, and traffic control as required by permits and special conditions.
   2. Provide temporary asphalt or plating for traffic or access at the end of each work day unless approved in writing by the Engineer.
   3. If unexpected utility conflicts or changed Site conditions require trenchless technologies or temporary bridges, immediately notify the Engineer in writing. Approval is required before proceeding with construction.
   4. When trench width at top of pipe is increased beyond width specified in this Section because of soil conditions, safety requirements, or other reasons, Engineer approval for remedy is required without additional cost to the Owner.
      a. Remedy may include upgrade laying conditions or install stronger pipe designed in accordance with Specifications.

3.04 TRENCH BACKFILL - GENERAL

A. Trench area terminology and locations as indicated on the Drawings.

B. Place material, except CLSM and concrete, in maximum **6**-inch lifts, measured before compaction.

C. Backfilling of manhole excavation: In accordance with backfilling requirements for trenches as specified in this Section.

3.05 PIPE FOUNDATION

A. Provide trench bottom with firm, dry, uniform bearing surface at the grade indicated on the Drawings.

B. Excess excavation below elevation indicated on the Drawings will require installation of pipe foundation material to bring the trench bottom back to the elevation indicated on the Drawings at no additional cost to the Owner.

C. If bottom of trench excavation consists of soil:
   1. Scarify bottom of trench to a depth of 6 inches below the grade indicated on the Drawings.
   2. Materials and placement:
      a. Recompact scarified material to **95** percent of maximum density.

D. If bottom of trench excavation consists of rock or any material that, by reason of its hardness, cannot be excavated to provide uniform bearing surface:
   1. Remove such rock or other material to a depth of not less than 4 inches below pipe embedment zone.
   2. Materials:
      a. CLSM.
      b. Class C concrete.

E. If bottom of trench excavation consists of mud or other soft unstable material:
   1. Remove such unacceptable material to a depth of not less than 18 inches below pipe embedment zone.
   2. Material and placement:
      a. **Lightweight material.**

3.06 PIPE EMBEDMENT ZONE

A. Pipe displacement:
   1. Take necessary precautions in placement and compaction of bedding material to prevent displacement of piping.
   2. In event there is movement or floating of the piping, re-excavate, re-lay, and backfill the pipe.

B. Fine grading:
   1. Place 6 inches of approved haunch zone bedding material from the trench bottom to the bottom of the pipe or duct to provide support at the bottom of the trench and to bring those elements to required line and grade.

C. Depressions for joints or couplings:
   1. Excavate holes in the fine grading material at the bottom of the trench.
   2. Provide holes of sufficient width to provide ample room for grouting, banding, or welding as necessary for making joints and to ensure that pipe rests upon prepared trench bottom and not supported by any portion of the joint.

D. Rigid pipe:
    1. Pipe embedment zone: Below pipe springline:
        a. Materials and placement:
            1) Aggregate base course compacted to 95 percent maximum dry density.
    2. Pipe embedment zone: Above pipe springline:
        a. Compacted to a depth above pipe: 12 inch minimum.
        b. Materials and placement:
            1) Aggregate base course compacted to 95 percent maximum dry density.

E. Flexible pipe:
    1. Pipe embedment zone:
        a. Compacted to a depth above pipe: 12 inch minimum.
        b. Materials and placement:
            1) Aggregate base course compacted to 95 percent maximum dry density.

3.07 BACKFILL

A. Trenches:
    1. Materials and placement:
        a. Aggregate base course compacted to 95 percent maximum dry density.
        b. CLSM.

B. Trenches below or within 10 feet of the outside perimeter of structures:
    1. Backfill to underside of structure, as specified in Section 02300 - Earthwork.
    2. Materials and placement:
        a. Aggregate base course compacted to 95 percent of maximum density.
        b. CLSM.

C. Trenches in roadways and paved areas:
    1. Backfill trench to underside of pavement.
    2. Materials and placement:
        a. Aggregate base course compacted to 95 percent of maximum density.
        b. CLSM.

D. Trenches in areas outside the improved section of roadways or in open country:
    1. Backfill to finished grade.
    2. Materials and placement:
        a. Aggregate base course compacted to 90 percent of maximum density.

E. Trenches under existing intersecting pipes, duct banks, or conduits larger than 3 inches in diameter:
    1. Backfill from above top of new pipe embedment zone to springline of intersecting pipe or conduit.
        a. Extend backfill at least 2 feet on either side of intersecting pipe or conduit to ensure backfill material remains in place while other backfill is being placed.

b. Materials and placement:
1) CLSM, unless otherwise indicated on the Drawings.

2. Backfill remainder of trench:
a. Materials and placement:
1) CLSM.
2) Class C concrete.

3.08 EXCESS MATERIAL

A. Remove excess excavated material from the Project Site as specified in Section 02300 - Earthwork.

3.09 FIELD QUALITY CONTROL

A. Provide field quality control for the Work as specified in Section 01450 - Quality Control.

B. Confirmation tests: As specified in Section 02300 - Earthwork.
1. Minimum frequency of confirmation testing:
a. At each test location include tests for each type or class of backfill from bedding to finished grade.
b. For trenches: 1 location every 200 linear feet.
c. Crossing paved roads: 1 location at each crossing.
d. Under pavement cuts or within 2 feet of pavement edges: 1 location every 400 linear feet.

C. Compliance tests:
1. Engineer will make periodic compliance tests to verify that compaction is meeting requirements as specified in this Section.
2. Perform remedial work if compaction test fails to meet specified requirements using one of the following methods:
a. Remove and replace backfill at the proper density.
b. Other means acceptable to the Engineer.
3. Retesting:
a. Costs of retesting: Contractor is responsible for the costs of retesting required to confirm and verify that remedial work has brought compaction within specified requirements.
b. Contractor’s confirmation tests during performance of remedial work:
1) Performance: Perform tests in manner acceptable to the Engineer.
2) Frequency: Double amount specified for initial confirmation tests.

END OF SECTION

SECTION 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.

B. Seismic Design Category (SDC) for structures: SDC = A.

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-XP.

2.03 ACRYLIC AND HYBRID ADHESIVE

A. Materials:
1. 2-component, high-solids, acrylic-based or hybrid acrylic and epoxy-based adhesive.
2. Approved by the manufacturer for installation at substrate temperatures of 0 degrees Fahrenheit and above.

B. Packaging:
1. Disposable, self-contained cartridge system furnished in side-by-side cartridges designed to fit into a manually or pneumatically operated caulking gun, and with resin and hardener components isolated until mixing through manufacturer's static mixing nozzle. Nozzle designed to dispense components in the proper ratio and to thoroughly blend the components for injection from the nozzle directly into prepared hole.
2. Container markings: Include manufacturer's name, product name, batch number, mix ratio by volume, product expiration date, ANSI hazard classification, and appropriate ANSI handling precautions.

C. Manufacturers: One of the following or equal:
1. Hilti, Inc., HIT-HY-200.
2. Simpson Strong-Tie Co., Inc., AT-XP.

2.04 ALL THREAD RODS

A. Materials: As specified in Section 05120 - Structural Steel Framing for rods, nuts and washers.

2.05 REINFORCING BARS

A. As specified in Section 03200 - Concrete Reinforcing.

PART 3 EXECUTION

3.01 GENERAL

A. Execution of this work is restricted to installers who have personally completed the adhesive manufacturer's on-site training for the products to be installed, and who are personally certified through a qualified certification program described under Quality Assurance and accepted by the Engineer and the Building Official.
   1. Do not install holes or adhesive until training is complete.

B. Perform work in strict compliance with the accepted MPII and the following instructions. Where the accepted MPII and the instructions conflict, the MPII shall prevail.

C. Install reinforcing bars and all thread rods to embedment depth, and at spacing and locations indicated on the Drawings.
   1. If embedment depth is not indicated, contact 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.

B. Special inspections, special tests, and structural observation:
   1. Provide as specified in Section 01455 - Regulatory Quality Assurance.

2. Frequency of inspections:
    a. Unless otherwise indicated on the Drawings or in this Section, provide periodic special inspection as required by the Evaluation Report for the product installed.
    b. Provide continuous inspection for the initial installation of each type and size of adhesive bonded reinforcing bar and all thread rod. Subsequent installations of the same anchor may be installed with periodic inspection as defined in subsequent paragraphs.
    c. Provide continuous inspection of drilling, cleaning and bonding activities for bars and rods installed in horizontal and upwardly inclined positions.
3. Preparation:
    a. Review Drawings and Specifications for the Work to be observed.
    b. Review adhesive manufacturer's MPII and recommended installation procedures.
    c. Review Evaluation Report "Conditions of Use" and "Special Inspection" requirements.
4. Inspection: Periodic:
    a. Initial inspection. Provide an initial inspection for each combination of concrete and reinforcing bar strength or concrete strength and all thread rod material being installed. During initial inspection, observe the following for compliance with the installation requirements.
        1) Concrete: Class (minimum specified compressive strength) and thickness.
        2) Environment: Temperature conditions at work area, and moisture conditions of concrete and drilled hole.
        3) Holes: Locations, spacing, and edge distances; verification of drill bit compliance with requirements; cleaning equipment and procedures; cleanliness of hole. Before adhesive is placed, confirm that depth and preparation of holes conforms to the requirements of the Contract Documents, the MPII, and the "Conditions of Use" listed in the Evaluation Report.
        4) Adhesive: Product manufacturer and name; lot number and expiration date; temperature of product at installation; installation procedure. Note initial set times observed during installation.
        5) Reinforcing bars and all thread rods: Material diameter and length; steel grade and/or strength; cleaning and preparation; cleanliness at insertion; minimum effective embedment provided.
    b. Subsequent inspections: Subsequent installations of the same reinforcing bars or all thread rods may be performed without the presence of the special inspector, provided that:
        1) There is no change in personnel performing the installation, the general strength and characteristics of the concrete receiving the inserts, or the reinforcing bars and all thread rods being used.
        2) For ongoing installations, the special inspector visits the site at least once per day during each day of installation to observe the work for compliance with material requirements and installation procedures.
5. Inspection: Continuous.
    a. Make observations as described under "Inspection - Periodic, Initial Inspection" during drilling, cleaning, and bonding activities for all bars and rods installed.

6. Records of inspections:
   a. Provide a written record of each inspection using forms acceptable to the Engineer and to the Building Official.
   b. Submit electronic copies of inspection reports to the Engineer within 24 hours after completion of inspection.

END OF SECTION

SECTION 03071

EPOXIES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Epoxy.
   2. Epoxy gel.
   3. Epoxy bonding agent.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. C881 - Standard Specification for Epoxy-Resin-Base Systems for Concrete.
   2. C882 - Standard Test Method for Bond Strength of Epoxy-Resin Systems Used with Concrete by Slant Shear.
   3. D638 - Standard Test Method for Tensile Properties of Plastics.
   4. D695 - Standard Test Method for Compressive Properties of Rigid Plastics.

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: 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 in accordance with the manufacturer.
   3. Perform and conduct Work of this Section in a 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. 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.

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.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install and cure epoxy materials in accordance with the manufacturer's installation instructions.

B. Epoxy:
   1. Apply in accordance with the manufacturer's installation instructions.

C. Epoxy gel:
   1. Apply in accordance with the 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 the manufacturer's installation instructions.
   2. Will not be required for filling form tie holes or for normal finishing and patching of similar sized small defects.

END OF SECTION

SECTION 03072

EPOXY RESIN/PORTLAND CEMENT BONDING AGENT

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Epoxy resin/portland cement bonding agent.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. C109 - Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. Cube Specimens).
   2. C348 - Standard Test Method for Flexural Strength of Hydraulic-Cement Mortars.
   3. C496 - Standard Test Method for Splitting Tensile Strength of Cylindrical Concrete Specimens.
   4. C882 - Standard Test Method for Bond Strength of Epoxy-Resin Systems Used With Concrete By Slant Shear.

B. Federal Highway Administration (FHWA):
   1. FHWA-RD-86-193 - Highway Concrete Pavement Technology Development and Testing Volume V: Field Evaluation of SHRP C9206 Test Sites (Bridge Deck Overlays).

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Sika Corp., Sika Armatec 110.

B. Substitutions: The use of other than the specified product will be considered, providing the Contractor requests its use in writing to the Engineer. This request shall be accompanied by:
   1. A certificate of compliance from an approved independent testing laboratory that the proposed substitute product meets or exceeds specified performance criteria, tested in accordance with the specified test standards.
   2. Documented proof that the proposed substitute product has a 1-year proven record of performance of bonding portland cement mortar/concrete to hardened portland cement mortar/concrete, confirmed by actual field tests and 5 successful installations that the Engineer can investigate.

2.02 MATERIALS

A. Epoxy resin/portland cement adhesive:
   1. Component "A" shall be an epoxy resin/water emulsion containing suitable viscosity control agents. It shall not contain butyl glycidyl ether.

2. Component "B" shall be primarily a water solution of a polyamine.
3. Component "C" shall be a blend of selected portland cements and sands.
4. The material shall not contain asbestos.

2.03 DESIGN AND PERFORMANCE CRITERIA

A. Properties of the mixed epoxy resin/portland cement adhesive:
   1. Pot life: 75 to 105 minutes.
   2. Contact time: 24 hours.
   3. Color: Dark gray.

B. Properties of the cured epoxy resin/portland cement adhesive:
   1. Compressive strength in accordance with ASTM C109:
      a. 3 day: 4,500 pounds per square-inch minimum.
      b. 7 days: 6,500 pounds per square-inch minimum.
      c. 28 days: 8,500 pounds per square-inch minimum.
   2. Splitting tensile strength in accordance with ASTM C496:
      a. 28 days: 600 pounds per square-inch minimum.
   3. Flexural strength:
      a. 1,100 pounds per square-inch minimum in accordance with ASTM C348.
   4. Bond strength in accordance with ASTM C882 modified at 14 days:
      a. 0 hours open time: 2,800 pounds per square-inch minimum.
      b. 24 hours open time: 2,600 pounds per square-inch minimum.
   5. The epoxy resin/portland cement adhesive shall not produce a vapor barrier.
   6. Material must be proven to prevent corrosion of reinforcing steel when tested under the procedures as set forth by the FHWA Program Report Number FHWA-RD-86-193. Proof shall be in the form of an independent testing laboratory corrosion report showing prevention of corrosion of the reinforcing steel.

PART 3 EXECUTION

3.01 INSTALLATION

A. Mixing the epoxy resin: Shake contents of Component "A" and Component "B." Empty all of both components into a clean, dry mixing pail. Mix thoroughly for 30 seconds with a jiffy paddle on a low-speed with 400 to 600 revolutions per minute drill. Slowly add the entire contents of Component "C" while continuing to mix for a minimum of 3 minutes and until uniform with no lumps. Mix only the quantity that can be applied within its pot life.

B. Placement procedure:
   1. Apply to prepared surface with stiff-bristle brush, broom, or "hopper-type" spray equipment:
      a. For hand applications: Place fresh plastic concrete/mortar while the bonding bridge adhesive is wet or dry, up to 24 hours.
      b. For machine applications: Allow the bonding bridge adhesive to dry for 12 hours minimum.

C. Adhere to all limitations and cautions for the epoxy resin/portland cement adhesive in the manufacturer's current printed literature.

3.02 CLEANING

A. Leave finished work and work area in a neat, clean condition without evidence of spillovers onto adjacent areas.

END OF SECTION

SECTION 03102

CONCRETE FORMWORK

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Concrete formwork.

1.02 REFERENCES

A. American Concrete Institute (ACI):
   1. 117 - Specifications for Tolerances for Concrete Construction and Materials and Commentary.

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

C. Underwriters Laboratories (UL).

1.03 SUBMITTALS

A. Information on proposed forming system:
   1. Submit in such detail as the Engineer may require to assure themselves that intent of the Specifications can be complied with by use of proposed system.
   2. Alternate combinations of plywood thickness and stud spacing may be submitted.

B. Form release agent: NSF 61 certification prepared by NSF, UL, or other similar nationally recognized testing laboratory acceptable to the Engineer.

1.04 QUALITY ASSURANCE

A. Qualifications of formwork manufacturers: Use only forming systems by manufacturers having a minimum of 5 years of experience, except as otherwise specified, or accepted in writing by the Engineer.

B. Regulatory requirements: Install Work of this Section in accordance with local, state, and federal regulations.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

A. Design requirements:
   1. Concrete forms, falsework, and shoring in accordance with local, state, and federal regulations.

2. Forms and ties to withstand concrete pressures without bulging, spreading, or lifting of forms.

B. Performance requirements:
   1. Construct forms so that finished concrete conforms to shapes, lines, grades, and dimensions indicated on the Drawings.
   2. It is intended that surface of concrete after stripping presents smooth, hard, and dense finish that requires minimum amount of finishing.
   3. Provide sufficient number of forms so that the Work may be performed rapidly and present uniform appearance in form patterns and finish.
   4. Use forms that are clean and free from dirt, concrete, and other debris.
      a. Coat with form release agent if required, prior to use or reuse.

2.02 MANUFACTURED UNITS

A. Forms:
   1. Built-up plywood:
      a. May be substituted for prefabricated forming system, subject to the following minimum requirements:
         1) Size and material:
            a) Use full size 4-foot by 8-foot plywood sheets, except where smaller pieces are able to cover entire area.
            b) Sheet construction: 5-ply plywood sheets, 3/4-inch nominal, made with 100 percent waterproof adhesive, and having finish surface that is coated or overlaid with surface which is impervious to water and alkaline calcium and sodium hydroxide of cement.
         2) Wales: Minimum 2-inch by 4-inch lumber.
         3) Studding and wales: No loose knots and free of warps, cups, and bows.
   2. Steel:
      a. Rigidly constructed and capable of being braced for minimum deflection of finish surface.
      b. Capable of providing finish surfaces that are flat without bows, cups, or dents.
   3. Steel-framed plywood:
      a. Provide forms that are rigidly constructed and capable of being braced.
      b. Plywood paneling: 5-ply, 5/8-inch nominal or 3/4-inch nominal, made with 100 percent waterproof adhesive, and having finish surface that is coated or overlaid with surface which is impervious to water and alkaline calcium and sodium hydroxide of cement.

B. Form release agent.
   1. Effective, non-staining, bond-breaking coating compatible with form surfaces and concrete mixes used.
   2. Certified for conformance to NSF 61 and leaving no taste or odor on the concrete surface.

C. Form ties:
   1. General:
      a. Provide form ties for forming system selected that are manufactured by a recognized manufacturer of concrete forming equipment.

b. Do not use wire ties or wood spreaders.
c. Provide ties of type that accurately tie, lock, and spread forms.
d. Provide form ties of such design that when forms are removed, they locate no metal or other material within 1-1/2 inches of the surface of the concrete.
e. Do not allow holes in forms for ties to allow leakage during placement of concrete.

2. Cone-snap ties:
   a. Shall form a cone shaped depression in the concrete with minimum diameter of 1 inch at the surface of the concrete and minimum depth of 1-1/2 inches.
   b. Provide neoprene waterseal washer that is located near the center of the concrete.
3. Taper ties:
   a. Neoprene plugs for taper tie holes: Size so that after they are driven, plugs are located in center third of wall thickness.

D. Incidentals:
1. External angles:
   a. Where not otherwise indicated on the Drawings, provide with 3/4-inch bevel, formed by utilizing true dimensioned wood or solid plastic chamfer strip on walkways, slabs, walls, beams, columns, and openings.
   b. Provide 1/4-inch bevel formed by utilizing true dimensioned wood or solid plastic chamfer strip on walkways, walls, and slabs at expansion, contraction, and construction joints.
2. Keyways: Steel, plastic, or lumber treated with form release agent.

PART 3 EXECUTION

3.01 EXAMINATION

A. Site verification of conditions:
1. Do not place concrete until forms have been checked for alignment, level, and strength, and mechanical and electrical inserts or other embedded items for correct location.

3.02 INSTALLATION

A. Forms:
1. Built-up plywood:
   a. Studding:
      1) Spaced at 16 inches or 24 inches on center.
      2) Closer spacing may be required depending upon strength requirements of the forms, in order to prevent any bulging surfaces on faces of finished concrete work.
      3) Install studs perpendicular to grain of exterior plys of plywood sheets.
   b. Wales: Double lumber material with minimum size as specified in this Section.

c. Number of form reuses: Depends upon durability of surface coating or overlay used, and ability to maintain forms in condition such that they are capable of producing flat, smooth, hard, dense finish on concrete when stripped.

2. Steel:
   a. Adequately brace forms for minimum deflection of finish surface.
3. Steel-framed plywood:
   a. Rigidly construct and brace with joints fitting closely and smoothly.
   b. Number of form reuses: Depends upon durability of surface coating or overlay used.
4. As specified in this Section, built-up plywood forms may be used in conjunction with steel forms or steel-framed plywood forms for special forming conditions such as corbels and forming around items which will project through forms.

B. Form bracing and alignment:
   1. Line and grade: Limit deviations to tolerances which will permit proper installation of structural embedded items or mechanical and electrical equipment and piping.
   2. Formwork:
      a. Securely brace, support, tie down, or otherwise hold in place to prevent movement.
      b. Make adequate provisions for uplift pressure, lateral pressure, and deflection of forms.
   3. When second lift is placed on hardened concrete, take special precautions in formwork at top of old lift and bottom of new lift to prevent:
      a. Spreading and vertical or horizontal displacement of forms.
      b. Grout “bleeding” on finish concrete surfaces.
   4. Pipe stubs, anchor bolts, conduits, and other embedded items:
      a. Set in forms, position, and secure prior to placement of concrete to maintain a minimum 1-1/2-inch clearance between the item and any concrete reinforcement.
      b. Securing embedded items in position by wiring or welding to the reinforcement is not permitted.
   5. Cracks, openings, or offsets at joints in formwork: Close those that are 1/16 inch or larger by tightening forms or by filling with acceptable crack filler acceptable to the Engineer.

C. Forming incidentals:
   1. Keyways: Construct as indicated on the Drawings.
   2. Reentrant angles: May be left square.
   3. Level strips: Install at top of wall concrete placements to maintain true line at horizontal construction joints.
   4. Inserts:
      a. Encase pipes, anchor bolts, steps, reglets, castings, and other inserts, as indicated on the Drawings or as required, in concrete.

D. Form release agent:
   1. Apply in accordance with the manufacturer’s instructions.

E. Form ties:
   1. Cone-snap ties: Tie forms together at not more than 2-foot centers vertically and horizontally.

3.03 FORM REMOVAL

A. General:
   1. Keep forms in place, as specified in the following paragraphs, to provide curing and to protect concrete surfaces and edges from damage.
   2. Immediately after forms are removed, carefully examine concrete surfaces, and repair any irregularities in surfaces and finishes as specified.

B. Form removal:
   1. Do not remove forms from concrete which has been placed when outside ambient air temperature is below 50 degrees Fahrenheit until the following conditions are satisfied:
      a. Concrete has sufficient strength to allow form removal without damage to surfaces.
      b. At least 48 hours have elapsed since the end of concrete placement.
      c. Provisions are in place to maintain moisture for curing concrete, and temperature at or above the required minimum curing temperature specified.
   2. Vertical forms:
      a. Retain in place for a minimum of 24 hours after concrete is placed.
      b. If concrete has sufficient strength and hardness to resist surface or other damage after 24 hours, forms may be removed.
   3. Other forms supporting concrete, and shoring: Retain in place as follows:
      a. Formed sides of footings: 24 hours minimum.
      b. Formed vertical sides of beams, girders, and similar members: 48 hours minimum.
      c. Forms below slabs, beams, and girders: Until concrete strength reaches specified strength f'c or until shoring is installed.
         1) Shoring for slabs, beams, and girders: Shore until concrete strength reaches minimum specified 28-day compressive strength.

3.04 SURFACE REPAIRS AND FINISHING

A. Immediately after forms are removed, carefully examine concrete surfaces, and repair any irregularities in surfaces and finishes as specified in Section 03300 - Cast-in-Place Concrete.

B. Form ties:
   1. Snap ties:
      a. Break off ties and remove from concrete.
      b. Roughen cone shaped tie holes by heavy sandblasting before repair.
      c. Dry pack cone shaped tie holes with dry-pack mortar as specified in Section 03600 - Grouting.

2. Taper ties:
    a. Rubber plugs in tie holes:
        1) After forms and taper ties are removed from wall, plug tie holes with neoprene plug as follows:
            a) Heavy sandblast and then clean tie holes.
            b) After cleaning, drive neoprene plug into each of taper tie holes with steel rod.
                (1) Final location of neoprene plug shall be in center third of wall thickness.
                (2) Bond neoprene plug to concrete with epoxy.
            c) Locate steel rod in cylindrical recess and against middle of plug during driving.
                (1) Do not drive on flat area outside cylindrical recess.
    b. Dry-pack of tie holes:
        1) After installing plugs in tie holes, coat tie hole surface with epoxy bonding agent and fill with dry-pack mortar as specified in Section 03600 - Grouting.
            a) Place dry-pack mortar in holes in layers with thickness not exceeding tie hole diameter and heavily compact each layer.
            b) Dry-pack hole on the outside of the face of the wall no sooner than 7 days after hole on the inside of the face of the wall has been dry packed.
            c) Wall surfaces in area of dry-packed tie holes: On the water side of water containing structures and the outside of below grade walls:
                (1) Cover with minimum of 10 mils of epoxy gel.
                (2) Provide epoxy gel coating on wall surfaces that extends a minimum of 2 inches past dry-pack mortar-filled tie holes.
                (3) Provide finish surfaces that are free from sand streaks or other voids.

3.05 CONCRETE TOLERANCES

A. Finish concrete shall conform to shapes, lines, grades, and dimensions indicated on the Drawings.

B. Construct Work within the tolerances in accordance with ACI 117, except as modified in the following paragraphs or as indicated on the Drawings.
    1. General:
        a. At certain locations, tolerances required for equipment placement and operation may be more restrictive than the general tolerance requirements in this Section.
        b. Confirm equipment manufacturers' required tolerances for location and operation of equipment that will be installed, and construct concrete to satisfy those requirements.
    2. Slabs:
        a. Slope: Uniformly sloped to drain when slope is indicated on the Drawings.
        b. Slabs indicated to be level: Maximum vertical deviation of 1/8 inch in 10-foot horizontal length without any apparent changes in grade.

3. Circular tank walls:
    a. May deviate from finish line indicated on the Drawings by use of forms with chord lengths not to exceed 2 feet.
4. Inserts and embedments:
    a. Set to tolerances required for proper installation and operation of equipment or systems to which insert pertains.
    b. Maximum tolerances as follows:

Item	Tolerance
Sleeves and inserts	Plus 1/8 inch; minus 1/8 inch.
Anchor bolts:	
Projected ends	Plus 1/4 inch; minus 0.0 inch.
Axial alignment	Not more than 2 degrees off the axis indicated on the Drawings.
Setting location	Plus 1/16 inch; minus 1/16 inch.
All embedments	Minimum 1 inch clearance from reinforcing steel.

    c. Securing embedded items in formwork by wiring or welding to reinforcement is not permitted.

C. Remove and replace Work that does not conform to the required tolerances.

END OF SECTION

SECTION 03150

CONCRETE ACCESSORIES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Waterstops.
   2. Joint fillers.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. D570 - Standard Test Method for Water Absorption of Plastics.
   2. D624 - Standard Test Method for Tear Strength of Conventional Vulcanized Rubber and Thermoplastic Elastomers.
   3. D638 - Standard Test Method for Tensile Properties of Plastics.
   4. D746 - Standard Test Method for Brittleness Temperature of Plastics and Elastomers by Impact.
   5. D747 - Standard Test Method for Apparent Bending Modulus of Plastics by Means of a Cantilever Beam.
   6. D792 - Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement.
   7. D1751 - Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types).
   8. D1752 - Standard Specification for Preformed Sponge Rubber Cork and Recycled PVC Expansion Joint Fillers for Concrete Paving and Structural Construction.
   9. D2240 - Standard Test Method for Rubber Property - Durometer Hardness.

B. American National Standards Institute (ANSI):
   1. A135.4 - Basic Hardboard.

C. U. S. Army Corps of Engineers (USACE):
   1. CRD-C-572, Specification for Polyvinyl Chloride Waterstop.

1.03 SUBMITTALS

A. Product data:
   1. Polyvinyl chloride waterstops: Complete physical characteristics.
   2. Preformed expansion joint material: Sufficient information on each type of material for review to determine conformance of material to requirements specified.

B. Samples:
   1. Polyvinyl chloride waterstop.

C. Laboratory test reports: Indicating that average properties of polyvinyl chloride waterstops material and finish conform to requirements specified in this Section.

D. Quality control submittals:
   1. Certificates of Compliance:
      a. Written certificates that polyvinyl chloride waterstops supplied on this Project meet or exceed physical property in accordance with USACE CRD-C-572 and the requirements of this Section.
   2. Manufacturer's instructions: For materials specified in this Section that are specified to be installed with such instructions.

1.04 QUALITY ASSURANCE

A. Mock-ups:
   1. Welding demonstration:
      a. Demonstrate ability to weld acceptable joints in polyvinyl chloride waterstops before installing waterstop in forms.

B. Field joints:
   1. Polyvinyl chloride waterstops field joints: Free of misalignment, bubbles, inadequate bond, porosity, cracks, offsets, and other defects which would reduce the potential resistance of material to water pressure at any point. Replace defective joints. Remove faulty material from site and disposed of by Contractor at its own expense.

C. Inspections:
   1. Quality of welded joints will be subject to acceptance of Engineer.
   2. Polyvinyl chloride waterstop: Following defects represent partial list that will be grounds for rejection:
      a. Offsets at joints greater than 1/16 inch or 15 percent of the material thickness, at any point, whichever is less.
      b. Exterior crack at joint due to incomplete bond, which is deeper than 1/16 inch or 15 percent of material thickness, at any point, whichever is less.
      c. Any combination of offset or crack that will result in net reduction in cross section of waterstop in excess of 1/16 inch or 15 percent of material thickness, at any point, whichever is less.
      d. Misalignment of joint that will result in misalignment of waterstop in excess of 1/2 inch in 10 feet.
      e. Porosity in welded joint as evidenced by visual inspection.
      f. Bubbles or inadequate bonding.

PART 2 PRODUCTS

2.01 JOINT FILLERS

A. General:
   1. Use specific type in applications as indicated on the Drawings.
   2. Do not use scrap or recycled materials to manufacture joint fillers.

B. Preformed expansion joint materials:
   1. Bituminous fiber expansion joint material:
      a. Properties:
         1) Thickness: To match joint width indicated on the Drawings.
         2) Asphalt-impregnated fiber in accordance with ASTM D1751.
      b. Manufacturers: One of the following or equal:
         1) Durajoint.
         2) W.R. Meadows, SealTight Fibre Expansion Joint.
   2. Synthetic sponge rubber expansion joint material:
      a. Properties:
         1) Thickness: As recommended for width indicated on the Drawings.
         2) Material in accordance with ASTM D1752, Type I.
      b. Manufacturers: One of the following or equal:
         1) Williams Products Inc., Everlastic 1300.
         2) W.R. Meadows, SealTight Sponge Rubber.

2.02 WATERSTOPS

A. Waterstops - polyvinyl chloride (PVC):
   1. Manufactured from prime virgin polyvinyl chloride plastic compound containing the plasticizers, resins, stabilizers, and other materials necessary to meet the requirements as specified in this Section.
   2. Manufacturers: One of the following or equal:
      a. Vinylex Corp.
      b. Sika Corp., Greenstreak PVC Waterstop.
   3. Type: Ribbed waterstop:
      a. Construction joints: 6-inch wide ribbed type.
      b. Expansion joint for wall penetrations for concrete encased electrical duct banks: 6-inch ribbed type with hollow center bulb.
      c. Expansion joints: 9-inch wide ribbed type with hollow center bulb.
      d. Dumbbell-type waterstop will not be allowed unless otherwise specified or indicated on the Drawings.
      e. No scrap or reclaimed material shall be used.
   4. Properties as indicated in the following table:

Physical Characteristics	Test Method	Required Results
Specific Gravity	ASTM D792	Not less than 1.3.
Hardness	ASTM D2240	70 to 90 Type A15 Shore durometer.
Tensile Strength	ASTM D638	Not less than 2,000 pounds per square inch.
Ultimate Elongation	ASTM D638	Not less than 300 percent.
Alkali Extraction	CRD-C-572	Change in weight after 7 days: Between minus 0.1 percent and plus 0.25 percent. Change in hardness after 7 days: Not more than plus 5 points.

Physical Characteristics	Test Method	Required Results
Low Temperature Brittle Point	ASTM D746	No sign of cracking or chipping at -35 degrees Fahrenheit.
Water Absorption	ASTM D570	Not more than 0.15 percent after 24 hours.
Accelerated Extraction Test	CRD-C-572	Tensile strength: Not less than 1,600 pounds per square inch. Elongation: Not less than 280 percent.
Stiffness in Flexure	ASTM D747	Not less than 600 pounds per square inch.
Tear Resistance	ASTM D624	Not less than 225 pounds per inch.
Thickness	-	3/8 inch.
Center Bulb		
6-inch Waterstops	-	7/8 inch or 1-inch nominal outside diameter.
9-inch Waterstops	-	For expansion joints 1 inch and narrower: 1-inch nominal outside diameter. For expansion joints wider than 1 inch: 2-inch nominal outside diameter.
Allowable Tolerances		
Width	-	Plus or minus 3/16 inch.
Thickness	-	Plus or minus 1/32 inch.

PART 3 EXECUTION

3.01 INSTALLATION

A. Waterstops:
   1. General:
      a. Store waterstops so as to permit free circulation of air around waterstop material and prevent direct exposure to sunlight.
      b. Install waterstops in concrete joints where indicated on the Drawings.
      c. Carry waterstops in walls into lower slabs and join to waterstops in slabs with appropriate types of fittings.
      d. In waterbearing structures: Provide all joints with waterstops, whether indicated on the Drawings or not.
      e. Provide waterstops that are continuous.
      f. Set waterstops accurately to position and line as indicated on the Drawings.
      g. Hold and securely fix edges in position at intervals of not more than 24 inches so that they do not move during placing of concrete.

h. Position the waterstop so that symmetrical halves of waterstop are equally divided between concrete pours. Center axis of waterstop shall be coincident with centerline of the joint.
i. Do not drive nails, screws, or other fasteners through waterstops in vicinity of construction joints.
j. Use wires at not more than 24 inches on centers near outer edge of waterstop to tie waterstops into position.
k. Special clips may be used in lieu of wires, at Contractor's option.
l. Terminate waterstops 3 inches from top of finish surfaces of walls and slabs unless otherwise specified or indicated on the Drawings.
m. When any waterstop is installed in concrete on one side of joint, while the other half or portion of the waterstop remains exposed to the atmosphere for more than 2 days, take suitable precautions to shade and protect exposed waterstop from direct rays of sunlight during entire exposure and until exposed portion is embedded in concrete.
n. When placing concrete at waterstops in slabs, lift edge of waterstop while placing concrete below the waterstop. Manually force waterstop against and into concrete, and then cover waterstop with fresh concrete.

2. Polyvinyl chloride waterstop:
a. Install waterstops so that joints are watertight.
b. Weld joints such as unions, crosses, ells, and tees, with thermostatically controlled equipment recommended by waterstop manufacturer:
1) Do not damage material by heat sealing.
2) Make joints by overlapping, then simultaneously cut ends of sections to be spliced so they will form smooth even joint. Heat cut ends with splicing tool until the plastic melts. Press 2 ends together until plastic cools.
3) Maintain continuity of waterstop ribs and tubular center axis.
4) The splices shall have tensile strength of not less than 60 percent of unspliced materials tensile strength.
c. Butt joints of ends of 2 identical waterstop sections may be made while material is in forms.
d. Split-type waterstops will not be permitted except where specifically indicated on the Drawings.

B. Joints:
1. Construct construction and expansion joints as indicated on the Drawings.
2. Preformed expansion joint material: Fasten expansion joint strips to concrete, masonry, or forms with adhesive. No nailing will be permitted, nor shall expansion joint strips be placed without fastening.

END OF SECTION

SECTION 03200

CONCRETE REINFORCING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Reinforcing bars.
      a. Carbon steel.
   2. Thread bars.
   3. Bar supports.
   4. Tie wires.
   5. Welded wire fabric.

1.02 REFERENCES

A. American Concrete Institute (ACI):
   1. 318 - Building Code Requirements for Structural Concrete and Commentary.
   2. SP-66 - ACI Detailing Manual.

B. American Iron and Steel Institute (AISI).

C. ASTM International (ASTM):
   1. A493 - Standard Specification for Stainless Steel Wire and Wire Rods for Cold Heading and Cold Forging.
   2. A615 - Standard Specification for Deformed and Plain Carbon Steel Bars for Concrete Reinforcement.
   3. A706 - Standard Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement.
   4. A1064 - Standard Specification of Carbon-Steel wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete.

D. Concrete Reinforcing Steel Institute (CRSI):
   1. Manual of Standard Practice.

1.03 TERMINOLOGY

A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
   1. Architectural concrete: Concrete surfaces that will be exposed to view in the finished work.
      a. Additionally, for purposes of this Section, includes:
         1) Concrete surfaces that are designated to receive paints or coatings.
         2) Exposed concrete in open basins, channels, and similar liquid containing structures: Surfaces shall be considered exposed to view if located above a line 2 feet below the normal operating water surface elevation in that structure.

2. Bars: Reinforcement or reinforcing bars as specified in this Section.
3. Evaluation Report: Report prepared by ICC-ES, or by other testing agency acceptable to the Engineer and to the Building Official, that documents testing and review of a product to confirm that it complies with the requirements of designated ICC-ES Acceptance Criteria, and its acceptance for use under the Building Code specified in Section 01410 - Regulatory Requirements.
4. Give away bars: Reinforcing bars that are not required by the Contract Documents but are installed by the Contractor to provide support for the required reinforcing bars.
5. Wire supports: Metal reinforcing supports constructed of steel wire as specified. Includes individual high chairs, continuous high chairs, bolsters and other similar configurations and shapes.

1.04 SUBMITTALS

A. General:
   1. Submit in accordance with Section 01330 - Submittal Procedures.
   2. Changes to reinforcement in Contract Documents:
      a. Indicate in a separate letter submitted with Shop Drawings any changes to reinforcement indicated on the Drawings or specified.
      b. Such changes will not be acceptable unless the Engineer has accepted them in writing.

B. Product data:
   1. Bar supports:
      a. Wire bar supports:
         1) Schedule of support materials to be provided and locations of use.
      b. Precast concrete bar supports (“dobies”):
         1) Manufacturer's data indicating compression strength of concrete and confirming dimensions and thickness(es).height(s) to be provided for each location where used.

C. Shop Drawings:
   1. Reinforcement Shop Drawings:
      a. Submit Drawings showing bending and placement of reinforcement required by the Contract Documents.
      b. Provide CAD generated Shop Drawings.
      c. Clearly indicate structures or portions of structures covered by each Submittal.
      d. Shop Drawings shall conform to the recommendations of the CRSI Manual of Standard Practice and be in accordance with ACI SP-66.
      e. Use the same bar identification marks on bending detail Drawings, placement Drawings, and shipping tags.
      f. Submittals consisting solely of reinforcing bar schedules, without accompanying placement Drawings, will not be accepted unless accepted under prior written agreement with the Engineer.
   2. Reinforcement placement Drawings:
      a. Clearly show placement of each bar listed in the bill of materials, including additional reinforcement at corners and openings, and other reinforcement required by details in the Contract Documents.

b. Clearly identify locations of reinforcement with coatings (e.g., galvanized or epoxy) and with yield strength other than ASTM A615, Grade 60.
c. Show anchor bolt locations based on anchor bolt templates for approved equipment.
d. Show splice locations.

3. Reinforcement fabrication Drawings:
a. If bend types or nomenclature differs from that recommended in the CRSI Manual of Standard Practice, provide details showing bend types and dimensional designations.
b. Clearly identify reinforcement with coatings and with yield strength other than ASTM A615, Grade 60.

D. Samples (when requested by the Engineer):
1. Bar supports/wire reinforcement supports: Samples of each type of chair and bolster proposed for use. Submit with letter stating where each type will be used.
2. Precast concrete bar supports: Samples of each type of precast support proposed for use. Submit with letter stating where each will be used.

E. Test reports:
1. Certified copy of mill test for each steel used. Show physical properties and chemical analysis.
a. Mill test reports may be submitted as record documents at the time the reinforcement from that heat of steel is shipped to the site.
b. In such cases, submit certificates under the Shop Drawing Submittal number with the letter “R” (for record date) appended to the end (e.g., if the reinforcement was submitted as 03200-002-1, deliver the associated mill certificate as Submittal 03200-002-1R).

F. Closeout documents:
1. Field quality control and inspection reports.
2. Field quality assurance special inspection and testing reports.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Packing and shipping:
1. Deliver bars bundled and tagged with identifying tags.

B. Acceptance at site:
1. Reinforcing bars: Deliver reinforcing bars lacking grade identification marks with letter containing manufacturer's guarantee of grade.

1.06 SEQUENCING AND SCHEDULING

A. Bar supports:
1. Do not place concrete until samples and product data for bar supports have been accepted by the Engineer.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

A. Drawings contain notes describing the size and spacing of reinforcement and its placement, details of reinforcement at wall corners and intersections, and details of extra reinforcement around openings in concrete, and other related information.

2.02 MATERIALS

A. Reinforcing bars:
   1. Provide reinforcement of the grades and quality specified, fabricated from new stock, free from excessive rust or scale, and free from unintended bends or other defects affecting its usefulness.
   2. ASTM A615 Grade 60 deformed bars, including the following requirements:
      a. Actual yield strength based on mil tests of reinforcement provided shall not exceed the minimum yield strength specified in this Section by more than 18,000 pounds per square inch.
      b. Ratio of actual ultimate tensile strength to actual tensile yield strength shall not be less than 1.25.

B. Bar supports:
   1. Wire supports:
      a. All stainless steel bar supports:
         1) Conforming to CRSI Manual of Standard Practice recommendations for types and details, but custom fabricated entirely from stainless steel wire in accordance with ASTM A493, AISI Type 316.
      b. Stainless steel protected bar supports:
         1) Conforming to CRSI Manual of Standard Practice Class 2, Type B, and consisting of bright basic wire support fabricated from cold-drawn carbon steel wire with stainless steel ends attached at the bottom of each leg.
         2) Stainless steel wire ends shall be in accordance with ASTM A493, AISI Type 316 and shall extend at least 3/4 inch inward from the formed surface of the concrete.
      c. Bright basic wire bar supports.
         1) Conforming to CRSI Manual if Standard Practice, Class 3.
   2. Plastic supports:
      a. Manufacturers: The following or equal:
         1) Aztec Concrete Accessories.
   3. Deformed steel reinforcing bar supports:
      a. Fabricated of materials and to CRSI details recommended for typical reinforcement embedded in concrete and bent to dimensions required to provide specified clearances and concrete cover.
   4. Precast concrete bar supports (“dobies”):
      a. Pre-manufactured, precast concrete blocks with cast-in annealed steel wires, 16-gauge or heavier.
      b. Compression strength of concrete: Equal to or exceeding the compression strength of the surrounding concrete.
      c. Block dimensions:
         1) Height to provide specified concrete cover.

2) Footprint not less than 3 inches by 3 inches, and adequate to support the weight of the reinforcement and maintain specified concrete cover without settling into the underlying surface.

C. Tie wires:
   1. General use: Black annealed steel wire, 16-gauge or heavier.

D. Welded wire fabric reinforcement:
   1. Material:
      a. Carbon steel in accordance with ASTM A1064.
   2. Provide welded wire reinforcement in flat sheet form. Rolled wire fabric is not permitted.
   3. Fabric may be used in place of reinforcing bars if accepted by the Engineer:
      a. Provide welded wire fabric having cross-sectional area per linear foot not less than the cross-sectional area per linear foot of reinforcing bars indicated on the Drawings.

2.03 FABRICATION

A. Shop fabrication and assembly:
   1. Cut and bend bars in accordance with provisions of ACI 318 and the CRSI Manual of Standard Practice.
   2. Bend bars cold. Use bending collars to develop the recommended bend radius.
   3. Provide bars free from defects and kinks and from bends not indicated on the Drawings.
   4. Circumferential and radiused reinforcement: Roll to the radius required for its location in the structure before installation.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verification of conditions:
   1. Reinforcing bars and welded wire reinforcement:
      a. Verify that reinforcement is new stock, free from rust scale, loose mill scale, excessive rust, dirt, oil, and other coatings that will adversely affect bonding capacity when placed in the Work.
   2. Welded wire fabric:
      a. Verify that sheets are not curled or kinked before or after installation.

3.02 PREPARATION

A. Surface preparation:
   1. Reinforcing bars - uncoated:
      a. Clean reinforcement of concrete, dirt, oil and other coatings that will adversely affect bond before embedding bars in subsequent concrete placements.
      b. Thin coating of red rust resulting from short exposure will not be considered objectionable. Thoroughly clean bars having rust scale, loose mill scale, or thick rust coat.

c. Partially embedded reinforcement: Remove concrete or other deleterious coatings from dowels and other projecting bars by wire brushing or sandblasting before bars are embedded in subsequent concrete placements.

3.03 INSTALLATION

A. Reinforcing bars: General:
   1. Field-cutting of reinforcing bars is not permitted.

Table 1. Reinforcement Placing Tolerances

Member	Tolerance on Reinforcement Location (1)	Tolerance on Minimum Concrete Cover (1,2)
Slabs, beams, walls and columns except as noted below:		
10 inches thick and less	± 3/8 inch	- 3/8 inch
More than 10 inches thick	± 1/2 inch	- 1/2 inch
Formed soffits	As noted above	- 1/4 inch
Longitudinal location of bends and ends of reinforcement:		
Conditions not listed below	± 2 inches	- 1/2 inch
At discontinuous ends of brackets and corbels	± 1/2 inch	- 1/4 inch
At discontinuous ends of other members	± 1 inch	- 1/2 inch

Notes:
(1) ± indicates “plus or minus;” - indicates “minus;” + indicates “plus.”
(2) Tolerance on cover is limited as noted but decrease in cover shall not exceed one third of the minimum cover indicated on the Drawings.

   2. Field-bending of reinforcing bars, including straightening and rebending, is not permitted.

B. Placing reinforcing bars:
   1. Accurately place bars to meet position and cover requirements indicated on the Drawings and specified. Secure bars in position.
   2. Tolerances for placement and minimum concrete cover: As listed in Table 1.
   3. Spacing between bars:
      a. Minimum clear spacing between bars in a layer:
         1) As indicated on the Drawings, but not less than the larger of 1.5 times the bar diameter or 1-1/2 inches.
      b. Minimum clear spacing between bars in 2 or more parallel layers:
         1) Place bars in upper layers directly above bars in lower layers.
         2) Minimum spacing between layers: As indicated on the Drawings, but not less than the larger of 1.5 times the bar diameter or 1-1/2 inches.
      c. Limits on minimum clear spacing between bars also applies to the clear spacing between a lap splice and the adjacent bars and/or lap splices.

4. Lap splices for bars:
    a. Lap splice locations and lap splice lengths: As indicated on the Drawings. Where lap lengths are not indicated, provide in accordance with ACI 318.
    b. Unless otherwise specifically indicated on the Drawings (and noted as “non-contact lap splice”), install bars at lap splices in contact with each other and fasten together with tie wire.
    c. Where bars are to be lap spliced at concrete joints, ensure that bars project from the first concrete placement a length equal to or greater than minimum lap splice length indicated on the Drawings.
    d. Stagger lap splices where indicated on the Drawings.
    e. Where lap splice lengths are not indicated on the Drawings, provide lap splice lengths in accordance with ACI 318.

C. Reinforcing supports:
1. Provide supports of sufficient numbers, sizes, and locations to maintain concrete cover, to prevent sagging and shifting, and to support loads during construction without displacement and without gouging or indentation into forming surfaces.
    a. Quantities and locations of supports shall not be less than those indicated in ACI SP-66 and the CRSI Manual of Standard Practice.
2. Do not use brick, concrete masonry units, concrete spalls, rocks, wood, or similar materials for supporting reinforcement.
3. Do not use “give away bars” that have less cover than that required by the Contract Documents. Do not adjust the location of reinforcement required by the Contract Documents to provide cover for give away bars.
4. Provide bar supports of height required to maintain the clear concrete cover indicated on the Drawings.
5. Provide bar supports at formed vertical faces to maintain the clear concrete cover indicated on the Drawings.
6. Schedule of reinforcement support materials: Provide bar supports as indicated in Table 2.

Table 2. Reinforcement Support Materials

Case	Location	Material
a.	Concrete placed over earth and concrete seal slabs (“mud mats”)	Precast concrete bar supports.
b.	Concrete placed against forms and exposed to water or wastewater process liquids (whether or not such concrete received additional linings or coatings)	All stainless steel bar supports.
c.	Concrete placed against forms and exposed to earth, weather, frequent washdown, or groundwater in the finished work	Stainless steel protected bar supports.
d.	Concrete placed against forms and exposed to interior equipment/piping areas in the finished work	Stainless steel protected bar supports.
e.	Between mats of reinforcement, and fully embedded within a concrete member	Bright basic wire bars supports, or deformed steel reinforcing bars.

D. Tying of reinforcing:
   1. Fasten reinforcement securely in place with wire ties.
   2. Tie reinforcement at spacings sufficient to prevent shifting.
      a. Provide at least 3 ties in each bar length. (Does not apply to dowel lap splices or to bars shorter than 4 feet, unless necessary for rigidity).
   3. Tie slab bars at every intersection around perimeter of slab.
   4. Tie wall bars and slab bar intersections other than around perimeter at not less than every fourth intersection, but at not more than the spacing indicated in Table 3:

Table 3. Maximum Spacing of Tie Wires for Reinforcement

Bar Size	Slab Bar Spacing (inches)	Wall Bar Spacing (inches)
Bars Number 5 and Smaller	60	48
Bars Number 6 through Number 9	96	60
Bars Number 10 and Number 11	120	96

   5. After tying:
      a. Bend ends of wires inward towards the center of the concrete section. Minimum concrete cover for tie wires shall be the same as cover requirements for reinforcement.
      b. Remove tie wire clippings from inside forms before placing concrete.

E. Welded wire fabric reinforcement:
   1. Install only where indicated on the Drawings or accepted in advance by the Engineer.
   2. Install necessary tie wires, spacing chairs, and supports to keep welded wire fabric at its designated position in the concrete section while concrete is being placed.
   3. Straighten welded wire fabric to make sheets flat in the Work.
   4. Do not allow wire fabric to drape between supports unless such a configuration is specifically indicated on the Drawings.
      a. If fabric is displaced during placement of concrete, make provisions to restore it to the designated location using methods acceptable to the Engineer.
   5. Bend welded wire fabric as indicated on the Drawings or required to fit Work.
   6. Lap splice welded wire fabric as indicated on the Drawings.
      a. If lap splice length is not indicated, splice in accordance with ACI 318, but not less than 1 1/2 courses of fabric or 8 inches minimum. Tie laps at ends and at not more than 12 inches on center.

F. Welding reinforcing bars:
   1. Welding of reinforcing bars is not permitted.

3.04 FIELD QUALITY CONTROL

A. Provide quality control for the Work of this Section as specified in Section 01450 - Quality Control.

B. Field inspections and testing:
   1. Submit records of inspections and testing to the Engineer in electronic format within 24 hours after completion.

3.05 FIELD QUALITY ASSURANCE

A. Provide quality assurance as specified in Section 01450 - Quality Control.

B. Special inspections and tests:
   1. Provide as specified in Section 01455 - Regulatory Quality Assurance.
   2. Frequency of inspections:
      a. Unless otherwise indicated on the Drawings or in this Section, provide periodic special inspection as required by the Building Code specified in Section 01410 - Regulatory Requirements.
   3. Preparation:
      a. Review Drawings and Specification for the Work to be observed.
      b. Review approved Submittals and Shop Drawings.
   4. Inspections: Special inspection shall include, but is not limited to, the following items:
      a. Reinforcement: General:
         1) Type (material) and location of reinforcement supports.
         2) Bar material/steel grade and bar size.
         3) Location, placement, and spacing of bars.
         4) Clear concrete cover over reinforcement.
         5) Lap splice: Location and lap length. Bars within tolerances for contact (unless non-contact splice is indicated on the Drawings.)
         6) Bar hooks and development lengths embedded within concrete sections as indicated on the Drawings.
         7) Reinforcement tired in position and tie wire legs turned inward toward the center of the concrete section.
      b. Reinforcement: Welding:
         1) Inspector qualification and inspections shall be in accordance with the requirements of AWS D1.4.
         2) Provide periodic inspection for:
            a) Weldability of reinforcement other than ASTM A706.
            b) Single pass fillet welds with thickness less than or equal to 5/16 inch.
         3) Provide continuous inspection for:
            a) Other welds.
            b) Welds at mechanical reinforcing bar couplers and end anchors.
         4) In addition to visual inspection, Owner may inspect reinforcing bar welds by other methods, including radiographic inspection.
   5. Records of inspections:
      a. Provide a written record of each inspection using forms acceptable to the Engineer and to the Building Official.
      b. Submit electronic copies of inspection reports to the Engineer within 24 hours after completion of inspections.

3.06 NON-CONFORMING WORK

A. Before placing concrete, adjust or remove and re-install reinforcement to conform to the requirements of the Contract Documents.

END OF SECTION

SECTION 03300

CAST-IN-PLACE CONCRETE

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PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Cast-in-place concrete.

B. The requirements of this Section require advance planning for preparation and testing of trial batches. Review the mix design and testing requirements carefully, and schedule preparations and testing with sufficient time to complete tests, to obtain the Engineer's review of mixes and testing results, and to complete revisions and re-testing if required.

1.02 REFERENCES

A. American Concrete Institute (ACI):
   1. CODE-318 - Building Code Requirements for Structural Concrete and Commentary.
   2. CODE-350 - Code Requirements for Environmental Engineering Concrete Structures and Commentary.
   3. PRC-212.3 - Report on Chemical Admixtures for Concrete.
   4. PRC-302.1 - Guide to Concrete Floor and Slab Construction.
   5. PRC-305 - Guide to Hot Weather Concreting.
   6. PRC-306 - Guide to Cold Weather Concreting.

B. ASTM International (ASTM):
   1. C29 - Standard Test Method for Bulk Density ("Unit Weight") and Voids in Aggregate.
   2. C31 - Standard Practice for Making and Curing Concrete Test Specimens in the Field.
   3. C33 - Standard Specification for Concrete Aggregates.
   4. C39 - Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.
   5. C40 - Standard Test Method for Organic Impurities in Fine Aggregates for Concrete.
   6. C42 - Standard Test Method of Obtaining and Testing Drilled Cores and Sawed Beams of Concrete.
   7. C88 - Standard Test Method of Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate.
   8. C94 - Standard Specification for Ready-Mixed Concrete.
   9. C114 - Standard Test Methods for Chemical Analysis of Hydraulic Cement.
   10. C117 - Standard Test Method for Materials Finer that 75-m (No. 200) Sieve in Mineral Aggregates by Washing.
   11. C123 - Standard Test Method for Lightweight Particles in Aggregate.
   12. C131 - Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.
   13. C136 - Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
   14. C138 - Standard Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete.

15. C142 - Standard Test Method for Clay Lumps and Friable Particles in Aggregate.
16. C143 - Standard Test Method for Slump of Hydraulic-Cement Concrete.
17. C150 - Standard Specification for Portland Cement.
18. C156 - Standard Test Method for Water Loss from a Mortar Specimen Through Liquid Membrane-Forming Curing Compounds for Concrete.
19. C157 - Standard Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete.
20. C171 - Standard Specifications for Sheet Materials for Curing Concrete.
21. C172 - Standard Practice for Sampling Freshly Mixed Concrete.
22. C173 - Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method.
23. C260 - Standard Specification for Air-Entraining Admixtures for Concrete.
24. C293 - Standard Test Method for Flexural Strength of Concrete (Using Simple Beam With Center-Point Loading).
25. C295 - Standard Guide to Petrographic Examination of Aggregates for Concrete.
26. C309 - Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete.
27. C311 - Standard Test Methods for Sampling and Testing Fly Ash or Natural Pozzolans for Use in Portland-Cement Concrete.
28. C494 - Standard Specification for Chemical Admixtures for Concrete.
29.
30. C618 - Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.
31. C702 - Standard Practice for Reducing Samples of Aggregate to Testing Size.
32. C856 - Standard Practice for Petrographic Examination of Hardened Concrete.
33. C1064 - Standard Test Method for Temperature of Freshly Mixed Hydraulic-Cement Concrete.
34. C1218 - Standard Test Method for Water-Soluble Chloride in Mortar and Concrete.
35. C1260 - Standard Test Method of Potential Alkali Reactivity of Aggregates (Mortar Bar Method).
36. C1293 - Standard Test Method for Determination of Length Change of Concrete due to Alkali-Silica Reaction.
37. C1567 - Standard Test Method for Determining the Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials and Aggregate (Accelerated Mortar-Bar Method).
38. C1602 - Standard Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete.
39. C1778 - Standard Guide for Reducing the Risk of Deleterious Alkali-Aggregate Reaction in Concrete.
40. D75 - Standard Practice for Sampling Aggregates.
41. D2103 - Standard Specification for Polyethylene Film and Sheeting.
42. D3665 - Standard Practice for Random Sampling of Construction Materials.
43. D4791 - Standard Test Method for Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate.

C. National Ready-Mixed Concrete Association (NRMCA).

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. Alkali: The sum of sodium oxide and potassium oxide calculated as sodium oxide.
   2. Alkali load: Amount of alkalies contributed by the Portland cement in a concrete mixture, expressed in pounds per cubic yard (lb/yd^3) and calculated by multiplying the Portland cement content of the concrete in lb/yd^3 by the alkali content of the Portland cement, divided by 100.
   3. Architectural concrete: Concrete surfaces that will be exposed to view in the finished Work.
      a. For purposes of this Section, includes only those surfaces that receive paint or coatings.
      b. Exposed concrete surfaces in open basins, channels, and similar liquid containing structures: Surfaces will be considered exposed to view if located above the water line as defined in Section 03366 - Concrete Finishes.
      c. Exterior concrete surfaces with portions above and below grade: Surface will be considered exposed to view of located above the grade line as defined in Section 03366 - Concrete Finishes.
   4. Average daily temperature: Calculated by summing hourly measurements of air temperature in the shade at the face of the concrete and dividing that sum by 24. In calculating the sum of the temperatures recorded, any measurement less than 50 degrees Fahrenheit shall be recorded as 0 degrees Fahrenheit and included in the sum.
   5. Cementitious materials: Portland cement and supplementary cementitious materials.
   6. Class of concrete: Refers to a mix with characteristics, proportions, and constituents (including a specific combination of admixtures) as specified in this Section.
      a. Any change in the source or characteristics of constituent materials, in the proportions of materials, or in the admixtures included in a mix shall be considered as creating a new and separate class of concrete.
      b. Any mix to be placed by pumping shall be considered as creating a new and separate class of concrete.
   7. Cold weather: Includes one or more of the following conditions:
      a. Current air temperature is 45 degrees Fahrenheit and falling.
      b. Air temperature during the first 24 hours after placement is expected to fall into the range of 45 degrees Fahrenheit to 40 degrees Fahrenheit.
      c. A period when, for more than 3 consecutive days, the following conditions exist:
         1) The average daily air temperature drops below 40 degrees Fahrenheit.
         2) The air temperature is not greater than 50 degrees Fahrenheit for more than one-half of any consecutive 24-hour period.
   8. Cold weather concreting: Operations for placing, finishing, curing, and protecting concrete during cold weather.

9. Green concrete: Concrete that has not yet achieved 100 percent of the minimum specified compressive strength, f'c, for that mix.
10. Hairline crack: Crack with a crack width of less than 4 thousandths of an inch (0.004 inches).
11. Hot weather: Any combination of ambient temperature, concrete temperature, relative humidity, wind speed, and solar radiation intensity that creates conditions that will evaporate water from a free concrete surface at a rate equal to or greater than 0.2 pounds per square foot per hour as determined by the Menzel Formula and nomograph published in ACI PRC-305 and in this Section, Attachment A - Menzel Formula and Nomograph.
12. Hot weather concreting: Operations for placing, finishing, curing, and protecting concrete during hot weather.
13. Paste content: The total concrete volume minus the volume of aggregate, expressed as a percentage of total volume. Paste volume includes volume of cementitious materials, water, air, admixtures materials, and any fibers.
14. Supplemental cementitious material: Inorganic material such as fly ash, natural pozzolans, silica fume, or slag cement that reacts pozzolanically or hydraulically.

1.04 DELEGATED DESIGN

A. As specified in Section 01357 - Delegated Design Procedures.

B. Concrete mix designs.

1.05 SUBMITTALS

A. General:
   1. Data for concrete mixes and mix constituents supplied to the Work shall be coordinated through a single supplier.
   2. A maximum of 2 mix designs will be reviewed by the Engineer for each class of concrete required.
      a. Review of additional mix designs shall be at the expense of the Contractor.

B. Product data:
   1. Submit data completely describing products and demonstrating compliance with the requirements of this Section.
   2. Data for all products in the mix for each class of concrete shall be submitted concurrently with that mix design.
   3. Where products conforming to NSF 61 are required, submit evidence of testing and listing under NSF 61 for use in direct contact with potable water. Testing and listing shall be by a nationally recognized agency acceptable to the Engineer.
   4. Admixtures:
      a. For each admixture included in concrete mixes, submit manufacturer's product data demonstrating compliance with standards specified.
      b. If air entraining admixture requires test method other than ASTM C173 to accurately determine air content, make special note of requirements in Submittal.
   5. Curing compound: Submit complete data on proposed compound.

C. Delegated Design Submittals:
    1. Concrete mix designs:
        a. Submit full details, including mix design calculations and plots, for concrete mixes proposed for use for each class of concrete.
        b. Include mix design calculations of proportions by both weight and volume.
        c. Determine and include the alkali load of the proposed mix.
        d. Include information on correction of batching for varying moisture contents of fine aggregate.
        e. Submit source quality test records with mix design Submittal.
        f. Provide calculations demonstrating that the mixes proposed provide the required average compression strength of concrete (f'cr) based on source quality test records.
        g. For each Class A mix design submitted, plot the mix design Attachment B - Coarseness Factor Chart and submit.
        h. For each Class A mix design submitted, plot the combined aggregate gradation on the chart Attachment C - Combined Aggregate Gradation Chart and submit.

D. Concrete mixes - Trial batches:
    1. Drying shrinkage test results.
        a. Submit results of testing.
    2. Compression strength test results.
        a. Submit results of testing. Provide data for each cylinder tested.
        b. Submit data indicating trial batch mix designator, slump, and specimen number for each test cylinder.
            1) Using indelible marker, clearly label each cylinder with concrete class, trail batch number, and specimen number.
    3. If there is any change in suppliers or in quality of concrete mix constituents, submit new test data.

E. Test reports:
    1. Dated not more than 24 months prior to the date of Submittal.
    2. Aggregate:
        a. Submit certified copies of commercial laboratory tests proposed for use in concrete.
        b. Sieve analyses:
            1) During construction, submit sieve analyses of coarse, fine, and combined aggregates used any time there is a change in supplier, or a significant change in the character and/or grading of materials, and when requested by the Engineer.
        c. Aggregates - coarse:
            1) Physical properties:
                a) Sieve analysis.
                b) Percentage of particles having flat and/or elongated characteristics.
                c) Abrasion loss.
                d) Soundness.
            2) Deleterious substances:
                a) Clay lumps and friable particles content.
                b) Materials finer than No. 200 sieve (percentage).
                c) Shale and chert content.

d) Coal and lignite content.
3) Alkali reactivity.
4) Deleterious substances:
a) Clay lumps and friable particles content.
b) Chert and shale content.
c) Coal and lignite content.
d) Materials finer than No. 200 sieve.
5) Alkali reactivity.
d. Aggregates - Fine:
1) Physical properties:
a) Sieve analysis and fineness modulus.
b) Soundness.
2) Deleterious substances:
a) Clay lumps and friable particles (percentage).
b) Materials finer than No. 200 sieve (percentage).
c) Coal and lignite (percentage).
d) Shale and chert.
e) Organic impurities (“Color” as determined by ASTM C40).
3) Alkali reactivity.
e. Aggregates - Combined:
1) Test combined gradation for the following sieve sizes: 1.5 inches, 1 inch, 3/4 inch, 1/2 inch, 3/8 inch, No. 4, No. 8, No. 16, No. 30, No. 100, No. 200.
2) Bulk density in accordance with ASTM C29.
3) Void content in accordance with ASTM C29.
4) Submit at:
a) Initial mixture design Submittal.
b) Intervals of not more than 4 weeks.
c) Any time there is a change in character or grading of constituent materials.
d) When requested by the Engineer.

3. Cement:
a. Mill tests, including alkali content measured as equivalent alkalies, for each shipment of cement included in the Work.
1) During construction, submit mill certificates for cement being used at intervals of not more than 90 days, any time there is a change in supplier or a significant change in the character of the materials, and when requested by the Engineer.
4. Supplemental cementitious material:
a. Fly ash: Identify source and provide testing results to demonstrate compliance with requirements of ASTM C618 and this Section.
1) Include the Supplier’s report certifying the total alkali content of the material, expressed as equivalent percentage of sodium oxide (Na_2Oe).

F. Certificates:
1. Current NRMCA certification for all plants and trucks that will be used to supply concrete.

G. Source Quality Control Submittals:
   1. Truck batch tickets for each load of concrete delivered to the Site, whether accepted or rejected.
   2. Concrete supplier's quality control plan. Include the following elements, at a minimum:
      a. Names and qualifications of key quality control personnel:
         1) Quality control manager.
         2) Testing and inspection personnel.
      b. Names and qualifications of testing laboratories:
         1) Each laboratory shall hold current accreditation from the AASHTO Accreditation Program, or other accreditation program acceptable to the Engineer, for each test performed.
      c. Example forms for: Inspection reports, certificates of compliance, and test results.
      d. Quality control procedures: Method and frequency of performing each procedure, including inspections and materials testing. At a minimum, the plan shall include:
         1) Daily testing of aggregate gradation.
         2) Monthly testing of cement quality.
         3) Monthly testing of fly ash quality.
      e. Procedures to control quality characteristics, including standard procedures to address properties outside the specified operating limits, and example reports to document non-conformances and corrective actions taken. Include procedure for notifying the Contractor and Engineer of non-conformances.
      f. Procedures for verifying that:
         1) Materials are properly stored during concrete batching operations.
         2) Batch plants have the ability to maintain concrete consistency during periods of extreme heat and of low temperatures.
         3) Admixtures are dispensed in the correct dosages within the accuracy requirements specified.
         4) Delivery trucks have a valid NRMCA certification card.
      g. Procedures for verifying that weighmaster certificate for each load of concrete shows:
         1) Cement and supplementary materials are from sources designated in the approved Submittals.
         2) Concrete as-batched complies with the constituent weights designated in the approved Submittals.
         3) Corrections for aggregate moisture are being correctly applied.
         4) Any mix water withheld from the batch.
      h. Procedures for visually inspecting concrete during discharge.

H. Field Quality Control Submittals:
   1. Contractor's notifications of readiness for concrete placement.
   2. Contractor's reports of field quality control testing.
      a. Include with each report the concrete batch ticket number and identification numbers for associated cylinders used for compressive strength testing.
      b. Testing results for slump, temperature, unit weight, and air entrainment.
      c. Testing results for compressive strength at 7 and 28 days, and for any compressive strength tests after 28 days.

d. Note on batch ticket the amount of water that was withheld and the maximum amount that can be added on site as “Max add water.” Record on the batch ticket the volume of water actually added at the Site.
e. Note on the batch ticket the concrete mix classification as defined in Table 3 of this Section.

I. Special procedure Submittals:
1. Sequence of concrete placing:
a. Submit proposed sequence of placing concrete showing proposed beginning and ending of individual placements. Submittal shall include plans sections and details to address all pours.
2. Cold weather concreting plan.
3. Hot weather concreting plan.
4. Repair of defective concrete: Submit mix design for repair materials to be used.

1.06 QUALITY ASSURANCE

A. Pre-installation meetings:
1. Schedule and conduct pre-installation meeting at least 10 days prior to batching and placing of concrete.
a. Provide additional meetings if necessary, to discuss specific concrete Submittals, mixes, or placing and curing conditions.
b. Notify the Engineer of location and time of each conference.
2. Required attendees:
a. Contractor, including Contractor’s superintendent and key personnel.
b. Concrete supplier.
c. Technical representative(s) of supplier(s) of concrete admixtures.
d. Subcontractor(s) providing pumping, placing, finishing, and curing.
e. Subcontractor(s) providing embedded items (structural embedded plates, electrical conduit).
f. Sampling and testing personnel.
g. Engineer.
h. On-site inspectors representing the Engineer.
i. Other persons deemed by the Engineer and the Contractor to be critical to the quality and efficiency of the Work.
3. Agenda:
a. Review of requirements of Drawings and Specifications.
b. Project and product safety requirements.
c. Discussion of points of interface and coordination between various trades or products to be used in the Work.
d. Contractor’s schedule for cast-in-place concrete work.
e. Mix designs, mix tests, and Submittals.
f. Admixture types, dosing, performance, requirements for monitoring, and limits on dosing or re-dosing at the Site.
g. Placement and consolidation methods, techniques, and equipment and the effects of those methods on form pressures.
h. Slump and limits on placing time or conditions to maintain placeability.
1) Field adjustment of slump and air content.
i. Procedures for finishing, curing, and retention of moisture during these operations.
j. Procedures and protection for hot and cold weather conditions.

k. Requirements and coordination for inspections.
    1) Responsibility for test specimen curing and storage.
    2) Distribution of test reports.
l. Other Specification requirements requiring coordination between parties to the Work.

4. Prepare and submit minutes of the pre-installation meeting as specified in Section 01312 - Project Meetings.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Packing and shipping:
1. Deliver, store, and handle concrete materials in a manner that prevents damage and inclusion of foreign substances.
2. Deliver and store packaged materials in original containers until ready for use.
3. Deliver aggregate to mixing site and handle in such manner that variations in moisture content will not interfere with steady production of concrete of specified degree of uniformity and slump.

B. Acceptance at Site:
1. Reject material containers or materials showing evidence of water or other damage.
2. Concrete mixes: Do not accept or incorporate into the Work concrete mixes that do not comply with the specified requirements for water content, slump, temperature, and air content.

1.08 PROJECT CONDITIONS

A. Cold weather concreting: During periods of cold weather as defined in this Section, implement cold weather concreting procedures in this Section.

B. Hot weather concreting: During periods of hot weather as defined in this Section, implement hot weather concreting procedures in this Section.

1.09 SEQUENCING AND SCHEDULING

A. Schedule placing of concrete in a manner that completes all placing operations from one construction, contraction, or expansion joint to another construction, contraction, or expansion joint.

B. Joints at each end of the placement shall be as indicated on the Drawings, or as identified and accepted in advance by the Engineer.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

A. Provide concrete with a homogeneous mixture, that, when hardened, will have required strength, watertightness, and durability.

B. Provide a workable, low-shrinkage concrete mix that maximizes aggregate content and minimizes paste content.

C. Performance requirements:
   1. General:
      a. Except as otherwise specified, provide concrete composed of Portland cement, supplemental cementitious materials, aggregate, admixtures and water, proportioned and mixed to produce a plastic, workable mixture in accordance with requirements of this Section, and suitable to specific conditions of placement.
      b. Proportion aggregates to produce a gradation of aggregate that combines fine and coarse aggregate in well-graded proportions that maximizes the aggregate content and minimizes the paste content of the mix. Gradation should maximize long-term durability and strength of the concrete mixture.
      c. Durability requirements will be deemed to be satisfied when:
         1) Mixture is proportioned with a well-graded combined aggregate.
         2) Specified water-cement ratio is satisfied.
         3) Concrete contains the specified range of air content.
         4) Maximum specified paste content is satisfied.
      d. Proportion materials in a manner that will secure the lowest cement content, water-cementitious materials ratio, and paste volume that is consistent with good workability that provides a plastic and cohesive mixture, and that provides a slump that is within the specified range.
      e. Construction and expansion joints have been positioned in structures as indicated on the Drawings, and curing methods have been specified, for purpose of to reduce the number and size of cracks, resulting from normal expansion and contraction expected from the concrete mixes specified.
      f. Remove and replace, or repair as specified in this Section, non-conforming work and surfaces with cracks, voids and honeycombs, or surface wetness.
   2. Workmanship and methods: Provide concrete work, including detailing of reinforcing, conforming with best standard practices and as set forth in ACI CODE-318, and ACI CODE-350.

2.02 MATERIALS - GENERAL

A. Water and ice:
   1. Water for concrete mixes, for washing aggregate, and for curing concrete: Clean and free from oil and deleterious amounts of alkali, acid, organic matter, or other substances from a municipal potable water source.
   2. Do not use water from concrete production operations, or combined water from concrete production operations as defined in ASTM C1602.

2.03 MATERIALS - CONCRETE MIX CONSTITUENTS

A. Water and ice:
   1. As specified in the preceding paragraphs.

B. Cementitious materials:
   1. Portland cement:
      a. In accordance with ASTM C150.
         1) Type II.

b. In accordance with ASTM C595.
    1) Type IL.
c. Single source: To provide uniformity of appearance, for each structure use only one source, type, and brand of Portland cement for walls and slabs that will be exposed in the finished Work.
    1) Confirm adequate supply of cement over duration of the Project before making trial batches or beginning concrete placements.
d. Cement for finishing: Provide cement from the same source and of the same type as concrete to be finished or repaired.

C. Supplementary cementitious materials:
1. Fly ash:
    a. Class C or Class F fly ash in accordance with the requirements of ASTM C618, except as modified in this Section.
        1) Class C may be used in concrete made with Type II Portland cement.
        2) Class F required if used in concrete mixes containing aggregates classified as potentially reactive based on ASTM C1293 or ASTM C1260.
            a) CaO content: Less than 18 percent.
    b. Loss on ignition: Not exceeding 3 percent.
    c. Replace Portland cement at ratio of 1.0 pound fly ash for each pound of cement, up to minimum and maximum replacement as specified in Requirements for mix proportioning.

D. Admixtures:
1. General:
    a. Do not include admixtures, other than those specified, unless written acceptance has been obtained from the Engineer during Submittal of mix designs.
    b. Compatible with concrete constituents and with other admixtures.
        1) All admixtures in a given mix shall be products of the same manufacturer to ensure compatibility.
        2) Manufacturers: One of the following or equal.
            a) Euclid Chemical.
            b) GCP Applied Technologies (formerly W.R. Grace).
            c) Master Builders Solutions/Sika.
            d) Sika Corp.
    c. Do not use admixtures containing chlorides, calculated as chloride ion, in excess of 0.5 percent by weight of cement.
    d. Use in accordance with manufacturer’s recommendations. Add each admixture to concrete mix separately.
    e. Admixtures used shall be the same products used in concrete trial batches, or the same products used in concrete represented by submitted field test records.
2. Air entraining admixture (AEA):
    a. In accordance with ASTM C260 and dosed to provide entrained air percentages specified in this Section.
    b. Provides entrained air as bubbles, evenly dispersed at the time of placement and during curing.
3. Water reducing admixture (WRA):
    a. May be used at the Contractor’s option.

b. In accordance with ASTM C494, Type A (water-reducing).
    1) ASTM C494, Type D (water-reducing and retarding) may be used during periods of hot weather with prior acceptance by the Engineer.
c. Not containing air-entraining agents.
d. Liquid form before adding to the concrete mix.

1. High-range water-reducing admixture (superplasticizer) (HRWR):
    a. In accordance with ASTM C494, Type F (high-range, water-reducing).
        1) ASTM C494, Type G (high-range, water-reducing and retarding) may be used during periods of hot weather with prior acceptance by the Engineer.
        2) [Polycarboxylate based.]
    b. Producing non-segregating, plasticized concrete with little bleeding and the physical characteristics of low water/cement ratio concrete.
    c. Admixture shall maintain treated concrete in a plasticized state for not less than 1 hour.
2. Shrinkage reducing admixture (SRA):
    a. May be used at the Contractor's option.
        1) Provide shrinkage reducing admixture in sufficient dosage so as to produce shrinkage within the limits specified.
    b. Not containing expansive agents.
    c. In accordance with ASTM C494, Type S (specific performance).
    d. One of the following or equal:
        1) Euclid Chemical: Eucon SRA Series.
        2) GCP Applied Technologies: Eclipse Series.
        3) Master Builders Solutions/Sika: SRA Series.
3. Set-controlling admixtures:
    a. Shall not be used without prior acceptance from the Engineer.
    b. Retarders: not permitted.
    c. Accelerating admixtures: Not permitted.

E. Coloring admixtures:
    1. Conduit encasement coloring agent:
        a. Red color concrete used for encasement of electrical ducts, conduits, and similar type items.
        b. Manufacturers: One of the following or equal:
            1) Davis Co., #100 Utility Red.
            2) Euclid Chemical Co., Increte Division, Colorcrete Brick Red.
            3) I. Reiss Co., Inc., equivalent product.
        c. Conduit encasement concrete: Mix into each cubic yard of concrete 10 pounds of coloring agent.

F. Aggregate:
    1. General:
        a. Provide concrete aggregates that are sound, graded as specified, and free of deleterious material in excess of allowable amounts specified.
        b. Provide aggregates to produce in place concrete with unit weight as follows:
            1) Normal weight concrete: Not less than 140 pounds per cubic foot.
        c. Do not use aggregate made from recycled materials such as crushed and screened hydraulic-cement concrete, brick, and other construction materials.

d. Do not use aggregate recycled from fresh concrete returned to the batching facility.

2. Alkali-silica reactivity:
   a. Provide aggregate classified as aggregate-reactivity class of R0 in accordance with ASTM C1778 with expansion not greater than 0.10 percent at 14 days when tested in accordance with ASTM C1260, and not greater than 0.04 percent at 1 year when tested in accordance with ASTM C1293.
   b. Aggregates classified as potentially reactive based on the preceding tests may be permitted, at the discretion of the Engineer, if the following condition is satisfied:
      1) ASTM C1567: Testing with the reactive aggregate, cement, and supplemental cementitious materials demonstrate that expansion is less than 0.10 percent at 14 days. Include ASTM C1260 and ASTM C1293 test results to demonstrate that mitigation of alkali-silica reaction by ASTM C1567 is suitable. See Figure 3 of ASTM C1778 for reactivity of aggregates where ASTM C1567 testing is not recommended.
3. Fine aggregate:
   a. Material graded such that 95 to 100 percent of material passes the No. 4 (4.75 mm) sieve, when sampled in accordance with ASTM D75 and ASTM D3665, and tested in accordance with ASTM C136.
   b. Provide fine aggregate consisting of clean, natural sand, or sand prepared from crushed stone or crushed gravel.
   c. In accordance with ASTM C33 requirements for grading, deleterious substances, soundness, and alkali reactivity, except as modified in the following paragraphs:
      1) Grading: For sieve sizes listed in ASTM C33 for fine aggregate, not more than 45 percent passing any sieve and retained on the next consecutive sieve.
      2) Deleterious substances: Not in excess of the percentages by weight specified in Table 1 of this Section.

Table 1. Fine Aggregate, Limits on Deleterious Substances

Item	Test Method	Percent (maximum)
Materials finer than No. 200 sieve(2)	ASTM C117	3.00(2)
Clay lumps and friable particles	ASTM C142	1.00
Lightweight particles (SG < 2.40)	ASTM C123	1.00
Chert or shale(1)	ASTM C295	1.00(1)
Coal and lignite	ASTM C123	0.50

Notes:

(1) ASTM C123 tests for particles in the sample having a specific gravity less than 2.40. ASTM C295 is used to identify which of those lightweight particles are chert, shale, or coal and lignite. If testing under ASTM C123 indicates a combined percentage of lightweight particles (sum of shale, chert, coal and lignite) not greater than 1.00, testing under ASTM C295 will not be required.

(2) For manufactured sand, if material finer than the No. 200 sieve consists of crusher dust and the aggregate is essentially free of clay or shale, maximum percentage may be increased to 5.0 percent.

3) Organic impurities: Free of injurious amounts of organic matter and producing a supernatant liquid with color not darker than “standard color” when tested in accordance with ASTM C40.
4) Soundness: In accordance with requirements of ASTM C33 when tested in accordance with ASTM C88 using sodium sulfite solution.

4. Coarse aggregate:
   a. Materials graded such that not more than 10 percent of material passes the 3/8-inch sieve, when sampled in accordance with ASTM D75 and ASTM D3665 and tested in accordance with ASTM C136.
   b. Consisting of gravel, crushed gravel, crushed stone, or a combination of these materials having clean, hard, durable particles free from calcareous coatings, organic matter, or other deleterious substances.
   c. Conforming to the requirements of ASTM C33, Class 4S for physical properties, deleterious substances, and alkali reactivity, except as modified in the following paragraphs:
      1) Grading:
         a) Size number as specified in ASTM C33, and as indicated in Table 3 of this Section, except as otherwise specified or accepted by the Engineer.
         b) Weights of flat or elongated particles (particles having a length greater than 3 times average width or thickness) not exceeding 15 percent when tested in accordance with ASTM D4791.
      2) Deleterious substances: Not in excess of the percentages by weight specified in Table 2 of this Section and having total of all deleterious substances exceeding 2 percent.

Table 2. Coarse Aggregate, Limits on Impurities

Item	Test Method	Percent (maximum)
Clay lumps and friable particles	ASTM C142	0.50
Lightweight particles (SG < 2.40)	ASTM C123	1.25
Chert or shale(1)	ASTM C295	1.00(1)
Materials finer than No. 200 sieve	ASTM C117	0.50(2)
Coal and lignite	ASTM C123	0.25

Notes:
(1) ASTM C123 tests for particles in the sample having a specific gravity less than 2.40. ASTM C295 is used to identify which of those lightweight particles are chert, shale, or coal and lignite. If testing under ASTM C123 indicates a combined percentage (sum of shale, chert, coal and lignite) not greater than 1.25, testing under ASTM C295 will not be required.
(2) When material finer than No. 200 sieve consists of crusher dust, maximum percentage may be increased to 1.00 percent. When mix design complies with provisions of ASTM C33, Table 4, footnote C, the maximum percentage may be increased in accordance with the equation in footnote C, up to a maximum of 1.5 percent.

3) Abrasion loss: Loss not greater than 45 percent after 500 revolutions when tested in accordance with ASTM C131.
4) Soundness: Loss not greater than 10 percent when tested in accordance with ASTM C88 using sodium sulfate solution.

2.04 MATERIALS FOR PLACING, CURING AND FINISHING

A. General:

1. Materials shall be compatible with concrete and with other materials.
2. Materials for placing, curing and finishing concrete that will be in contact with potable water:
    a. Non-toxic and shall not impart taste or odor to the water.
    b. Listed under NSF 61 for use in contact with potable water.

B. Cement grout:
1. Use: For spreading over surface of construction and cold joints in concrete before placing additional concrete above those joints.
2. As specified in Section 03600 - Grouting.

C. Concrete sealer:
1. As specified in Section 03366 - Concrete Finishes.
2. Not for use in water-containment structures.

D. Evaporation retardant:
1. Tested and listed under NSF 61 for use direct contact with potable water.
2. Use: For mitigating surface moisture evaporation from freshly placed concrete during rapid drying conditions. Placed after screeding.
3. Waterborne, monomolecular, spray-applied compound, with fugitive dye to indicate coverage.
4. Manufacturers: One of the following or equal:
    a. Euclid Chemical Co., Eucobar.
    b. Master Builders Solutions/Sika, MasterKure ER 50.

E. Nonslip abrasive:
1. Aluminum oxide abrasive size 8/16, having structure of hard aggregate that is, homogenous, nonglazing, rustproof, and unaffected by freezing, moisture, or cleaning compounds.
2. Manufacturers: One of the following or equal:
    a. Abrasive Materials, Inc.
    b. Exolon Co.

F. Plastic membrane for curing:
1. Polyethylene film: In accordance with ASTM C171.
2. Properties:
    a. Color: White.
    b. Thickness: Nominal thickness of polyethylene film shall not be less than 0.0040 inches when measured in accordance with ASTM D2103. Thickness of polyethylene film at any point shall not be less than 0.0030 inches.
    c. Loss of moisture: Not exceeding 0.055 grams per square centimeter of surface when tested in accordance with ASTM C156.

G. Sprayed membrane curing compound:
1. Tested and listed under NSF 61 for use direct contact with potable water.
2. Combination curing and sealing products (cure and seal) will not be permitted.
3. Properties:
    a. Clear type with fugitive dye conforming with ASTM C309, Type 1D and containing no wax, paraffin, or oils.

b. For concrete placed or cured during hot weather, curing compound shall be as specified, except that:
   1) It shall include a white, reflective fugitive dye.
   2) Moisture loss during a 72-hour period shall not exceed 0.55 kg/square meter when tested in accordance with ASTM C156.

H. Surface-applied crystalline coating:
   1. Tested and listed under NSF 61 for use direct contact with potable water.
   2. Manufacturers: One of the following or equal:
      a. Euclid Chemical Co., Vandex Super.
      b. Kryton International, Inc., Krystol T1.
      c. Xypex Chemical Corp., Xypex Concentrate.
   3. Where surface-applied crystalline coating is placed over concrete containing permeability reducing admixture for concrete exposed to hydrostatic conditions (PRAH), provide products of same manufacturer providing the admixture.

2.05 EQUIPMENT

A. General:
   1. Provide adequate equipment and facilities for accurate measurement and control of materials and for readily changing proportions of material into mixers.

B. Batching equipment, or batch plant.
   1. Capable of controlling delivery of all material to mixer within 1 percent by weight of individual material.

C. Mixing equipment:
   1. Mixers may be of stationary plant, paver, or truck mixer type, as appropriate to the Work.
   2. Capable of combining aggregates, water, and cementitious materials, and admixtures within specified time into a thoroughly mixed and uniform mass, and of discharging the mixture without segregation.
      a. Maintain concrete mixing equipment in good working order, and operate at loads, speeds, and timing recommended by manufacturer or as specified.
      b. Proportion cementitious materials and aggregate by weight.
   3. If bulk cementitious materials are used, weigh them on separate visible scale which will accurately register scale load at any stage of weighing operation from zero to full capacity.
   4. Prevent cementitious materials from coming into contact with aggregate or with water until materials are in mixer ready for complete mixing with all mixing water.
   5. Procedure of mixing cementitious materials with sand or with sand and coarse aggregate for delivery to the Project Site, for final mixing and addition of mixing water will not be permitted.
   6. Retempering of concrete will not be permitted.
   7. Discharge entire batch before recharging.
   8. Volume of mixed material per batch: Not to exceed manufacturer’s rated capacity of mixer.
   9. Equip each mixer with device for accurately measuring and indicating quantity of water entering concrete, and operating mechanism such that leakage will not occur when valves are closed.

10. Equip each mixer with device for automatically measuring, indicating, and controlling time required for mixing:
    a. Interlock device to prevent discharge of concrete from mixer before expiration of mixing period.
11. Transit-mixed concrete:
    a. Mix and deliver in accordance with ASTM C94.
    b. Total elapsed time between addition of water at batch plant and discharging completed mix.
    c. Not to exceed 90 minutes.
    d. Elapsed time at the Project Site shall not exceed 30 minutes.
    e. Under conditions contributing to quick setting, total elapsed time permitted may be reduced by the Engineer.
    f. Equip each truck mixer with device interlocked to prevent discharge of concrete from drum before required number of turns and furnish device that is capable of counting number of revolutions of drum.
12. Continuously revolve drum after it is once started until it has completely discharged its batch:
    a. Do not add water until drum has started revolving.
    b. Right is reserved to increase required minimum number of revolutions or to decrease designated maximum number of revolutions allowed, if necessary, to obtain satisfactory mixing. Contractor will not be entitled to additional compensation because of such increase or decrease.

D. Other types of mixers: For other types of mixers, mixing shall be as follows:
    1. Mix concrete until there is uniform distribution of materials, and discharge mixer completely before recharging.
    2. Neither speed nor volume loading of mixer shall exceed manufacturer's recommendations.
    3. Continue mixing for minimum of 1-1/2 minutes after all materials are in drum, and for batches larger than 1 cubic yard increase minimum mixing time 15 seconds for each additional cubic yard or fraction thereof.

2.06 CONCRETE MIXES

A. General:
    1. Develop and provide mix designs for each concrete class listed in Table 3 of this Section.
    2. Select and proportion mixes and document properties using one of the 2 methods that follow. Procedures and requirements for use of each alternative are specified in subsequent paragraphs of this Section.
        a. Field experience method.
        b. Trial batch method.
    3. Organize and submit mix designs with data on all constituent materials and products for that mix for the Engineer's review.
    4. Do not place concrete until the mix design for that concrete class has been accepted by the Engineer.
    5. After acceptance, do not modify accepted mixes or provide new mixes without the Engineer's prior review and acceptance of the proposed alternative.
        a. Exception: At all times, adjust batching of water to compensate for free moisture content of the fine aggregate used.

b. For any change to approved mixes, the Engineer may require new trial batching and testing program as specified in this Section before acceptance and use.
c. For any change to approved mixes, make modifications within limits set forth in this Section.
d. If there is change in source or quality of any constituent of the concrete class or mix, the revised mix will be considered a new class of concrete and shall require full re-submittal of all data describing mix constituents, design, and testing.

6. Material sampling, mix designs, trial batch preparation and testing, modifications to mix designs, and any re-testing required to satisfy the requirements of this Section or to obtain satisfactory performance shall be at the Contractor's expense and shall not be considered cause for delay.

B. Measurements of materials:
1. Measure materials by weighing, except as otherwise specified or where other methods are specifically authorized in writing by the Engineer.
2. Furnish apparatus for weighing aggregates and cementitious materials that is suitably designed and constructed for this purpose.
3. Accuracy of weighing devices: Furnish devices that have capability of providing successive quantities of individual material that can be measured to within 1 percent of desired amount of that material.
4. Measuring or weighing devices: Subject to review by the Engineer. Shall bear valid seal of the Sealer of Weights and Measures having jurisdiction.
5. Weighing cementitious materials:
a. Weigh cementitious materials separately.
b. Cement in unbroken standard packages (sacks): Need not be weighed.
c. Weigh bulk cementitious materials and fractional packages.
6. Measure mixing water by volume or by weight.

C. Requirements for mix proportioning:
1. Develop and provide mixes that:
a. Can be readily worked into corners and angles of forms and around reinforcement, without excessive vibration, and without permitting materials to segregate or free water to collect on surface.
b. Prevent unnecessary or haphazard changes in the consistency of the concrete supplied.
2. Constituent materials:
a. Provide concrete mixes composed of Portland cement, blended aggregates, admixtures and water.
1) Admixtures required for each concrete class are indicated in Table 3 of this Section. Admixtures not specifically required by that table for a specific concrete class are optional and may be included at the discretion of the Contractor based on the Contractor's planned means and methods of construction.
b. In no case shall returned fresh concrete or its constituents be incorporated into concrete batched for the Work.
3. Minimum specified compressive strength:
a. Minimum specified compressive strength is designated at 28 days, unless otherwise indicated in Table 3 of this Section.

b. For locations where the placed concrete is adequately protected and is not subjected to loads for an extended period during construction, the Contractor may request that the period for achieving the minimum specified compressive strength be extended to 56 days.
    1) If accepted by the Engineer, provide mixes that achieve at least 75 percent of their minimum specified compressive strength after 28 days.

4. Proportions and consistency:
    a. Ratio of water to cementitious materials, and cementitious materials content:
        1) Conform to maximum and minimum cementitious material content requirements specified in Table 3 of this Section.
        2) Cementitious materials content: Consisting of Portland cement as indicated in Table 3 of this Section, plus supplemental cementitious materials if aggregate testing indicates potentially reactive aggregates:
            a) Fly ash content:
                (1) Minimum: 15 percent of the total weight of cementitious materials.
                (2) Maximum: 25 percent of the total weight of cementitious materials.
    b. Aggregate size and content:
        1) Blend aggregates to produce an optimized gradation that combines well-graded coarse, intermediate, and fine aggregates in proportions that maximize the aggregate content of the mix, and that minimize the cement paste content of the mix.
            a) Percentage of individual fractions of the combined aggregate gradation retained on individual sieve sizes: Within the range shown in Attachment C - Combined Aggregate Gradation Chart (Tarantula Curve).
            b) Sum of the percentages of individual fractions retained on the No. 8, No. 16, and No. 30 sieves: Greater than 20 percent.
            c) Sum of the percentages of individual fractions retained on the No. 30, No. 50, No. 100, and No. 200 sieves: Within the range of 25 percent to 40 percent.
    c. Determine bulk density and void content of the combined gradation of aggregates in accordance with ASTM C29. Results for combined aggregates shall not be the summation of results of testing of the individual gradations.
        1) Sample the combined aggregate from a flowing aggregate stream or conveyor in accordance with ASTM D75. Take care to ensure that the sample is representative of the proportions of the combined aggregate of the proposed mix.
        2) Reduce sample of combined aggregate to test sample size in accordance with ASTM C702, Method A - mechanical splitter or Method B - quartering.
        3) Perform bulk density test of combined aggregate in accordance with ASTM C29, Procedure A - rodding.

4) Determine void content of the combined aggregate in accordance with ASTM C29, Procedure A - rodding. Specific gravity of the combined aggregate shall be determined in accordance with ASTM C136.

d. Paste content: Limited to the following:
   1) Class A mixes without air entrainment: Maximum 28 percent measured by volume.
   2) Class A mixes with air entrainment: Maximum 28 percent measured by volume plus the target air content.
   3) Paste content shall be limited to 200 percent of the void content of the combined aggregate gradation determined by ASTM C29.

e. Total water content:
   1) Not exceeding the water to cementitious material ratio specified in Table 3 of this Section.
   2) Not exceeding 245 pounds of water per cubic yard of concrete for Class A mix.

f. Coarseness/workability (Shilstone Method):
   1) Proportion mixes to fall into the “Optimal” zone (Zone II) when plotted on the Coarseness Factor Chart (“Coarseness Factor” versus “Workability Factor”) included as Attachment B - Coarseness Factor Chart to this Section. Provide plot for each Class A mix to be used in the Work.
   2) Coarseness factor (CF) for each mix shall be calculated as the percent of the combined aggregate gradation retained on the 3/8-inch sieve, divided by the percent of the combined aggregate gradation retained on the No. 8 sieve, multiplied by 100, or:

$$CF = \frac{(\%\ \text{retained on 3/8-in sieve})}{(\%\ \text{retained on No. 8 sieve})} \times 100$$

   3) Workability factor (WF) for each mix shall be the percent of the combined aggregate gradation retained on the No. 8 sieve, adjusted for cement content in the mix.
      a) Determine volume of total cementitious material in the mix.
      b) For each 94 pounds of cement content above 564 pounds per cubic yard, increase workability factor by 2.5 units.
      c) For each 94 pounds of cement below 564 pounds per cubic yard, decrease workability factor by 2.5 units.
      d) Proportion adjustment factor by linear interpolation for each fraction of 94 pounds above or below the 564 pound basis.
      e) Example:
         650 pounds per cubic yard = 564 pounds + 86 pounds.
         Adjustment = (86 lb / 94 lb) x 2.5 = + 2.28.

D. Concrete classes for use in the Work:
   1. Provide concrete classes listed in Table 3 of this Section.
   2. Provide normal weight concrete, having minimum weight of 140 pounds per cubic foot, unless otherwise noted.
   3. Pumped concrete:
      a. Provide pumped concrete that complies with all requirements of this Section.

b. Mixes placed by pumping shall be considered a sub class of each concrete class listed in Table 3 of this Section. Prepare and submit a separate mix design for each mix to be placed by pumping.

4. Class PM concrete: In addition to the requirements of Table 3 of this Section, conform to the following:
   a. Minimum 28 day flexural strength: 650 psi when tested in accordance with ASTM C293.
   b. Cementitious materials content: 75 percent Portland cement plus 25 percent Class F fly ash (by weight).
   c. Aggregate:
      1) Minimum 55 percent coarse aggregate conforming to ASTM C33 size number 357 or size number 467.
      2) Substitute ASTM C33 size number 57, or size number 67 if mechanical paving equipment is not used.

Table 3. Concrete Classes

Concrete Class[1]	Minimum Specified Compressive Strength at 28 days, f'c [2] (pounds per square inch)	Ratio of water to cementitious materials[3] (minimum - maximum)	Cementitious Materials Content (pounds per cubic yard of concrete by weight)[4]	Cement Type	Maximum Chloride Content (percent by weight of cement)	Maximum Size of Coarse Aggregate (ASTM C33)	Air Entrainment (percent), (n/a: not applicable)	Admixtures required[4,5,6]	Slump Range (inches)
A	4,000	0.40 to 0.42	535 to 575	ASTM C150, Type II(MH)	0.15	#57	n/a	WRA	2 to 4
C	2,500	0.62 max.	423 min.	ASTM C150, Type II(MH)	No limit	#57	n/a	AEA WRA	3 to 6
CE	3,000	0.62 max.	423 min.	ASTM C150, Type II(MH)	No limit	#8	n/a	AEA WRA	3 to 6
PM	5,000	0.40	535 to 575	ASTM C150, Type II(MH)	0.15	#57	n/a	AEA WRA	3 to 6

Notes:

(1) Sub classes within major concrete classes are designated as follows:
NA: Without air entrainment.

(2) At locations where concrete will not be subjected to load from other elements of the structure or from the Contractor's placing and/or backfilling operations, maximum time period for achievement of specified compressive strength may be extended to 56 days when accepted by the Engineer.

(3) W/C Ratio = Ratio of water to cementitious materials by weight. Include weight of admixtures in the water content of the mix when the quantity of the admixtures exceeds 10 ounces per 100 pounds of cement.

(4) Cementitious material includes Portland cement plus supplemental cementitious materials. If trial batch testing demonstrates that the required strength cannot be met at 28 or 56 days with the specified combined aggregate gradation and the paste content limits, cementitious material content may be increased with the Engineer's approval if Class M concrete is provided and Thermal Control Plan and Temperature Monitoring Program in accordance with Section 03703 - Thermal Control of Concrete is provided for cast-in-place concrete elements. Cement content and/or threshold for the thermal control

Table 3. Concrete Classes									
Concrete Class[1]	Minimum Specified Compressive Strength at 28 days, f'c [2] (pounds per square inch)	Ratio of water to cementitious materials[3] (minimum - maximum)	Cementitious Materials Content (pounds per cubic yard of concrete by weight)[4]	Cement Type	Maximum Chloride Content (percent by weight of cement)	Maximum Size of Coarse Aggregate (ASTM C33)	Air Entrainment (percent), (n/a: not applicable)	Admixtures required[4,5,6]	Slump Range (inches)
requirement may be adjusted by the Engineer based on the Equivalent Cement Content (ECC) of the approved Class M concrete mix.									
(5) Admixtures are designated as follows: AEA: Air entraining admixture. HRWR: High-range water-reducing admixture. PRAH: Permeability-reducing admixture for concrete exposed to hydrostatic conditions. SFR: Synthetic fiber reinforcement. SRA: Shrinkage-reducing admixture. WRA: Water-reducing admixture.									
(6) At the Contractor's option, each concrete class may include a high-range water reducing admixture (HRWR). Designate such mixes as the "class" specified followed by "SP" (e.g., A-SP, A-NA-SP, P-SP, etc.). Submit as separate mixes for review. Slump range after addition of HRWR: 4 to 6 inches.									

E. Install concrete classes in accordance with the following requirements, unless otherwise indicated on the Drawings.
   1. Class A concrete: Structural concrete.
      a. Use at all locations unless other Classes are specified or indicated on the Drawings.
   2. Class C concrete: Miscellaneous concrete fill and encasement.
      a. May be used for fill for unauthorized excavation, for thrust blocks and ground anchors for piping, for bedding of pipe, and where indicated on the Drawings.
   3. Class CE concrete: Use for electrical conduit encasements.
   4. Class PM concrete: Use for concrete pavement, cart paths, curbs, gutters, and sidewalks.

F. Concrete mix design documented by field experience:
   1. Mix design:
      a. Prepare preliminary mix design for each concrete class. Submit mix design with product and testing data for materials to be used in the mix for the Engineer's review.
   2. Historical records for similar mix.
      a. Determinations of similarity of materials and proportions between historical and proposed mixes shall be by the Engineer, and that shall be final.
      b. Historical record - Materials:

1) Submit with each mix design the following data for a previously-supplied concrete mix similar to that proposed for this Work.
2) Records demonstrating that the previously supplied mix included similar materials and proportions as those of the proposed mix.
    a) Documentation that the same concrete supplier will provide both mixes.
    b) Documentation that the materials used was from the same suppliers and had essentially the same properties, demonstrated by test data, as those proposed.
    c) Documentation that proportions of materials in the record mix are essentially the same as those proposed and that the specified compressive strength of the record mix is within 1,000 pounds per square inch of that required by this Section.
    d) Concrete supplier's statement describing any changes made to production of the record mix during the time period reported.
    e) Concrete supplier's statement that preparation and quality control procedures for the record mix were essentially the same as those to be employed for this Work.

c. Historical record - Testing:
1) Submit with each record mix, corresponding test data for slump, compressive strength (with relationships for rate of strength gain between testing ages), and drying shrinkage.
2) Only records satisfying the following requirements will be accepted.
    a) All tests were conducted within a period of 1 year preceding the date of the Submittal.
    b) All tests were conducted over a period including not less than 45 days.
    c) Record of compressive strength testing includes at least 30 tests for slump and 28-day compressive strength.
    d) Record of compressive strength tests is consecutive. In other words, it includes all tests conducted on the subject mix within the 1-year time period described above (not just selected tests during that period).
    e) Submit concrete supplier's sworn statement confirming that all tests for the record mix have been reported.
    f) Tests for drying shrinkage are described in subsequent paragraphs of this Section for "concrete mix design documented by trial batch preparation and testing".
    g) Provide supplementary testing if requested by the Engineer.

d. For mixes determined to be similar and to have an acceptable test history, acceptance criteria shall be as follows:
1) Acceptance criteria:
    a) Slump: All tests within limits specified for record mix.
    b) Compressive strength: Average compression strength for tests, as determined by ACI CODE-350 not less than minimum required average strength.
    c) Drying shrinkage: Within limits stated in subsequent paragraphs of this Section for "concrete mix design documented by trial batch preparation and testing".

G. Concrete mix design documented by trial batch preparation and testing:

1. Mix design and trial batches:
    a. Prepare preliminary mix design for each concrete class. Submit mix design with product and testing data for each combination of materials and proportions to be used for the Engineer's review.
        1) Determine water content of the mix based on curves showing the relation between water-cementitious materials ratio and the 7- and 28-day compressive strength of the concrete.
        2) Determine each curve using 4 or more points, each representing the average compressive strength value of at least 3 specimens tested at each age.
    b. After materials and proposed mix designs have been accepted by the Engineer, have trial batches for each concrete mix design prepared by the Contractor's testing laboratory.
        1) Prepare trial batches using the cementitious materials, aggregates, and admixtures proposed to be used for the Work.
        2) Provide batches of sufficient quantity to determine slump, workability, consistency, and finishing characteristics, and to provide sufficient specimens for testing.
    c. For each trial batch, make and test specimens to determine and report slump, compressive strength (with relationships for rate of strength gain between testing ages), and drying shrinkage.
        1) If trial batches do not produce concrete conforming to the specified requirements for slump, strength, workability, consistency, drying shrinkage, restrained shrinkage, and finishing, change mix proportions and, if necessary, sources of materials.
        2) Make additional trial batches and perform additional tests until a batch that conforms to requirements of this Section is produced.
2. Testing - Slump:
    a. Determine slump in accordance with ASTM C143.
    b. Acceptance criterion: Slump within range specified.
3. Testing - Compressive strength:
    a. Prepare 4-inch diameter by 8-inch long cylinders in accordance with ASTM C31 for tests specified in this Section.
    b. Determine average compressive strength:
        1) Test at least 12 cylinders from each trial batch for compressive strength in accordance with ASTM C39.
        2) Test 4 cylinders at 7 days, another 4 at 28 days, and another 3 at 56 days.
        3) Calculate average compression strength for 7-day tests, for 28-day tests, and for 56-day tests.
        4) Calculate ratios for:
            a) Average 7 day strength to average 28 day strength.
            b) Average 28 day strength to average 56 day strength.
    c. Determine the required average compressive strength for each mix, f'cr, as described in the following paragraphs:
        1) Calculate required average compressive strength (f'cr) based on the minimum specified 28-day compressive strength, f'c, plus a standard deviation determined from the test history available for that mix.
        2) Determine f'cr as specified in ACI CODE-350, except as modified in the following paragraphs:

a) Where 15 or more 28-day compressive strength tests are available, calculate standard deviation as described in the preceding paragraphs for “concrete mix design documented by field experience”. Add this standard deviation to the specified minimum compressive strength to determine the required average compressive strength (f’cr) for the mix.
b) Where fewer than 15 compressive strength tests at 28 days are available, determine minimum required compressive strength, (f’cr) from Table 4 of this Section.

Table 4. Required Average Compressive Strength, Fewer than 15 Tests Available

Minimum Specified Compressive Strength, f’c (pounds per square inch)	Required Average Compressive Strength, f’cr (pounds per square inch)
Less than 3,000	f’c + 1,000
3,000 to 5,000	f’c + 1,200
Over 5,000	f’c + 1,400

d. Acceptance criterion: Average compressive strength of the 4 cylinders tested at 28 days, or of the 4 cylinders tested at 56 days when permitted by the Engineer, shall equal or exceed the required average compression strength, f’cr for that concrete mix design.

4. Testing - Chloride content:
   a. Submit test results showing that the concrete mix contains water-soluble chloride ion content contributed from the constituents, including water, aggregates, cementitious materials, and admixtures is less than the limit specified in Table 3 of this Section. Test shall be performed in accordance with ASTM C1218 at age between 28 and 42 days.
5. Testing - Drying shrinkage - Prism specimens:
   a. Class A (including A, A-NA, A-SP, and A-NA-SP) and Class PM: From trial batch for each mix, prepare 10 drying shrinkage specimens in accordance with ASTM C157.
      1) Divide specimens into 2 groups of 5 specimens each: 1 group including shrinkage-reducing admixture and 1 group without shrinkage-reducing admixture.
   b. Prepare, cure, and test both groups in accordance with ASTM C157, except as modified in the following paragraphs.
      1) Remove drying shrinkage specimens from molds at age of 23 hours, plus or minus 1 hour, after trial batching.
         a) Immediately place them in lime-saturated water maintained at 73 degrees Fahrenheit, plus or minus 3 degrees, for at least 30 minutes.
         b) Remove specimens from the water and wipe with a damp cloth.
         c) Measure to nearest 0.0001 inch to determine original length.
         d) Record measurements and re-submerge specimens in lime-saturated water at 73 degrees Fahrenheit, plus or minus 3 degrees, for moist curing.
      2) Maintain submerged curing conditions at 73 degrees Fahrenheit, plus or minus 3 degrees, for 7 days. 7 days after batching, remove specimens from water and repeat measuring procedures.

3) Immediately store specimens in a humidity controlled room maintained at 73 degrees Fahrenheit, plus or minus 3 degrees, and at 50 percent relative humidity plus or minus 4 percent for remainder of the test.
4) At periods of 14, 21, 28, and 56 days after batching, remove specimens from curing room and repeat measurements.

c. Drying shrinkage test report:
1) Report measurements of all specimens at 1, 7, 14, 21, 28, and 56 days after batching.
2) Using measured length at 7 days as base length for drying shrinkage, calculate the following for each measuring period:
a) Drying shrinkage of each specimen. Determine as difference between the 7-day base length and measured length for each period.
b) Average of these differences. If drying shrinkage of any specimen departs from the average of the measurements for each period by more than 0.0004 inch, disregard results obtained from that specimen.
c) Percentage of drying shrinkage from batching to date of measurement.

d. Drying shrinkage acceptance criteria:
1) Average shrinkage of trial batch concrete specimen group at 28 days after batching, when measured and cured as indicated, shall not exceed 0.035 percent.

e. Mixes accepted by the Engineer:
1) Retain drying shrinkage test specimens. Bag in re-sealable plastic bags and submit to the Engineer.
2) Indicate trial batch identifier, specimen number, and date of final measurements on each specimen bag.

2.07 SOURCE QUALITY CONTROL

A. Sample and test materials in accordance with the following requirements:
1. Sampling, testing, and reporting frequency:
a. In preparation for mix design submittals and trial batch tests.
b. Whenever there is a change in source of the material, or a significant change in the characteristics or quality of materials from the same source.
c. For each 10,000 cubic yards of concrete mix produced.
d. At intervals not exceeding 90 calendar days, unless otherwise specified in the following paragraphs.
2. Supplemental cementitious materials.
a. Sample and test fly ash in accordance with ASTM C311.
3. Aggregate:
a. Sample combined aggregate in accordance with ASTM D75 and ASTM D3665, and test for gradation in accordance with ASTM C136.
b. At least once every 30 days, and when requested by the Engineer.
c. Submit test results.
4. Cementitious materials:
a. Sample and test cementitious materials and provide mill certificates demonstrating compliance with ASTM C150 and additional requirements of this Section.

1) Determine alkali content by method set forth in ASTM C114.
b. At least once every 90 days, and when requested by the Engineer.
c. Submit test results.

B. Batch materials in accordance with the following requirements:
1. Concrete batch weights: Control and adjust so as to secure maximum yield, and at all times maintain proportions of concrete mix within specified limits.
2. Aggregates:
a. Obtain aggregate from a source capable of providing uniform quality, moisture content, and grading during any single day's operation.
b. Furnish satisfactory means at batching plant for checking moisture content of fine aggregate for each batch.
3. Admixtures:
a. Batch solutions using mechanical batcher capable of accurate measurement.
b. Air entraining admixture: Add to batch in portion of the mixing water, unless otherwise recommended by the admixture manufacturer.

PART 3 EXECUTION

3.01 PREPARATION

A. Prepare and submit mix designs for each concrete class indicated in Table 3 of this Section.

B. Submit proposed sequence of concrete placements. After acceptance, adhere to proposed sequence of placing concrete, except when specific changes are requested by the Contractor and accepted by the Engineer.
1. Use construction methods and sequence work to allow concrete placement to reach adequate strength and to be constructed with required support to prevent overstress of the concrete structure during construction.

C. Make provisions for monitoring weather conditions:
1. Install an outdoor weather station capable of measuring and recording ambient temperature, wind speed, and humidity. Furnish instruments accurate to within 2 degrees Fahrenheit, 5 percent relative humidity, and 1 mile per hour wind speed.
2. Monitor the weather forecast beginning at least 48 hours prior to any concrete placement and make provisions for cold weather concreting or hot weather concreting if those conditions exist or are forecast to exist during the period of placement, finishing, and curing.
a. Record temperature, relative humidity, and wind speeds for each placement beginning at least 24 hours before scheduled delivery of concrete.

D. Place no concrete without the Engineer's prior acceptance of conditions.

E. Notify the Engineer in writing that preparations are complete and ready for placement of concrete. Such notification shall indicate readiness - not just intention - to place concrete for the designated portion of the Work.

1. Submit notification to the Engineer on forms provided by or acceptable to the Engineer and bearing the signature of the Contractor's superintendent.
    a. Sample form is included at the end of this Section, see Attachment B - Coarseness Factor Chart.
2. Submittal of notification will be the Contractor's certification that preparations are complete and in accordance with the Contract Drawings and Specifications.
3. Provide notification for the Engineer to make final observations at the locations of concrete placements not less than 24 hours before commencing placement of concrete.

3.02 CONCRETE JOINTS

A. Locations of joints are indicated on the Drawings.
    1. In order to preserve strength and watertightness of structures, make no other joints, except as authorized by the Engineer.
    2. Construct joints where indicated, and as indicated on the Drawings.
    3. Where joint locations are not indicated on the Drawings, submit the Contractor's proposed locations for the Engineer's review and acceptance. Provide construction joints in slabs and walls at intervals not greater than 35 feet.

B. Time between placements of adjacent concrete separated by joints.
    1. Provide not less than 3 days (72 hours) between placement of adjacent sections for the following:
        a. Slabs.
        b. Walls.
    2. Provide not less than 7 days (168 hours) between placement of the lower and upper pours for the following:
        a. Walls over slabs.
        b. Slabs over walls.
        c. Slabs keyed into the sides of walls.

C. Edges of joints:
    1. Provide joints have edges detailed as indicated on the Drawings.
    2. Protect wall and slab surfaces at edges from concrete splatter. Thoroughly clean adjacent surfaces after completion of each placement.

D. Joint construction:
    1. Preparation of forms:
        a. Provide cleanout holes at base of each wall and column for inspection and cleaning.
        b. Wash forms and adjacent joint surfaces of sawdust, chips, and other debris after forms are built, and immediately before concrete or grout placement.
        c. Should formwork confine sawdust, chips, or other loose matter in such manner that it is impossible to remove them by flushing with water, use a vacuum cleaner for their removal and then flush cleaned surfaces with water.
    2. Before placing concrete against previously placed concrete, thoroughly clean the prior placement of laitance, grease, oil, mud, dirt, curing compounds, mortar droppings, or other objectionable matter by means of pressure washing.

3. Provide and install waterstops, expansion joint material, and other similar materials as indicated on the Drawings and as specified.
    a. Take special care to ensure that waterstops are secured in proper position.
    b. Take special care to ensure that concrete is well consolidated around and against waterstops during placement.
4. Horizontal joints:
    a. As initial placement over cold joints, thoroughly spread bed of cement grout as specified in Section 03600 - Grouting.
        1) Thickness: Not less than 1/2 inch or more than 1 inch.
    b. For wall placements above planned cold joints, placement of cement grout will not be required for locations where the wall mix includes high-range water-reducing admixture (superplasticizers), and the Contractor can demonstrate dense concrete joints without voids or honeycomb after the forms are removed.

3.03 MEASURING AND BATCHING MATERIALS

A. Measurements of materials:
1. Proportion and measure cementitious materials and aggregates by weight.
    a. Weigh cementitious materials separately.
    b. If bulk cementitious materials are used, weigh them on separate visible scale that will accurately register scale load at any stage of weighing operation from zero to full capacity.
    c. Cement in unbroken standard packages (sacks) need not be weighed.
2. Mixing water: Measure by volume or by weight.
3. Other mix constituents: Measure by weight, except as otherwise specified or accepted by the Engineer.
4. Weighing and measuring devices:
    a. Use equipment designed and constructed specifically for that purpose.
    b. Furnish devices capable of weighing successive quantities of individual material measured to within 1 percent of desired weight of that material.
    c. Bearing valid seal of the department of weights and measures for the authority having jurisdiction over the Work.
5. Measurements and measuring devices:
    a. Subject to review by the Engineer.

B. Batching:
1. Admixtures shall be added at the concrete batch plant.
2. Addition of admixtures in the field is permitted only with prior acceptance by the Engineer, and only when the following conditions are satisfied:
    a. Dosage and mixing is personally overseen by the concrete supplier’s trained technologist.
    b. Adequate mixing is provided after addition.
    c. Maximum time to placement of concrete remains 90 minutes after water added to mix - not 90 minutes after any field additions/adjustments.
    d. Slump at discharge after additions/modifications conforms to the requirements of Table 3 of this Section.

3.04 MIXING AND TRANSPORTING

A. Machine mixing:

1. Prevent cementitious materials from coming into contact with aggregate or with water until materials are in mixer and ready for complete mixing with all mixing water.
2. Procedure of mixing cementitious materials with sand, or with sand and coarse aggregate, for delivery to the Project Site for final mixing and addition of mixing water is not permitted.
3. Remixing of concrete that has started to take its initial set (retempering) is not permitted.
4. Discharge entire batch before recharging.
5. Volume of mixed material per batch: Not exceeding manufacturer's rated capacity of mixer.

B. Transit-mixed concrete:
   1. Mix and deliver in accordance with ASTM C94, except as modified in this Section.
   2. Total elapsed time between addition of water at batch plant and discharging completed mix:
      a. Not to exceed 90 minutes or 300 revolutions of the mixing drum.
      b. Under conditions contributing to rapid setting, total elapsed time permitted may be reduced by the Engineer.
   3. Temperature - minimum and maximum allowable during mixing and transporting:
      a. Minimum: 50 degrees Fahrenheit.
      b. Maximum: 95 degrees Fahrenheit.
   4. Continuously revolve drum after it is started until it has completely discharged its batch.
      a. Do not add water until drum has started revolving.
      b. Engineer reserves the right to increase required minimum number of revolutions or to decrease designated maximum number of revolutions allowed, if necessary, to obtain satisfactory mixing. Contractor will not be entitled to additional compensation because of such increase or decrease.

C. Concrete delivery:
   1. Furnish to the Engineer a delivery ticket for each batch of ready mixed concrete within 24 hours after delivery. Include the following information on each ticket:
      a. Time of day concrete was batched, and time of day that discharge from the truck is complete.
      b. Printed record of the individual weight of each of the following constituents in the batch: Fine aggregate, coarse aggregate, cement, pozzolan, and water.
      c. Concrete class as defined in Table 3 of this Section.
      d. Type, brand, and quantity of each admixture in the batch.
      e. Total volume of water allowed in the mix, volume of mixing water added at the batch plant, volume of mixing water withheld from the mix during batching, and total volume of any water added to the mix after leaving the batch plant.
         1) In no case shall volume of mixing water withheld result in a water/cementitious materials ratio less than the minimum values specified in Table 3 of this Section.

f. Number of revolutions of transit truck at arrival on site, and total number of revolutions when discharge is complete.
g. Volume of concrete delivered in the batch.
h. Numerical sequence of the batch delivered for that placement.

2. Additional water may only be added to the mix when the following conditions are fully satisfied:
   a. Batch ticket showing total volume of water already added and maximum volume of water that may be added is available for the Engineer's observation before any additional water is added.
   b. Total volume of water in the mix after the addition will be less than the maximum allowable volume of water indicated on the ticket.
   c. Full concrete load is still within the truck's mixing drum, and truck has not begun to discharge the load. Under no conditions shall water be added in the field to a partial truckload of concrete.
   d. Volume of water added, and time of addition are clearly marked for record on the batch ticket delivered to the Engineer.
3. Addition of admixtures in the field is permitted only with prior approval by the Engineer, and when the following conditions are satisfied:
   a. Dosage and mixing is personally overseen by the concrete supplier's trained technologist and the admixtures supplier's representative.
   b. Adequate mixing time is provided after addition of admixtures.
   c. Maximum time to placement of concrete remains 90 minutes after water is added to the mix - not 90 minutes after any field additions/adjustments.
   d. Slump at discharge after additions/modifications conforms to the requirements of Table 3 of this Section.

D. Conveying concrete:
1. Convey concrete from mixer to location of final deposit by methods that prevent separation or loss of materials.
2. Use equipment for chutes, pumps, and conveying of concrete of such size and design as to ensure practically continuous flow of concrete, from delivery to the point of placement, without separation of materials.
3. Design and use chutes and devices for conveying and depositing concrete that direct concrete vertically downward when discharged from chute or conveying device.
4. Keep equipment for conveying concrete thoroughly clean by washing and scraping upon completion of any day's placement.

3.05 PLACING AND CONSOLIDATING

A. Preparation:
1. Obtain the Engineer's acceptance of completed preparations before placing concrete.
   a. Notify the Engineer in writing that all preparations are complete and ready for placement of concrete. Such indication shall indicate readiness, not just intention, to place concrete for the designated portion of the Work.
   b. Submit completed Attachment D - Contractor's Concrete Placement Checklist Form.
2. Confirm completeness of the following before notification of readiness is given to the Engineer:

a. Place forms, reinforcement, screeds, anchors, ties, and inserts in final position.
b. Reinforcement is secure and properly fastened in its correct position.
c. Loose form ties at construction joints have been retightened.
d. Dowels, bucks, sleeves, hangers, pipes, conduits, anchor bolts, and any other fixtures required to be embedded in concrete have been placed and adequately anchored to maintain a minimum 2-inch clearance between the item and any concrete reinforcement.
    1) Securing embedded items in position by wiring or welding to the reinforcement is not permitted.
e. Forms have been cleaned of debris and form release agents are applied as specified.

3. Preparation for placement of footings and slabs on grade:
    a. Do not place concrete on ground or compacted fill until subgrade is in moist condition acceptable to the Engineer.
    b. If necessary, sprinkle subgrade with water not less than 6 or more than 20 hours in advance of placing concrete.
    c. If subgrade surface becomes dry prior to actual placing of concrete, sprinkle again, without forming pools of water.
    d. Do not place concrete if subgrade is muddy or soft.
4. Keep sufficient protective coverings on hand at all times for protection of concrete during and after placement.
    a. Protect concrete placed before rain to prevent water from coming in contact with such concrete.
    b. Protect concrete placed before winds to prevent excessive drying or embedment of debris in the finished surfaces.

B. Concrete placement:
1. Do not place concrete:
    a. With slump outside the limits specified in Table 3 of this Section.
    b. In which initial set has occurred, or that has been retempered.
    c. During rainstorms or high velocity winds.
2. Deposit concrete at or near its final position to avoid segregation caused by rehandling or flowing.
    a. Do not deposit concrete in large quantities in one place, and then work material along forms with vibrator or by other methods.
3. Do not drop concrete freely into place from height greater than 5 feet. Use tremies for placing concrete where drop is over 5 feet.
4. Place concrete on slopes starting from bottom of slope and working upward.
5. Place concrete in horizontal lifts not exceeding 24 inches in depth and bring up evenly in all parts of forms.
6. After concrete placement begins, continue in a continuous operation without significant interruption until the end of the placement. Plan and implement precautions to prevent any delay, between layers or adjacent volumes, from exceeding 20 minutes.
7. If concrete is to be placed over previously placed concrete and more than 20 minutes has elapsed, spread layer of cement grout over surface before placing additional concrete. Provide grout layer thickness of not less than 1/2 inch or more than 1 inch.
8. Placement of concrete for slabs, beams, or walkways:

a. If cast monolithically over walls or columns, do not commence until concrete in walls or columns has been allowed to set and shrink.
b. Allow set time of not less than 1 hour for shrinkage.
    1) During waiting time, keep top surface of concrete moist, but not wet.
    2) Do not permit water to pond or stand on the surface.
    3) Do not coat surface with evaporation retarders or curing agents.
c. Start placement above wall or column with layer of cement grout as described in the preceding paragraph.

C. Consolidating concrete:
1. Consolidate concrete with aid of acceptable mechanical vibrators.
2. Thoroughly consolidate concrete around reinforcement, pipes, or other shapes built into the Work.
3. Provide sufficiently intense vibration to cause concrete to flow and settle readily into place and to visibly affect concrete over radius of at least 18 inches.
4. Vibrators:
    a. Keep sufficient vibrators on hand at all times to vibrate concrete as placed.
    b. In addition to vibrators in actual use while concrete is being placed, have on hand a minimum of 1 spare vibrator in operable condition.
    c. Do not place concrete until it has been confirmed that all vibrating equipment, including spares, are in operable condition.
5. Place concrete solidly against forms and concrete surfaces, leaving no voids or honeycomb.
6. Make concrete solid, compact, and smooth. If for any reason surfaces or interiors have voids or are in any way defective, repair such concrete in manner acceptable to the Engineer.
7. Do not over-vibrate so as to produce segregation.

3.06 FINISHING CONCRETE

A. Provide concrete finishes in accordance with Section 03366 - Concrete Finishes, unless otherwise indicated on the Drawings.

B. Liquid evaporation retardant:
1. Under conditions that result in rapid evaporation of moisture from the surface of the concrete, coat the surface of the concrete with a liquid evaporation retardant immediately after screeding.
2. Conditions that result in rapid evaporation of moisture are defined as any combination of ambient temperature, concrete temperature, relative humidity, wind speed, and solar radiation intensity that creates conditions that will evaporate water from a free concrete surface at a rate equal to or greater than 0.1 pounds per square foot per hour as determined by the Menzel Formula and nomograph published in ACI PRC-305 and included as Attachment A - Menzel Formula and Nomograph to this Section.
3. Apply evaporation retardant again after each finishing operation as necessary to prevent drying shrinkage cracks.
4. Do not work evaporation retardant into the surface of the concrete.
5. Do not use evaporation retardant as finishing aid (to rehydrate surface a creamy state for finishing).
6. Concrete surfaces in direct contact with potable water in the finished Work:

a. After curing is complete, pressure wash concrete, using equipment and procedures acceptable to the Engineer, to remove residual evaporation retardant and other compounds prior to cleaning structure for disinfection.

C. Concrete sealer:
1. Floors and slabs to receive concrete sealer: See Room Finish Schedule on the Drawings, and Section 03366 - Concrete Finishes.

3.07 CURING

A. Cure concrete by methods specified in this Section.

B. Cure period: Keep concrete continuously moist and at an average daily temperature of at least 50 degrees Fahrenheit for a minimum of 7 days after placement.
1. If hourly temperatures at any surface of a concrete placement drop below 50 degrees Fahrenheit during the curing period, count the period below 50 degrees Fahrenheit as zero degrees, and extend the curing time to compensate.

C. Schedule of curing methods:
1. Cure the following concrete surfaces using water curing or plastic membrane curing.
a. Floor surfaces of water containment structures.
b. Surfaces where additional concrete will be placed over or against the surface, including concrete joints.
c. Surfaces where grout or other toppings will be placed over the surface.
d. Slabs scheduled to receive concrete sealer, or other bonded or adhered architectural finishes.
e. Formed surfaces scheduled to receive coatings, paint, adhered masonry, cementitious materials, or other similar finishes, and where formwork is removed within the specified cure period after concrete placement.
f. Horizontal concrete surfaces at tops of walls.
2. Cure the following concrete surfaces by water curing, plastic membrane curing, or sprayed curing membrane. Selection of methods shall be at the Contractor’s option.
a. Surfaces not listed in the preceding paragraph.

D. Water curing:
1. Keep surfaces of concrete constantly and visibly wet, day and night, for not less than the specified cure period.
a. Each day forms remain in place will be counted as 1 day of water curing.
b. Do not loosen form ties during period when concrete is cured by leaving forms in place. No further curing credit will be allowed for forms remaining in place after contact has been broken between concrete surface and forms.
2. Begin water curing as soon as concrete attains initial set.
3. Maintain a wet surface by ponding, continuous sprinkling, covering with saturated burlap, or otherwise saturating the surface by means acceptable to the Engineer.
a. Flood top of walls with water at least 3 times per day and keep surfaces moist at all times during the curing period.

b. Provide plastic sheet material over surfaces if required to maintain a wet surface during arid or windy conditions. See plastic membrane curing requirements for additional details.

4. Use water having a temperature within 20 degrees Fahrenheit of the temperature of concrete, and not lower than the minimum temperature allowed for the concrete surface during curing.

E. Plastic membrane curing:
   1. Install plastic membrane as soon as concrete is finished and can support limited pedestrian traffic without damage.
   2. Cover entire surface of finished concrete with membrane.
   3. Anchor membrane to prevent uplift from wind or air trapped below the sheet.
   4. Fully seal joints and edges to provide full seal around perimeter.
   5. Keep concrete under plastic membrane moist, regularly monitoring surfaces and adding supplemental moisture if necessary. Add water as specified for water curing.

F. Sprayed membrane curing compound:
   1. Apply curing compound to concrete surface after repairing and patching, and within 1 hour after forms are removed.
      a. If more than 1 hour elapses after removal of forms, do not use membrane curing compound. Instead, provide water curing for not less than the specified cure period.
      b. Do not remove sprayed membrane curing compound from concrete before the end of the specified cure period.
      c. When application of curing compound at concrete joints is accepted by the Engineer, take care to apply curing compound to all surfaces along full profile of joints.
   2. Apply curing compound by mechanical, power operated sprayer with mechanical agitator that will uniformly mix all pigment and compound.
      a. Apply curing compound in at least 2 coats. Each coat shall be applied at the manufacturer’s recommended application rate.
      b. Apply each coat in direction turned 90 degrees from application direction of the preceding coat.
      c. Apply curing compound in sufficient quantity so that concrete has uniform appearance and its natural color is effectively and completely concealed immediately after spraying. This requirement may require additional coats and/or application rates than indicated above.
      d. Continue to coat and recoat surfaces until specified coverage is achieved and until coating film remains on concrete surfaces.
   3. Thickness and coverage of curing compound:
      a. Provide curing compound having film thickness that can be scraped from surfaces at any and all points after drying for at least 24 hours.
      b. Contractor is cautioned that method of applying curing compound specified in this Section may require more curing compound than normally suggested by manufacturer of curing compound and is more than is customary in the trade. Apply amounts specified in this Section, regardless of manufacturer’s recommendations or customary practice.

4. If the Contractor desires to use a curing compound other than specified product, coat sample areas of concrete wall with proposed curing compound, and also coat similar adjacent area with the specified compound in the manner specified, for comparison:
    a. If proposed sample is not equal or better, in the opinion of the Engineer, the proposed substitution will not be allowed.
5. Removal of curing compound.
    a. After curing period is complete, remove curing compound placed on surfaces that will receive additional concrete, including all concrete joint surfaces, by heavy sandblasting or by other means acceptable to the Engineer. Complete removal and cleanup prior to placing any new concrete against the surface.
    b. Where additional finishes will be applied over concrete surfaces, unless otherwise recommended by the manufacturer of the finish to be applied, remove curing compound by sandblasting. Provide blasting as necessary to fully remove curing compound.
6. Prior to final acceptance of the Work, remove, by sandblasting or by other method acceptable to the Engineer, any curing compound on surfaces exposed to process water or exposed to view, so that only natural color of finished concrete is visible and uniform over the entire surface.

3.08 PROTECTION

A. General:
    1. Keep forms in place, as specified in Section 03102 - Concrete Formwork, to provide curing and to protect concrete surfaces and edges from damage.
    2. Immediately after forms are removed, carefully examine concrete surfaces, and repair any irregularities in surfaces and finishes as specified.

B. Loading of concrete members:
    1. Placement of loads on or against green concrete is not permitted.
    2. Do not place soil against walls, or fill over the top of concrete until conditions designated in the following paragraphs are satisfied:
        a. Walls have been cast to their full height in the structure and have achieved their minimum specified 28-day compressive strength.
        b. Connecting slabs and beams that brace the walls are in place, are complete, and (in the case of concrete) have achieved their minimum specified 28-day compressive strength.

3.09 HOT WEATHER CONCRETING

A. Implement hot weather concrete procedures during periods of hot weather as defined in this Section.
    1. Comply with the recommendations of ACI PRC-305 and this Section.

B. If placements during hot weather are expected, and when requested by the Engineer, prepare a hot weather concreting plan.
    1. Maintain at least 1 copy on site.
    2. Provide plan for review if requested by the Engineer.

a. Include procedures for batching, delivery, placement, curing, protection, and monitoring and recording the temperature of the concrete and the surrounding environment.
b. Describe procedures to be implemented in the event of abrupt changes in weather conditions, or in the event of equipment failure.
c. Review hot weather concreting plan during pre-construction meeting. Make provisions to address any concerns expressed by the Engineer before beginning concrete placements.

C. Preparation:
1. Do not place concrete against forms, reinforcement, or embedments with a surface temperature greater than 120 degrees Fahrenheit.
a. If necessary, to maintain maximum concrete temperature during placing, cool forms and reinforcement to temperature below 90 degrees Fahrenheit using water or shades.
b. Do not allow water to puddle in forms or placement areas.
2. Moisten forms or subgrade to maintain a saturated surface without standing water or soft spots.
3. Provide windbreaks, shades, fog spray, sprinkling, wet cover, or other means required to protect concrete from premature loss of moisture and rapid temperature gain.

D. Batching and delivery:
1. Retarding admixtures will not be permitted.
2. Temperature of concrete delivered for placement shall not exceed 90 degrees Fahrenheit.
a. Maintain uniform temperature in the mix below this level during batching, delivery, placing, and consolidation.
b. Temperature of mix, even if below the maximum allowable temperature specified, shall be maintained at a level to avoid loss of slump, flash setting, or cold joints in placements.
3. If necessary:
a. Mix water may be chilled or replaced with ice to maintain mix temperature. Where mix water is replaced with ice, provide replacement at a 1-to-1 ratio by weight.
b. Shade transit mixed concrete trucks, or cool mixing outside of container with water to control temperature of concrete.

E. Placing and finishing:
1. Place and finish concrete promptly. Place so that vertical lift lines will not be visible in exposed concrete surfaces.
2. Provide plastic sheeting, fog nozzles, shades or other means to reduce concrete temperature and protect from moisture loss.

F. Protection and curing:
1. Furnish and locate maximum/minimum temperature recording thermometers in sufficient numbers to confirm concrete temperatures over full area and edges of concrete.
2. Flatwork: Protect and cure using water curing methods as specified in this Section.
a. Water curing:

1) Keep concrete continuously wet and make provisions for runoff.
2) For sprinkling or soaker hoses, maintain temperature of water as close as possible to the temperature of the concrete to minimize effects of thermal shock.

3. Formed surfaces: Protect and cure using forms left in place or membrane curing methods as specified in this Section.
   a. Cover forms and keep continuously moist for at least 24 hours after placement.
   b. Loosen forms as soon as this can be accomplished without damaging the concrete.
   c. Maintain continuously moist surfaces by fogging or spraying with water, or by application of curing compound as specified.

3.10 FIELD QUALITY CONTROL BY CONTRACTOR

A. Provide quality control over the Work of this Section as required by Section 01450 - Quality Control.

B. Field tests:
   1. During progress of construction, provide testing to determine whether the concrete, as being produced, complies with requirements specified.
   2. Sampling and testing shall be performed by the Contractor's testing laboratory. See Section 01455 - Regulatory Quality Assurance - Special Tests and Inspections for requirements.
      a. Cooperate in testing by allowing free access to the Work for testing laboratory to sample and test materials.
      b. Provide full access for the Engineer to observe concrete sampling and testing at any time.
      c. Contractor is responsible for providing care of and curing conditions for test specimens in accordance with ASTM C31 until specimens are collected by testing laboratory.
      d. Provide 4 firmly braced, insulated, heated, closed wooden curing boxes, each sized to hold 10 specimens. Include cold weather temperature and hot weather temperature control thermostat for initial curing and storage from time of fabrication through shipment to the Owner's testing laboratory.
   3. Testing shall include:
      a. Sampling of concrete in accordance with ASTM C172.
      b. Temperature of concrete at delivery in accordance with the requirements of ASTM C1064 and as specified in this Section.
      c. Slump of concrete using slump cone in accordance with requirements of ASTM C143. Test slump at the following intervals:
         1) At the beginning of each placement.
         2) As often as necessary to keep slump within the specified range, but not less than every 6th truck.
         3) When requested to do so by the Engineer.
         4) Observe concrete during slump test for signs of segregation.
            a) Observe concrete to see if mortar or moisture flows from slumped concrete.
            b) Reject concrete if mortar or moisture flows out of mix.
      d. Unit weight of concrete in accordance with ASTM C138.

e. Air entrainment in accordance with ASTM C173. Test air content at the following intervals:
    1) At beginning of each placement.
    2) As often as necessary to keep entrained air within specified range, but not less than every 6th truck.
    3) When requested to do so by the Engineer.
    4) Test air entrainment in concrete in accordance with ASTM C173. If air entraining admixtures used for the Work require alternate testing procedures, advise the independent testing laboratory well in advance of the dates of testing, and confirm that appropriate equipment and personnel are provided for the test.
    5) Make air test at point of delivery (discharge from mixer). For pumped concrete, make air tests at point of delivery and at point where expelled after pumping for placement.
f. Compressive strength in accordance with ASTM C39. Required number of cylinders is as follows:
    1) Not less than 6 cylinder specimens, 4 inches in diameter by 8 inches long, will be tested for each 100 cubic yards of each class of concrete or 5,000 square feet of slab or wall, with minimum of 6 specimens for each class of concrete placed; not less than 6 specimens for each half day's placement; and not less than 2 sets of 6 specimens for each structure.
    2) 1 cylinder will be broken at 7 days, 1 at 14 days, and 3 at 28 days. 6th cylinder may be used to evaluate strength after 28 days if requested by the Engineer.
    3) Retain and store 6th cylinders (tested and untested) at testing laboratory until 56 days. Break 6th cylinder when directed by the Engineer.
g. Provide full access for the Engineer to observe concrete sampling and testing at any time.

C. Test completed liquid containment structures listed in Section 01759 - Water Leakage Test for Concrete Structures for watertightness.

3.11 FIELD QUALITY CONTROL BY OWNER

A. As specified in Section 01450 - Quality Control.

B. Special tests and inspections: As specified in Section 01455 - Regulatory Quality Assurance.

C. Field inspections:
1. Observe construction for conformance to the Contract Documents and the accepted submittals.
2. Records of inspections:
    a. Provide a record of each inspection.
    b. Submit copies to the Contractor upon request.

D. Field tests:

1. Engineer may request, at any time, additional testing to confirm materials being delivered and placed conform to the requirements of the Contract Documents.
    a. If such additional testing shows that the material do not conform to the specified requirements, the Contractor shall pay the cost of these tests.
    b. If such additional testing shows that the materials do conform to the specified requirements, the Owner will pay the cost of these tests.

3.12 NON-CONFORMING WORK

A. Remove and replace or repair non-conforming and defective work.
    1. Provide repairs having strength equal to or greater than specified concrete for areas involved.
    2. Provide replacement or repair of non-conforming work by means acceptable to the Engineer and at no additional cost to the Owner.
    3. Project schedule will not be extended based on work to address non-conforming concrete.

B. Concrete not conforming to the specified requirements for properties of plastic concrete: Remove from the Site and replace with conforming materials at no additional cost to the Owner.
    1. Temperature: Do not use concrete having a temperature above or below the limits specified in this Section.
    2. Slump: Do not place concrete that does not conform to requirements for slump.
    3. Air entrainment: Do not use concrete that does not conform to requirements for percentage of entrained air.

C. Concrete not conforming to the specified requirements for compressive strength:
    1. Concrete is expected to reach a compressive strength equal to or greater than the minimum specified compressive strength f'c in Table 3 of this Section.
    2. Strength of concrete will be considered acceptable if the following conditions are satisfied.
        a. Averages of all sets of 3 consecutive strength test results is greater than or equal to the specified compressive strength f'c.
        b. No individual strength test (average of 3 cylinders) falls below the strength specified in Table 6 of this Section.
        c. Where relationships between 7-day and 28-day compressive strength, or between 28-day and 56-day compressive strength, have been provided as part of the mix design submittals:
            1) 7-day strength may be considered as an indication of 28-day strength provided effects of temperature and humidity between 7 days and 28 days are taken into account.
            2) 28-day strength may be considered as indication of 56-day strength provided effects of temperature and humidity between 28 days and 56 days are taken into account.

Table 6. Strength Compliance Requirements

Minimum Specified Compressive Strength, f'c (pounds per square inch)	Lower Bound of an Individual Compressive Strength Test (pounds per square inch)
Less than 5,000	f'c - 500

Table 6. Strength Compliance Requirements	
Over 5,000	f'c - (0.10 x f'c)

3. Non-compliant strength tests.
    a. Mark non-compliant strength test reports to highlight the non-complying results, and immediately forward copies to all parties on the test report distribution list.
    b. Initial treatment may consist of additional curing of affected portion(s) followed by not less than 3 cores at each affected area, taken in accordance with ASTM C42 and ACI CODE-318. Obtain the Engineer's acceptance of proposed coring locations before proceeding with that work.
    c. Submit report of compressive strength testing for the Engineer's review.
    d. If requested by the Engineer, provide additional cores, and obtain petrographic testing in accordance with ASTM C856. Submit results for the Engineer's review.
    e. If additional curing does not bring the average strength of 3 cores taken in affected area to at least specified compressive strength f'c, designate such concrete in affected area will be considered defective.
    f. Engineer may require the Contractor to strengthen defective concrete by means of additional concrete, additional reinforcing steel, or replacement of defective concrete, all at the Contractor's expense.

D. Concrete sections or surfaces with honeycombing and voids:
    1. Provide repairs having surface appearance and finish consistent with that of the surrounding work and acceptable to the Engineer.
    2. Do not patch, repair, or cover defective work without prior inspection by the Engineer.
    3. Preparation of concrete for repair:
        a. Make no repair until the Engineer has accepted methods for preparing surfaces and for making and curing repairs.
        b. Chip out and key-in imperfections in the Work to make them ready for repair.
        c. Coat bonding surfaces and edges of repair area with one of the following bonding agents as accepted by the Engineer.
            1) Epoxy bonding agent as specified in Section 03071 - Epoxies; or,
            2) Epoxy resin/Portland cement bonding agent as specified in Section 03072 - Epoxy Resin/Portland Cement Bonding Agent.
    4. Methods of repair:
        a. Dry pack mortar method:
            1) Use for holes having depth nearly equal to or greater than least surface dimension of hole, for cone-bolt holes, and for narrow slots cut for repair.
            2) Smooth holes: Clean and roughen by heavy sandblasting before repair.
            3) Install dry-pack mortar as specified in Section 03600 - Grouting.
        b. Cement mortar method:
            1) Use for holes too wide to dry pack and too shallow for concrete replacement; and for comparatively shallow depressions, large or small, that extend no deeper than nearest surface reinforcement.
            2) Install cement mortar as specified in Section 03600 - Grouting.
        c. Concrete replacement:

1) Use when holes extend entirely through the concrete section or when holes are more than 1 square foot in area and extend halfway or more through the section.
2) Form, place, consolidate, and cure concrete of same mix as the surrounding work.

E. Leaking construction joints and cracks in concrete walls and slabs:
1. Repair cracks that develop in walls or slabs, and repair cracks that show any signs of leakage until all leakage is stopped.
2. Pressure inject visible cracks in the following areas, other than hairline cracks and crazing, with repair products and methods acceptable to the Engineer.
a. Floors and walls of water bearing structures.
b. Walls and overhead slabs of passageways and occupied spaces where the opposite face of the member is exposed to weather or may be washed down and where the opposite face does not receive a separate waterproofing membrane.
c. Other items not specified to receive separate waterproofing membrane, including slabs over water channels, wet wells, reservoirs, and other similar surfaces.
3. Continue pressure injection of cracks as specified until structure is watertight and remains watertight for not less than 1 year after date of Substantial Completion or date of final repair, whichever occurs later in time.

F. Leaking expansion joints in concrete walls or slabs that include waterstops:
1. Repair any signs of leakage until all leakage is stopped.
2. Pressure inject visible leaks with hydrophilic polyurethane foam resin as specified in Section 03933 - Hydrophilic and Hydrophobic Foam Polyurethane Resin Injection System.
3. Continue pressure injection along joints lines as specified until structure is watertight and remains watertight for not less than 1 year after date of Substantial Completion or date of final repair, whichever occurs later in time.

G. Walls and slabs at overhead channels that leak or sweat because of porosity or cracks too small for successful pressure injection with epoxy.
1. Seal on water or weather side by coating using surface-applied crystalline coating as specified in this Section.
2. Apply as recommended by manufacturer published instructions. Where concrete continues to sweat or leak, apply additional coats of surface-applied crystalline coating until the sweating or leaks stop.
3. Continue application of surface-applied crystalline coating until structure is watertight and remains watertight for not less than 1 year after date of Substantial Completion, or date of final repair, whichever occurs later in time.

END OF SECTION

ATTACHMENT A - MENZEL FORMULA AND NOMOGRAPH

MENZEL FORMULA AND NOMOGRAPH

Source: ACI PRC-305

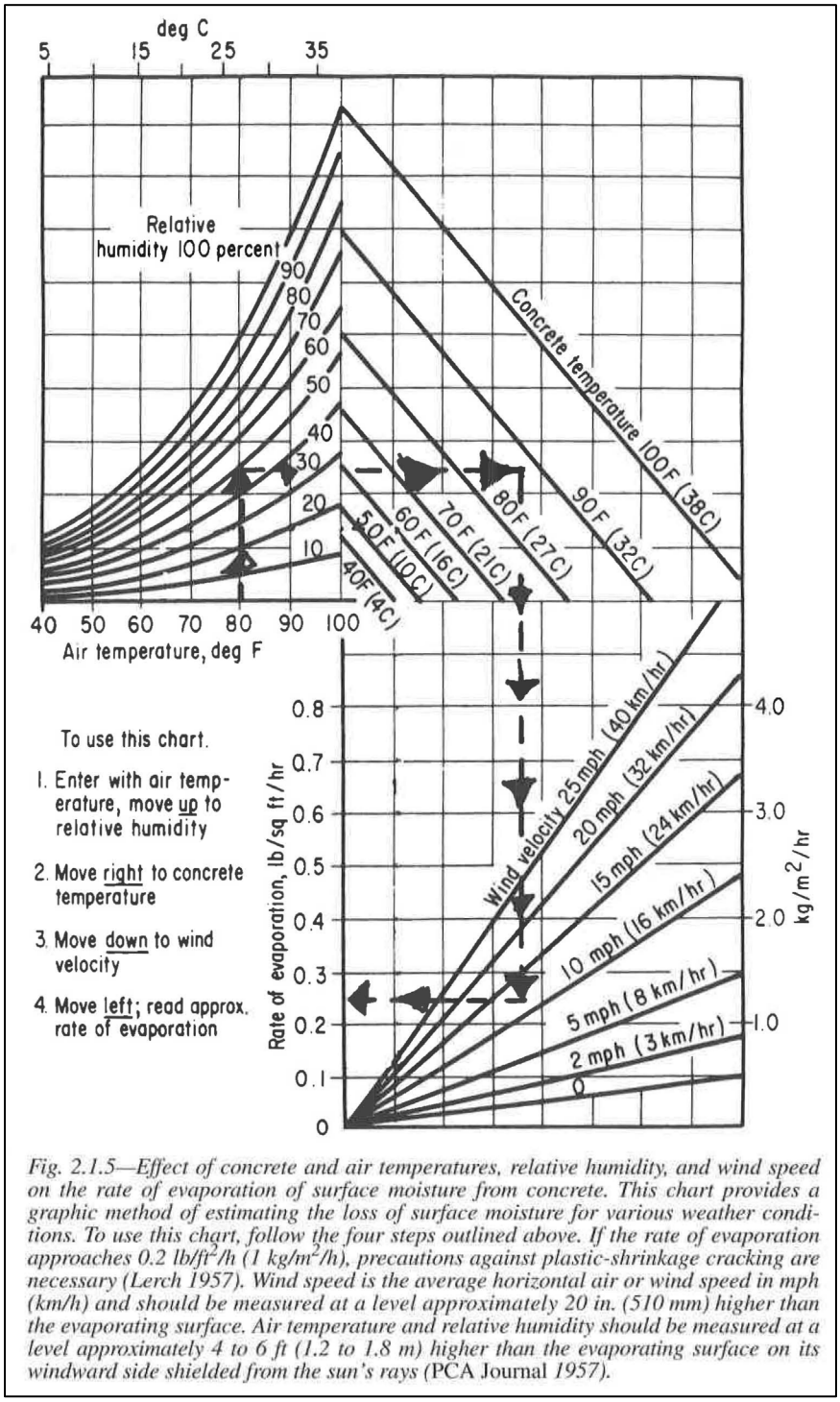


*Fig. 2.1.5—Effect of concrete and air temperatures, relative humidity, and wind speed on the rate of evaporation of surface moisture from concrete. This chart provides a graphic method of estimating the loss of surface moisture for various weather conditions. To use this chart, follow the four steps outlined above. If the rate of evaporation approaches 0.2 lb/ft²/h (1 kg/m²/h), precautions against plastic-shrinkage cracking are necessary (Lerch 1957). Wind speed is the average horizontal air or wind speed in mph (km/h) and should be measured at a level approximately 20 in. (510 mm) higher than the evaporating surface. Air temperature and relative humidity should be measured at a level approximately 4 to 6 ft (1.2 to 1.8 m) higher than the evaporating surface on its windward side shielded from the sun's rays (*PCA Journal *1957).*

ATTACHMENT B - COARSENESS FACTOR CHART

COARSENESS FACTOR CHART

Source: ACI PRC-302.1-15, Figure 8.9.2.2.

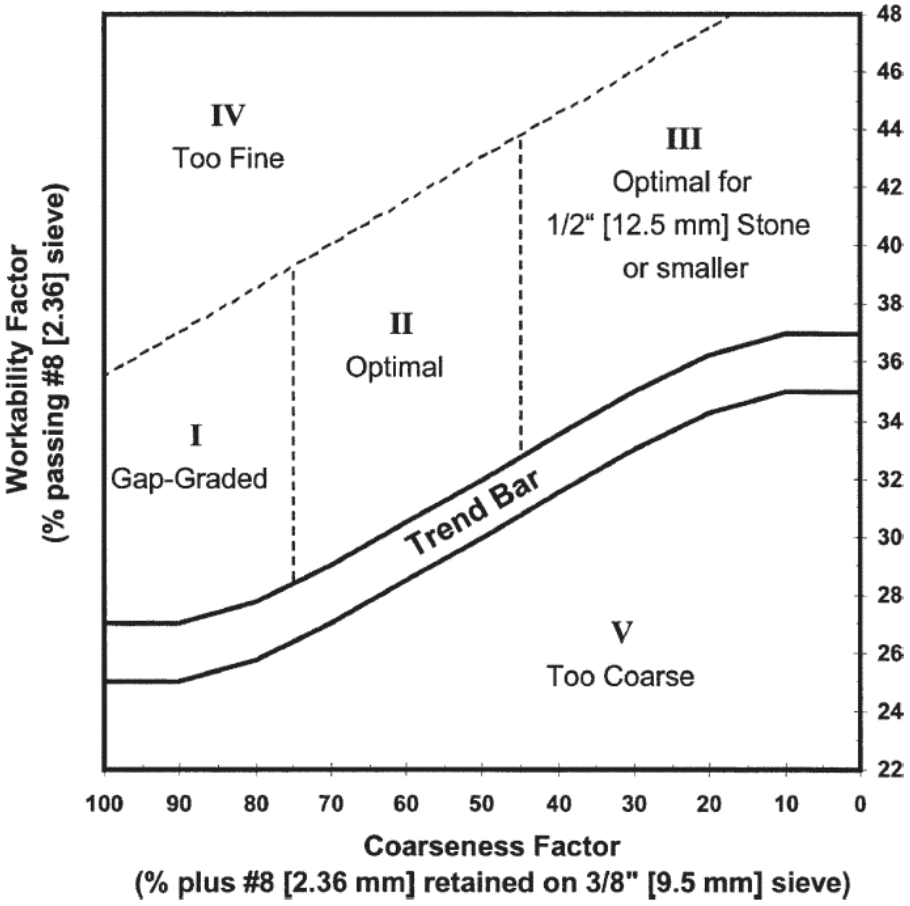
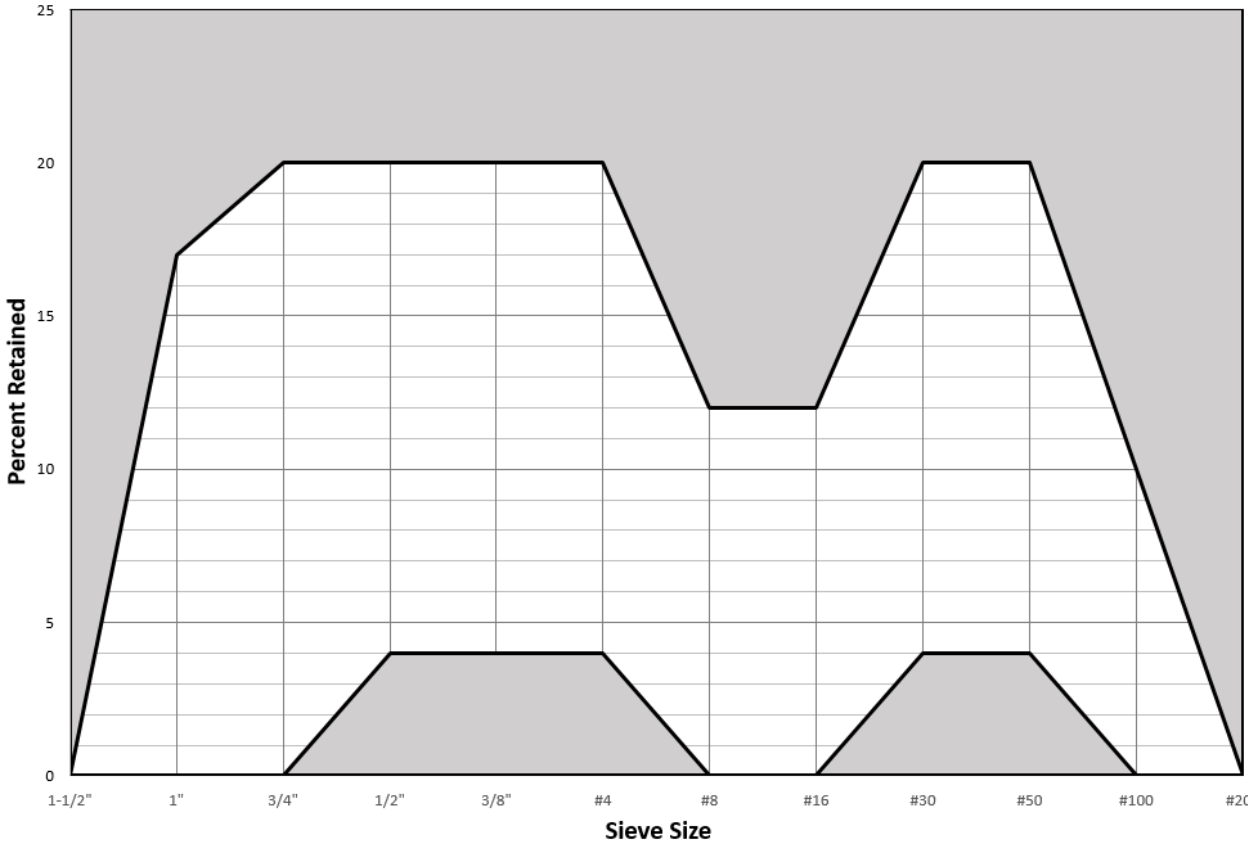


Fig. 8.9.2.2—Coarseness factor chart for evaluating potential performance of mixture.

ATTACHMENT C - COMBINED AGGREGATE GRADATION CHART

COMBINED AGGREGATE GRADATION CHART



ATTACHMENT D - CONCRETE PLACEMENT CHECKLIST

CONCRETE PLACEMENT CHECKLIST

Project: _____ Class of Concrete: _____

Project No: _____ Test Cylinders Taken? Yes: _____ No: _____

Preparation Slab	Contractor	N/A
Compaction Subgrade		
Filter Fabric/Drain Rock-ABC/Separator Fabric		
Drain Rock, Pea Gravel & Void Form		
Starter Wall Forms		
Reinforcing Steel		
Screeds		

Embedded Items	Contractor	N/A
A. Anchor Bolts		
B. Water Stop		
C. Rebar		
D. Electrical		
E. Plumbing Rough-in		
F. Mechanical		
G. HVAC		

Concrete Placement Equip.	Contractor	N/A
A. Crane		
B. Buckets		
C. Hoppers		
D. Vibrators		
E. Elephant trunks		
F. Floodlights		
G. Pump Truck		

Building Department Notification	
Date:	Time:

Prep Wall Concrete	Contractor	N/A
Access To Work		
Ladders Secured		
Clean up and Washed Out		
Reinforcing Steel		

Forms	Contractor	N/A
A. Alignment & Grade		
B. Scaffolding		
C. Sleeves & Wall Castings		
D. Embedded Items		
E. Electrical		
F. Plumbing Rough-in		
G. Piping		

Record of Curing Conditions During Placement	
Start:	Finish:
Date:	
Time:	
Weather:	
Temperature:	
Comments:	

Location of Placement _____

The Contractor certifies the above-proposed concrete placement is prepared as indicated and is in accord with the Contract Drawings and Specifications. The Contractor requests permission to begin placement of concrete on the date of _____ at _____. The estimated number of yards is _____. The estimated duration of the placement is _____.

By: _____
Contractor

Released for placement by: _____
Engineer

SECTION 03600

GROUTING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Cement grout.
   2. Cement mortar.
   3. Dry-pack mortar.
   4. Epoxy grout.
   5. Grout.
   6. Non-shrink epoxy grout.
   7. Non-shrink grout.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. C109 - Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (using 2-inch cube specimens).
   2. C230 - Standard Specification for Flow Table for Use in Tests of Hydraulic Cement.
   3. C531 - Standard Test Method for Liner Shrinkage and Coefficient of Thermal Expansion of Chemical-Resistant Mortars, Grouts, Monolithic Surfacings, and Polymer Concretes.
   4. C579 - Standard Test Method for Compressive Strength of Chemical-Resistant Mortars, Grouts, and Monolithic Surfacings and Polymer Concretes.
   5. C939 - Standard Test Method for Flow of Grout for Preplaced-Aggregate Concrete (Flow Cone Method).
   6. C942 - Standard Test Method for Compressive Strength of Grouts for Preplaced-Aggregate Concrete in the Laboratory.
   7. C1107 - Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Non-shrink).
   8. C1181 - Standard Test Methods for Compressive Creep of Chemical-Resistant Polymer Machinery Grouts.

B. International Concrete Repair Institute (ICRI):
   1. 310.2R - Selecting and specifying Concrete Surface Preparations for Sealers, Coatings, Polymer Overlays, and Concrete Repair.

1.03 SUBMITTALS

A. Cement grout:
   1. Mix design.
   2. Material Submittals.

B. Cement mortar:
   1. Mix design.
   2. Material Submittals.

C. Non-shrink epoxy grout:
   1. Manufacturer's literature.

D. Non-shrink grout:
   1. Manufacturer's literature.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials to jobsite in their original, unopened packages or containers, clearly labeled with manufacturer's product identification and printed instructions.

B. Store materials in cool dry place and in accordance with manufacturer's recommendations.

C. Handle materials in accordance with the manufacturer's instructions.

PART 2 PRODUCTS

2.01 MANUFACTURED UNITS

A. Non-shrink epoxy grout:
   1. Manufacturers: One of the following, or equal:
      a. Five Star Products, Inc., Five Star DP Epoxy Grout.
      b. L&M Construction Chemicals, Inc., EPOGROUT.
      c. Master Builder Solutions/Sika, MasterFlow 648.
   2. Non-shrink epoxy grout shall be 100 percent solid, premeasured, prepackaged system containing 2-component thermosetting epoxy resin and inert aggregate.
   3. Maintain flowable consistency for at least 45 minutes at 70 degrees Fahrenheit.
   4. Shrinkage or expansion: Less than 0.0006 inches per inch when tested in accordance with ASTM C531.
   5. Minimum compressive strength: 10,000 pounds per square inch at 24 hours and 14,000 pounds per square inch at 7 days when tested in accordance with ASTM C579, Method B.
   6. Compressive creep: Not exceed 0.0037 inches/per inch when tested under 400 pounds per square inch constant load at 140 degrees Fahrenheit in accordance with ASTM C1181.
   7. Coefficient of thermal expansion: Not exceed 0.000018 inches per inch per degree Fahrenheit when tested in accordance with ASTM C531, Method B.

B. Non-shrink grout:
   1. Manufacturers: One of the following, or equal:
      a. Five Star Products, Inc., Five Star Grout.
      b. L&M Construction Chemicals, Inc., CRYSTEX.
      c. Master Builder Solutions/Sika, MasterFlow 928.
   2. In accordance with ASTM C1107.
   3. Preportioned and prepackaged cement-based mixture.

4. Contain no metallic particles such as aluminum powder and no metallic aggregate such as iron filings.
5. Require only addition of potable water.
6. Water for pre-soaking, mixing, and curing: Potable water.
7. Free from emergence of mixing water from within or presence of water on its surface.
8. Remain at minimum flowable consistency for at least 45 minutes after mixing at 45 degrees Fahrenheit to 90 degrees Fahrenheit when tested in accordance with ASTM C230.
    a. If at fluid consistency, verify consistency in accordance with ASTM C939.
9. Dimensional stability (height change):
    a. In accordance with ASTM C1107, volume-adjusting Grade B or C at 45 degrees Fahrenheit to 90 degrees Fahrenheit.
    b. Have 90 percent or greater bearing area under bases.
10. Have minimum compressive strengths at 45 degrees Fahrenheit to 90 degrees Fahrenheit in accordance with ASTM C1107 for various periods from time of placement, including 5,000 pounds per square inch at 28 days when tested in accordance with ASTM C109 as modified by ASTM C1107.

2.02 MIXES

A. Cement grout:
    1. Use same sand-to-cementitious materials ratio for cement grout mix that is used for concrete mix.
    2. Use same materials for cement grout that are used for concrete.
    3. Use water-to-cementitious materials ratio that is no more than that specified for concrete.
    4. For spreading over surfaces of construction or cold joints.

B. Cement mortar:
    1. Use same sand-to-cementitious materials ratio for cement mortar mix that is used for concrete mix.
    2. Use same materials for cement mortar that are used for concrete.
    3. Use water-to-cementitious materials ratio that is no more than that specified for concrete being repaired.
    4. At exposed concrete surfaces not to be painted or submerged in water: Use sufficient white cement to make color of finished patch match that of surrounding concrete.

C. Dry-pack mortar:
    1. Proportions by weight: 1 part Portland cement to 2 parts concrete sand.
        a. Portland cement: As specified in Section 03300 - Cast-in-Place Concrete.
        b. Concrete sand: As specified in Section 03300 - Cast-in-Place Concrete.

D. Epoxy grout:
    1. Consist of mixture of epoxy or epoxy gel and sand.
        a. Epoxy: As specified in Section 03071 - Epoxies.
        b. Epoxy gel: As specified in Section 03071 - Epoxies.
        c. Sand: Clean, bagged, graded, and kiln-dried silica sand.

2. Proportioning:
    a. For horizontal work: Consist of mixture of 1 part epoxy with not more than 2 parts sand.
    b. For vertical or overhead work: Consist of 1 part epoxy gel with not more than 2 parts sand.

E. Grout:
    1. Mix in proportions by weight: 1 part Portland cement to 4 parts concrete sand.
        a. Portland cement: As specified in Section 03300 - Cast-in-Place Concrete.
        b. Concrete sand: As specified in Section 03300 - Cast-in-Place Concrete.

F. Non-shrink epoxy grout:
    1. Mix in accordance with manufacturer's installation instructions.

G. Non-shrink grout:
    1. Mix in accordance with manufacturer's installation instructions such that resulting mix has flowable consistency and is suitable for placing by pouring.

PART 3 EXECUTION

3.01 EXAMINATION

A. Inspect concrete surfaces to receive grout or mortar and verify that they are free of ice, frost, dirt, grease, oil, curing compounds, paints, impregnations, and loose material or foreign matter likely to reduce bond or performance of grout or mortar.

3.02 PREPARATION

A. Surface preparation for grouting other baseplates:
    1. Remove grease, oil, dirt, dust, curing compounds, laitance, and other deleterious materials that may affect bond to concrete and bottoms of baseplates.
    2. Roughen concrete surfaces in contact with grout to ICRI CSP-6 surface profile or rougher.
        a. Remove loose or broken concrete.
    3. Metal surfaces in contact with grout: Grit blast to white metal surface.

3.03 INSTALLATION

A. Mixing:
    1. Cement grout:
        a. Use mortar mixer with moving paddles.
        b. Pre-wet mixer and empty out excess water before beginning mixing.
    2. Cement mortar:
        a. Use mortar mixer with moving paddles.
        b. Pre-wet mixer and empty out excess water before beginning mixing.
    3. Dry-patch mortar:
        a. Use only enough water so that resulting mortar will crumble to touch after being formed into ball by hand.

4. Non-shrink epoxy grout:
    a. Keep temperature of non-shrink epoxy grout from exceeding manufacturer's recommendations.
5. Non-shrink grout:
    a. May be drypacked, flowed, or pumped into place. Do not overwork grout.
    b. Do not retemper by adding more water after grout stiffens.

B. Placement:
1. Cement grout:
    a. Exercise care in placing cement grout because it is required to furnish structural strength, impermeable water seal, or both.
    b. Do not use cement grout that has not been placed within 30 minutes after mixing.
2. Cement mortar:
    a. Use mortar mixer with moving paddles.
    b. Pre-wet mixer and empty out excess water before beginning mixing.
3. Epoxy grouts:
    a. Wet surfaces with epoxy for horizontal work or epoxy gel for vertical or overhead work prior to placing epoxy grout.
4. Non-shrink epoxy grout:
    a. Mix in complete units. Do not vary ratio of components or add solvent to change consistency of mix.
    b. Pour hardener into resin and mix for at least 1 minute and until mixture is uniform in color. Pour epoxy into mortar mixer wheelbarrow and add aggregate. Mix until aggregate is uniformly wetted. Over mixing will cause air entrapment in mix.
5. Non-shrink grout:
    a. Add non-shrink cement grout to premeasured amount of water that does not exceed the manufacturer's maximum recommended water content.
    b. Mix in accordance with manufacturer's instructions to uniform consistency.

C. Curing:
1. Cement based grouts and mortars:
    a. Keep continuously wet for minimum of 7 days. Use wet burlap, soaker hose, sun shading, ponding, and in extreme conditions, combination of methods.
    b. Maintain above 40 degrees Fahrenheit until it has attained compressive strength of 3,000 pounds per square inch, or above 70 degrees Fahrenheit for minimum of 24 hours to avoid damage from subsequent freezing.
2. Epoxy based grouts:
    a. Cure grouts in accordance with manufacturers' recommendations.
        1) Do not water cure epoxy grouts.
    b. Do not allow any surface in contact with epoxy grout to fall below 50 degrees Fahrenheit for minimum of 48 hours after placement.

D. Grouting equipment bases, baseplates, soleplates, and skids: As specified in Section 15050 - Common Work Results for Mechanical Equipment.

E. Grouting other baseplates:
1. General:
    a. Use non-shrink grout as specified in this Section.

b. Baseplate grouting shall take place from 1 side of baseplate to other in continuous flow of grout to avoid trapping air in grout.
c. Maintain hydrostatic head pressure by keeping level of grout in headbox above bottom of baseplate. Fill headbox to maximum level and work grout down.
d. Vibrate, rod, or chain non-shrink grout to facilitate grout flow, consolidate grout, and remove trapped air.

2. Forms and headboxes:
a. Build forms using material with adequate strength to withstand placement of grouts.
b. Use forms that are rigid and liquidtight. Caulk cracks and joints with elastomeric sealant.
c. Line forms with polyethylene for easy grout release. Coating forms with 2 coats of heavy-duty paste wax is also acceptable.
d. Headbox shall be 4 to 6 inches higher than baseplate and shall be located on 1 side of baseplate.
e. After grout sets, remove forms and trim back grout at 45 degree angle from bottom edges of baseplate.

3.04 FIELD QUALITY CONTROL

A. Non-shrink epoxy grout:
1. Test for 24-hour compressive strength in accordance with ASTM C579, Method B.

B. Non-shrink grout:
1. Test for 24-hour compressive strength in accordance with ASTM C942.

END OF SECTION

SECTION 05190

MECHANICAL ANCHORING AND FASTENING TO CONCRETE AND MASONRY

PART 1 GENERAL

1.01 SUMMARY

A. Section includes providing:
   1. Cast-in anchors and fasteners:
      a. Anchor bolts.
   2. Post-installed steel anchors and fasteners:
      a. Concrete anchors.

1.02 REFERENCES

A. American Concrete Institute (ACI):
   1. 355.2 - Qualification of Post-Installed Mechanical Anchors in Concrete & Commentary.

B. American National Standards Institute (ANSI):
   1. B212.15 - Cutting Tools - Carbide-tipped Masonry Drills and Blanks for Carbide-tipped Masonry Drills.

C. American Welding Society (AWS):
   1. D1.1 - Structural Welding Code - Steel.
   2. D1.6 - Structural Welding Code - Stainless Steel.

D. ASTM International (ASTM):
   1. A53 - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
   2. A108 - Standard Specification for Steel Bars, Carbon and Alloy, Cold Finished.
   3. A123 - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
   4. A153 - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
   5. A240 - Standard Specification for Chromium and Chromium Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
   6. A380 - Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems.
   7. A563 - Standard Specification for Carbon and Alloy Steel Nuts.
   8. B633 - Standard Specification for *Electrodeposited* Coatings of Zinc on Iron and Steel.
   9. B695 - Standard Specification for Coatings of Zinc Mechanically Deposited on Iron and Steel.
   10. E488 - Standard Test Methods for Strength of Anchors in Concrete Elements.
   11. F436 - Standard Specification for Hardened Steel Washers.

12. F593 - Standard Specification for Stainless Steel Bolts, Hex Cap Screws and Studs.
13. F594 - Standard Specification for Stainless Steel Nuts.
14. F1554 - Standard Specification for Anchor Bolts, Steel, 36, 55 and 105-ksi Yield Strength.
15. F2329 - Standard Specification for Zinc Coating, Hot-Dip, Requirements for Application to Carbon and Alloy Steel Bolts, Screws, Washers, Nuts, and Special Threaded Fasteners.

E. International Code Council Evaluation Service, Inc. (ICC-ES):
1. AC193 - Acceptance Criteria for Mechanical Anchors in Concrete Elements.

1.03 DEFINITIONS

A. Built-in anchor: Headed bolt or assembly installed in position before filling surrounding masonry units with grout.

B. Cast-in anchor: Headed bolt or assembly installed in position before placing plastic concrete around.

C. Overhead installations: Fasteners installed on overhead surfaces where the longitudinal axis of the fastener is more than 60 degrees above a horizontal line so that the fastener resists sustained tension loads.

D. Passivation: Chemical treatment of stainless steel with a mild oxidant for the purpose of enhancing the spontaneous formation of the steel's protective passive film.

E. Post-installed anchor: Fastener or assembly installed in hardened concrete or finished masonry construction, typically by drilling into the structure and inserting a steel anchor assembly.

F. Terms relating to structures or building environments as used with reference to anchors and fasteners:
1. Corrosive locations: Describes interior and exterior locations as follows:
    a. Locations used for delivery, storage, transfer, or containment (including spill containment) of chemicals used for plant treatment processes.
    b. Exterior and interior locations at the following treatment structures:
        1) Water treatment facilities--Liquids stream:
            a) Chlorine storage and feed rooms, and clearwells.
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 information listed for each type of anchor or fastener to be used.

B. Action submittals:
   1. Product data:
      a. Cast-in anchors:
         1) Manufacturer's data including catalog cuts showing anchor sizes and configuration, materials, and finishes.
      b. Post-installed anchors:
         1) For each anchor type, manufacturer's data including catalog cuts showing anchor sizes and construction, materials and finishes, and load ratings.
   2. Samples:
      a. Samples of each type of anchor, including representative diameters and lengths, if requested by the Engineer.
   3. Certificates:
      a. Cast-in anchors:
         1) Mill certificates for steel anchors that will be supplied to the site.
      b. Post-installed anchors:
         1) Manufacturer's statement or certified test reports demonstrating that anchors that will be supplied to the site comply with the materials properties specified.
   4. Test reports:
      a. Post-installed anchors: For each anchor type used for the Work:
         1) Current ICC-ES Report (ESR**)** demonstrating:
            a) Acceptance of that anchor for use under the building code specified in Section 01410 - Regulatory Requirements.
   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.
    2. Installers: Post-installed mechanical anchors:
        a. Conduct a training session with the manufacturer's authorized technical representative for the project on-site:
            1) Training shall cover the complete installation process for each type of anchor to be used and shall include, but not be limited to, hole drilling procedures and techniques, hole preparation and cleaning, bolt installation, and bolt proof loading and torquing.
            2) Use only trained and qualified personnel for anchor installation.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Deliver and install 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 anchors of materials as in this Section.

2.02 CAST-IN ANCHORS AND FASTENERS

A. Anchor bolts:
   1. Description:
      a. Straight steel rod having one end with an integrally forged head, and one threaded end. Embedded into concrete with the headed end cast into concrete at the effective embedment depth indicated on the Drawings or specified, and with the threaded end left to project clear of concrete face as required for the connection to be made.
      b. Furnish anchor bolts with heavy hex forged head or equivalent acceptable to Engineer.
         1) Rods or bars with angle bend for embedment in concrete (i.e., “L” or “J” shaped anchor bolts) are not permitted in the Work.
   2. Materials:
      a. Ship anchor bolts with properly fitting nuts attached.
      b. Type 316 stainless steel:
         1) Surfaces descaled, pickled, and passivated in accordance with ASTM A380.
         2) Bolts: ASTM F593, Group 2, Condition CW, coarse threads.
         3) Nuts: ASTM F594. Match alloy (group and UNS designation) and threads of bolts.
         4) Washers: Type 316 stainless steel.
      c. Galvanized steel:
         1) Hot-dip galvanized coating in accordance with ASTM F2329.
         2) Bolt: ASTM F1554, Grade 36 heavy hex, coarse thread.
         3) Nuts: ASTM A563, Grade A heavy hex, threads to match bolt.
         4) Washers: ASTM F436, Type 1.

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.
      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.

B. Concrete anchors:
   1. Description. Post-installed anchor assembly consisting of a threaded stud and a surrounding wedge expansion sleeve that is forced outward by torquing the center stud to transfer loads from the stud to the concrete through bearing, friction, or both. (Sometimes referred to as “expansion anchors” or “wedge anchors.”)
      a. Do not use slug-in, lead cinch, and similar systems relying on deformation of lead alloy or similar materials to develop holding power.
   2. Concrete anchors for anchorage to concrete:
      a. Acceptance criteria:
         1) Concrete anchors shall have a current ICC-ES Report demonstrating that the anchors have been tested and qualified for performance in both cracked and un-cracked concrete, and for short-term loading due to wind and seismic forces for Seismic Design Categories A through F in accordance with ACI 355.2 and with ICC-ES AC193 (including all mandatory tests and optional tests for seismic tension and shear in cracked concrete).
         2) Concrete anchor performance in the current ICC-ES Report shall be “Category 1” as defined in ACI 355.2.
      b. Manufacturers: One of the following or equal:
         1) Hilti, Kwik Bolt TZ Expansion Anchor.
         2) DEWALT/Powers, PowerStud.
         3) Simpson Strong-Tie, Strong Bolt 2 Wedge Anchor.
      c. Materials. Integrally threaded stud, wedge, washer, and nut:
         1) Stainless steel: Type 316.
         2) Galvanized: Carbon steel, zinc plated in accordance with ASTM B633, minimum 5 microns (Fe/Zn 5).

C. Flush shells:
   1. Description: Post-installed anchor assembly consisting of an internally threaded mandrel that is forced into a pre-drilled concrete hole with a setting tool until the top of the anchor is flush with the face of the concrete. Once installed, a removable threaded bolt is installed in the mandrel.
   2. Flush shell anchors are not permitted in the Work.

PART 3 EXECUTION

3.01 PROCUREMENT: POST-INSTALLED MECHANICAL ANCHORS

A. 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

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

3.02 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. “Other locations:”
      a. For connecting stainless steel members to concrete or masonry: Type 316 stainless steel.
      b. For connecting fiber-reinforced plastic (FRP) members to concrete or masonry.
   3. 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. Cast iron stop plank grooves.
   4. Concrete inserts.
   5. Handrails and guardrails.
   6. Ladders.
   7. Manhole frames and covers.
   8. Metal gratings.
   9. Metal tread plate.
   10. Preformed channel pipe supports.
   11. Stairs.
   12. Miscellaneous metals.
   13. 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. American Welding Society (AWS):
   1. A2.4 - Standard Symbols for Welding, Brazing, and Nondestructive Examination.

D. 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.

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. 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. Cast iron stop plank grooves.
   4. Handrails and guardrails.
   5. Manhole frames and covers.
   6. 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. Unless otherwise specified or indicated on the Drawings, structural and miscellaneous metals in accordance with the standards of the ASTM, including the following:

Item	ASTM Standard No.	Class, Grade Type, or Alloy No.
Cast Iron		
Cast iron	A48	Class 40B
Steel		
Galvanized sheet iron or steel	A653	Coating G90
Coil (plate)	A635	--
Structural plate, bars, rolled shapes, and miscellaneous items (except W shapes)	A36	--
Rolled W shapes	A992	Grade 50
Standard bolts, nuts, and washers	A307	--
High strength bolts, nuts, and hardened flat washers	F3125, Grade A325	--

Item	ASTM Standard No.	Class, Grade Type, or Alloy No.
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
Notes: * 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 indicated 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. American Safety Tread Co., Inc., Style 801 nosing.
      b. Wooster Products, Inc., Type 101 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. Cast iron stop plank grooves:
   1. Manufacturers: One of the following or equal:
      a. McKinley Iron Works, Type L.
      b. Neenah Foundry Co., R-7500 Series, Type A.
   2. Size: 2-inch wide groove opening by 1-1/2 inch deep, unless otherwise indicated on the Drawings.
   3. Recess groove with the cast iron surface of the groove set flush with the concrete surface.

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

E. Handrails and guardrails:
   1. General:
      a. Design and fabricate assemblies shall be in accordance with 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 the 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.
            a) AA DAF-25 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) Craneveyor Corp. Enerco Metals, C-V Rail.
    2) Golden Railings, Riveted System.
    3) Moultrie Manufacturing Co., Wesrail.

3. Guardrail gates:
    a. Supplied by the 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 accordance with OSHA minimum strength requirements.
4. Fastenings and fasteners: As recommended or furnished by the guardrail manufacturer for use with this system.

F. Ladders:
1. General:
    a. Type: Safety type in accordance with 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. Material: 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.
            a) AA DAF-45 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 fixed ladders over 24 feet high, provide a fall prevention system designed in accordance with state and OSHA requirements.

f. Fall prevention system: Including, but not limited to, railing, brackets, clamps, 2 sleeves, and 2 belts, in accordance with 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.

G. Manhole frames and covers:
1. Material: Gray iron castings, in accordance with ASTM A48, Class 30-B.
2. Type: Heavy-duty traffic type, with combined minimum set weight of 265 pounds.
3. Machine horizontal and vertical bearing surfaces to fit neatly, with easily removable cover bearing firmly in frame without rocking.
4. Frame:
    a. Bottom flange type.
    b. Approximately 4-1/2-inches frame height.
    c. Dimensions as indicated on the Drawings.
        1) Minimum inside clear dimension may not be smaller than nominal diameter minus 2 inches.
5. Cover:
    a. Skid-resistant grid pattern design stamped with name of utility service provided by manhole, such as ELECTRICAL, SEWER, TELEPHONE, or WATER.
    b. Solid type without ventilation holes.
6. Finish: Unpainted.

H. 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 the 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 the 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 the 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. Steel gratings:
   a. Hot-dip galvanized in accordance with ASTM A123.
   b. Bar size and spacing: As determined by the manufacturer to support design load.
   c. Design live load: A minimum of 100 pounds per square foot uniform live load on the entire area of the grating area, but not less than the live load indicated on the Drawings for the area where the grating is located.
   d. Maximum fiber stress for design load: 18,000 pounds per square inch.
   e. Maximum deflection under design load: 1/240 of grating clear span.
   f. Bar spacing: Maximum of 1-1/8 inches clear between bars.
   g. Manufacturers: The following or equal:
      1) Harsco Industrial IKG, IKG Weldforged.

4. Heavy-duty steel grating:
   a. 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.

I. Metal tread plate:
   1. Having a raised figured pattern on one surface to provide improved traction.

J. Preformed channel pipe supports:
   1. As specified in Section 15062 - Preformed Channel Pipe Support System.

K. 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. Handrails and guardrails: Aluminum pipe specified under the aluminum handrails and guardrails (nonwelded pipe) article.
      d. Fasteners: Type 304 or Type 316 stainless steel.
   2. Steel stairs:
      a. Ships ladders in accordance with local, state, and OSHA requirements as minimum.
      b. Stringers: Structural steel channels or plates.
      c. Treads: Open type attached to stringers with support angles and clips.
      d. Manufacturers: One of the following or equal:
         1) Harsco Industrial IKG, Welded Tread with Algrip® nosing.
      e. Railings: Steel pipe, sized as indicated on the Drawings.
      f. Anchors: Welded or bolted brackets designed for support and anchorage at top and bottom.
      g. Finish: Prime paint finish for interior locations.

L. 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.

M. Miscellaneous cast iron:
   1. Tough, gray iron, free from cracks, holes, swells, and cold shuts.
   2. Quality such that hammer blow will produce indentation on rectangular edge of casting without flaking metal.
   3. 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.

N. 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 be in accordance with 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.

O. Miscellaneous structural steel:
    1. Provide miscellaneous structural 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.

P. 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 the 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 on treads of concrete stairs, including top tread on upper concrete slab.
2. Omit where concrete is submerged.
3. Cast in fresh concrete, flush with tread and riser faces. Install nosing in center of step.

C. Cast iron stop plank grooves:
1. Recess stop plank grooves with cast iron surfaces of groove set flush with concrete surface.

D. 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 the Engineer or 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 the Drawings or in the manufacturer's installation instructions.
m. Completed installation shall have handrails and railings rigid and free of play at joints and attachments.
n. Protect handrail and guardrail finish from scratches, gouges, dents, stains, and other damage.
o. Replace damaged or disfigured handrails and guardrails with new.

p. Shortly before final acceptance of the Work, and after removal of protective polyethylene film, clean handrails and guardrails with mild detergent or with soap and water.
1) After cleaning, thoroughly rinse handrails and guardrails and wipe with soft cloth.
q. Erect guardrail straight, level, plumb, and true to the positions as indicated on the Drawings. Correct deviations from true line of grade, which are visible to the eye.

3. Steel pipe handrail and guardrail:
a. Anchor posts into concrete by grouting posts into galvanized steel sleeves embedded in concrete as indicated on the Drawings.
1) Do not cut reinforcing bars in concrete.
2) Where required to fasten guardrail to other construction, fasten as indicated on the Drawings.

4. 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 accordance with OSHA minimum strength requirements.

E. 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.

F. Manhole frames and covers:
1. Installation: As recommended by the manufacturer.

G. 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. Support on aluminum shelf angles or rebates.
3. Steel grating:
    a. Support on hot-dip galvanized structural steel shelf angles or rebates.
4. 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.

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

I. 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 06651

FIBERGLASS REINFORCED POLYESTER BAFFLES AND APPURTENANCES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Furnish and install fiberglass reinforced polyester (FRP) Clearwell Baffles and miscellaneous components for a complete installation.
   2. The work consists of furnishing and installing FRP baffles, support structures and miscellaneous components.

1.02 DESCRIPTION

A. Scope:
   1. The installation of the baffles shall be conducted while the clearwells are in operation. Access to the clearwells shall be by the single existing hatch in each clearwell.
   2. The clearwells contain disinfected potable water—all tools, materials, divers shall be disinfected prior to clearwell entry.
   3. All products shall be provided from a single manufacturer who shall provide all materials and incidentals as shown, specified, and required to furnish FRP baffles complete with all anchor bolts, fasteners, and accessories.
   4. Baffles, all other hardware, and incidentals shall be NSF 61 certified.
   5. The materials shall include, but not be limited to, the following items:
      a. FRP baffle panels.
      b. FRP structural framing members.
      c. Fasteners for FRP framing.
      d. Fasteners for attaching FRP baffles to FRP framing members.
      e. Anchor bolts and anchorage devices, which are to be embedded in cast in place concrete.
      f. NSF 61 caulking to reduce incidental bypassing of the baffles.
      g. Any other incidental materials required for the complete baffle system.
   6. The design of the baffle system shall be made to allow ease of installation in underwater conditions, within the operational clearwells.
   7. The baffle components shall be sized to be passed into the clearwell hatches as shown on the drawings.
   8. The proper installation of the baffle walls shall be documented by videos and photographs.

1.03 QUALITY ASSURANCE

A. Manufacturer's qualifications:
   1. Manufacturer shall maintain a continuous quality control program in the manufacture of items furnished under these Specifications.

2. Manufacturer shall have a minimum of five years of experience producing substantially similar equipment and shall show evidence of at least five installations in satisfactory operation.

B. Installer's qualifications:
   1. Installer shall have a minimum of five years of experience installing baffle walls within operational water treatment plants.

1.04 SUBMITTALS

A. Shop drawings:
   1. All submittals shall be in accordance with Section 01330 - Submittal Procedures.
   2. Submit manufacturer's literature, illustrations, specifications, and engineering data including materials of construction, dimensions, weight, and performance data.
   3. Drawings showing the general arrangement of the baffle walls and methods of installation with detailed anchoring information. Indicate provisions for thermal expansion and contraction, and the capability to sustain all external and internal loads that may be applied during construction and operation.
   4. Submit proposed disinfection method for divers and materials.
   5. Submit draft and final Operations and Maintenance manual for the baffle walls. Manual shall include manufacturer's literature; final approved shop drawings; warranty information; and maintenance and care recommendations. Three copies of the final manual shall be supplied in addition to an electronic copy.

B. Calculations: Submit design calculations, signed and sealed by a registered engineer for the following:
   1. Maximum lateral deflection.
   2. Vertical load deflection.
   3. Maximum stress developed in baffle walls.
   4. Stress at anchor bolts.

C. Documentation:
   1. Submit evidence that manufacturer has fabricated, supplied, and placed into satisfactory service materials equipment substantially similar to that specified herein. Criteria shall be a minimum of five installations in satisfactory service.
   2. Submit evidence that the installer has the specified experience. Criteria shall be a minimum of five years of experience with five installations successfully completed.
   3. Submit specified videos and photographs to document proper installation.

1.05 PRODUCT DELIVERY, PACKAGING FOR STORAGE, AND HANDLING

A. Deliver materials to the site and unload in a location designated by the Owner.

B. Packaging of Materials for Shipment:
   1. Tightly band baffle plates or suitably package to prevent damage during handling and shipping. Place fiberboard or plastic corners at edges of fabrications to prevent damage from bands.

2. Materials should be packaged to protect the surface of FRP units from cuts, scratches, gouges, abrasions, and impacts.

C. Storage Packing and Identification for Storage: Materials shall be stored flat and level. Package materials to permit ease of inspection and identification.

D. Replace all materials damaged during shipment or unloading to the satisfaction of the Engineer or Owner.

PART 2 PRODUCTS

2.01 SERVICE CONDITIONS AND DESIGN CRITERIA

A. General:
1. Baffles to be constructed of pultruded FRP resin components and to the dimensions and shapes shown.
2. Baffles shall be specifically designed, constructed, and installed to comply with the service conditions specified herein.
3. Contractor shall coordinate the design and supply of materials to allow for ease of the installation of the baffle panels onto the support columns and FRP angles. This work will be done underwater, with the clearwells in operation.
4. Dimensions and elevations shown on the Drawings are based upon the Engineer's design.
5. Contractor shall coordinate the Manufacturer’s design to allow for underwater adjustments to dimensions and elevations that may slightly differ from those shown on the Drawings.

B. Service requirements:
1. Service: Potable Water.
2. Ambient temperature range: 40 to 120 degrees Fahrenheit.
3. pH range: 6 to 8.5.
4. Chlorine residual range: 0 to 12 mg/L.

C. Loadings: Baffle walls shall be capable of supporting, within stress and deflection limitations, the following loads:
1. Vertical loads: All downward vertical loads including the weight of the baffles above and appurtenant attachments. All baffles shall be designated to accommodate the dead load of the baffle above and shall be interchangeable.
2. Lateral load: Loads acting against the baffle walls, specifically, those induced by differential water levels on either side of the baffle walls. Minimum differential for design shall be 2 inches.
3. When calculating deflection, fiber stress, and other critical properties, use the maximum possible differential based on the conditions specified.

D. Deflection: Baffles shall be designed for the following deflection criteria based on the worst-case loads:
1. Length/deflection = 100 for lateral loads.
2. Length/deflection = 360 for vertical loads.

E. Thermal expansion/contraction: Design baffles to accommodate a thermally induced expansion or contraction in length over the ambient temperature range specified herein. Baffles shall be capable of withstanding ambient temperature variations of up to 80 degrees Fahrenheit that could occur within a 24-hour period without exceeding specified deflection or stress limitations.

F. Seismic conditions: The baffle system is not intended to withstand a seismic event.

2.02 DETAILS OF CONSTRUCTION

A. Panels:
   1. FRP baffle panels shall be pultruded, 24-inch-wide panel.
   2. Baffle panel thickness to be a minimum of 3/16-inch nominal.

B. Posts:
   1. Manufacturers: One of the following or equal:
      a. Fibergrate, Dynaform.
      b. Strongwell - Bristol Division, Bristol, VA., EXTREN.
   2. Materials:
      a. Structural shapes and plate shall be made from vinyl ester resin with fire retardant additives to meet a flame spread rating of less than 25 per ASTM E84 and meet the self-extinguishing requirements of ASTM D635. All structural shapes shall contain a UV inhibitor.
      b. Structural FRP members' composition shall consist of a glass fiber reinforced polyester or vinyl ester resin matrix, approximately 50 percent glass by weight. A synthetic surface veil shall be the outermost layer covering the exterior surfaces. Glass strand rovings shall be used internally for longitudinal strength. Continuous strand glass mats or stitched reinforcements shall be used internally for transverse strength.
      c. Pultruded structural shapes are to have the minimum longitudinal mechanical properties listed below:

Property	ASTM Method	Value	Units
Tensile Strength	D638	30,000 (206)	psi (MPa)
Tensile Modulus	D638	2.5×10^6 (17.2)	psi (GPa)
Flexural Strength	D790	30,000 (206)	psi (MPa)
Flexural Modulus (min)	D790	1.6×10^6 (12.4)	psi (GPa)
Flexural Modulus (Full Section)	N/A	2.8×10^6 (19.3)	psi (GPa)
Short Beam Shear (Transverse)	D2344	4,500 (31)	psi (MPa)
Shear Modulus (Transverse)	N/A	4.5×10^5 (3.1)	psi (GPa)
Coefficient of Thermal Expansion	D696	4.4×10^{-6} (8.0×10^{-6})	in/in/°F (cm/cm/°C)
Flame Spread	E84	25 or less	N/A

C. Resin: The resin shall be a premium grade, chemically resistant isothalic polyester resin.

D. Glass reinforcing: Panels shall be reinforced with continuous glass fibers, to meet the loading requirement with a minimum glass content of 50 percent by weight.

E. Hardware:
   1. All fasteners and related metallic hardware to be type 316 stainless steel, minimum.
   2. Anchors to be epoxy adhesive type anchors, 3/8-inch minimum for slide guide anchors and 1/2-inch diameter for any column baseplate.
   3. Provide appropriate isolation kits to prevent corrosion caused by contact of dissimilar metals.

F. Mechanical and physical properties of the laminate shall equal or exceed those listed below:

LAMINATE MECHANICAL AND PHYSICAL PROPERTIES

Tensile Strength, psi x 10^3 (min.)	30,000
Flexural Strength, psi x 10^3 (min.)	30,000
Flexural Modulus, psi x 10^6 (min.)	2.5
Barcol Hardness (min.)	45
Water Absorption, % max.	0.6

2.03 MANUFACTURER

A. Manufacturer: Provide fiberglass reinforced plastic baffle walls and structural members manufactured by the following or approved equal:
   1. Enduro Composites.

PART 3 EXECUTION

3.01 DOCUMENTATION OF PROPER INSTALLATION

A. Provide a combination of videos and photographs to demonstrate that:
   1. Every baffle wall is located and spaced as per the Drawings.
   2. Every baffle wall is installed at the elevation as per the Drawings.
   3. Materials, such as panels, columns, and angles are installed as per the Submittals and Drawings.
   4. Location, spacing, and height of baffle walls shall be demonstrated by visible means on the videos and photographs.

END OF SECTION

SECTION 09960

HIGH-PERFORMANCE COATINGS

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ATTACHMENT A - SCHEDULE OF SURFACES TO BE COATED

ATTACHMENT B - COATING DETAIL SHEETS

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 perform surface repairs, surface preparations, and apply coating systems as 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. The 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. A380 - Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems.
      b. A780 - Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings.
      c. D16 - Standard Terminology for Paint, Related Coatings, Materials, and Applications.
      d. D2200 - Standard Practice for Use of Pictorial Surface Preparation Standards and Guides for Painting Steel Surfaces.
      e. D3359 - Standard Test Methods for Rating Adhesion by Tape Test.
      f. D3960 - Standard Practice for Determining Volatile Organic Compound (VOC) Content of Paints and Related Coatings.
      g. D4262 - Standard Test Method for pH of Chemically Cleaned or Etched Concrete Surfaces.
      h. D4263 - Standard Test Method for Indicating Moisture in Concrete by the Plastic Sheet Method.
      i. D4285 - Standard Test Method for Indicating Oil or Water in Compressed Air.
      j. D4414 - Standard Practice for Measurement of Wet Film Thickness by Notch Gages.
      k. D4417 - Standard Test Methods for Field Measurement of Surface Profile of Blast-Cleaned Steel.
      l. D4787 - Standard Practice for Continuity Verification of Liquid or Sheet Linings Applied to Concrete Substrates.

m. D5162 - Standard Practice for Discontinuity (Holiday) Testing of Nonconductive Protective Coating on Metallic Substrates.
n. D7234 - Standard Test Method for Pull-Off Adhesion Strength of Coatings on Concrete Using Portable Pull-Off Adhesion Testers.
o. E337 - Standard Test Method for Measuring Humidity with a Psychrometer (the Measurement of Wet- and Dry-Bulb Temperatures).
p. F1869 - Standard Test Method for Measuring Moisture Vapor Emission Rate of Concrete Subfloor Using Anhydrous Calcium Chloride.
q. 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.
   b. 600 - Health Effects Evaluation and Criteria For Chemicals In Drinking Water.
6. Occupational Safety and Health Administration (OSHA).
7. Society for 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 - Field Application of Coatings to Complex Industrial and Marine Structures.
   g. QP 3 - Shop Application of Complex Protective Coating Systems.
   h. SP 1 - Solvent Cleaning.
   i. SP 2 - Hand Tool Cleaning.
   j. SP 3 - Power Tool Cleaning.
   k. SP 5 - White Metal Blast Cleaning.
   l. SP 7 - Brush-Off Blast Cleaning.
   m. SP 10 - Near-White Metal Blast Cleaning.
   n. SP 11 - Power Tools Cleaning to Bare Metal.
   o. SP 13 - Surface Preparation of Concrete.
   p. SP 16 - Brush-Off Blast Cleaning of Coated and Uncoated Galvanized Steel, Stainless Steels, and Non-Ferrous Metals.
   q. SP VIS 1 - Guide and Reference Photographs for Steel Surfaces Prepared by Dry Abrasive Blast 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. Dew point: Temperature a given air/water vapor mixture starts to condense.
   7. Dry to recoat: Time interval between material application and its ability to receive the next coat.
   8. Dry to touch: Time interval between material application and its ability to tolerate a light touch without coating damage.
   9. Drying time: Time interval between application and material curing.
   10. Exposed surface: Any indoor or outdoor surface not buried or encased.
   11. Feather edging: Reducing coating thickness at its edge to blend with existing surrounding coating.
   12. Ferrous: Cast iron, ductile iron, wrought iron, and all steel alloys, except stainless steel.
   13. Field coat: Application of a surface coating system at the work site.
   14. Finish coat: Final coat in a paint system, including texture, color, smoothness of surface, and other properties affecting appearance.
   15. Hold point: A defined point, specified in this Section, at which Work shall be halted for inspection.
   16. Holiday: A discontinuity, skip, void, or pinhole in coating or coating system film that exposes the substrate.
   17. Honeycomb: Segregated and porous surface of hardened concrete due to insufficient consolidation.
   18. Hydroblast: High or ultra-high-pressure water jet surface preparation.
   19. Immersed/Immersion: A service condition in which substrate is submerged, is immediately above liquids, or is subject to frequent wetting, splashing, or washdown.
   20. 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.
   21. Laitance: A thin, weak, brittle layer of cement and aggregate fines on a concrete surface.
   22. Mil: 0.001 inch.
   23. Overspray: Dry spray, particularly paint bonded to an unintended surface.
   24. Pinhole: A small diameter discontinuity in a coating or coating system film, created by off gassing 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.

25. Pot life: Time interval after components are mixed and coating can be satisfactorily applied.
26. 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.
27. 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.
28. Shop coat: One or more coats applied in an off-site shop or plant before shipment to work site where field or finishing coat(s) are applied.
29. 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 the previous coats have cured. Once applied, the coat shall be allowed to cure before subsequent coats are applied.
30. System: Protective film with one or more coats applied in a predetermined order, including surface preparation and quality control requirements.
31. Thick film coating system: A coating system applied with a minimum dry film thickness of 25 mils.
32. 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.
33. 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.
34. 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. Methods for tenting blasting areas and methods to protect existing equipment from dust and debris.
   5. Abrasives and abrasive blast cleaning disposal.
   6. Product data, application, and safety data sheets.
   7. NSF certification of coatings for potable water supply systems, including NSF 600 and/or NSF 61.
   8. Compliance with regulatory requirements:
      a. VOC limitations.
      b. Hazardous lead compounds and polychlorinated biphenyls (removal and disposal methods).
   9. Manufacturer’s standard color samples.

10. 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.
11. 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.
12. Thick film coating systems (greater than 25 mils):
    a. 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.
    b. Include detailed treatment for coating system at concrete joints.
13. Quality assurance Submittals:
    a. Quality assurance plan.
    b. Qualifications:
        1) Field coating applicator includes:
            a) Provide a minimum of 5 project references where similar coating work has been performed by the company in the past 5 years:
                (1) Name and address of project.
                (2) Year of installation.
                (3) Year placed in operation.
                (4) Point of contact: Name and phone number.
            b) SSPC-QP 1 certified as required.
        2) Shop coating applicator includes:
            a) Provide a minimum of 5 project references where similar coating work has been performed by the company in the past 5 years:
                (1) Name and address of project.
                (2) Year of installation.
                (3) Year placed in operation.
                (4) Point of contact: Name and phone number.
            b) SSPC-QP 3 certified as required.
    c. Field Quality Control:
        1) Provide certification letters from NACE Certified Level 3 Coating Inspector for surface preparation and coating application conformance with these specifications for any field-applied procedures performed as may be applicable to the Project.
        2) Indicate results of applicators furnished tests and inspections, including, but not limited to, ambient environmental conditions, surface cleanliness, surface profile, DFT measurements, holiday testing, etc.
    d. CSA reports:
            a) Written daily quality control inspection reports.
            b) Reports to observe and approve surface preparation of structures to be coated.
            c) Reports to observe and approve coating application procedures.
            d) Reports on visits to plants to observe and approve surface preparation and coating application on shop-coated items.
14. For each substituted coating material "equal" to specified product in the coating tabulation:
    a. List of not less than 5 similar successful material applications:
        1) Project name, location, type of structure, and application dates.

2) Owner's name, address, and telephone number.
b. Certification that material meets or exceeds specified requirements:
1) Manufacturer's certification, including technical representative's signature and date of signature.
2) Independent laboratory's certified test reports.

1.05 QUALITY ASSURANCE

A. Coating inspector:
1. CSA inspector and/or third-party inspector shall be trained and knowledgeable in the specified coating's application.
2. Provide calibrated inspection instruments and demonstrate use as required.
3. Applicator's quality assurance inspector foreman shall oversee all aspects of coating work and shall be NACE Level III certified or an SSPC Protective Coatings Inspector (PCI).
a. Oversees lesser qualified inspectors and provides them training and guidance for testing and report preparations, provides documentation for all inspection equipment showing calibrations, and verifies the equipment is free from damage and is in proper working condition.

B. Regulatory requirements: Comply with governing agencies' regulations by using coatings in accordance with 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.

C. Obtain approval before coating other surfaces. Use products by the same manufacturer for prime coats, intermediate coats, and finish coats on same surface, unless specified otherwise. Coatings must be compatible with one another and complete a cohesive coating system.

D. Quality control requirements:
1. Applicator shall be responsible for the workmanship and quality of the coating system installation.
a. Inspections by the Owner, Engineer, or CTR will not relieve or limit the CSA'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 the Owner's or Engineer's personnel.
7. Provide ventilation, ingress, egress, or other means as necessary for the 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 the 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 the 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 specified 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.

E. 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 the Contractor's inspections on a scheduled basis.

3. Provide the Engineer with a minimum of **24** hours of notice before conducting Hold Point inspections.
4. Hold Points shall be as follows:
    a. Conditions before surface preparation: Before starting surface preparation, observe, record, and confirm that oil, grease, and/or soluble salts are gone from the surface.
    b. Post surface preparation: After completing surface preparation, measure and inspect for cleanliness and proper surface profile as specified in this Section and in the CSM's written instructions.
    c. Coatings application: At the beginning of any 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.
    d. Post application inspection: Identify defects in application work on all surfaces, including pinholes, holidays, excessive runs, or sags, inadequate or excessive film thickness, and other problems.
    e. Follow-up corrective actions and final inspection: Measure and re-inspect corrective coating work performed to repair defects at prior Hold Points and repeat until the surface condition is acceptable. Conduct final visual inspection with follow-up tests, such as holiday detection, adhesion tests, and DFT surveys.
    f. 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. As specified in Section 01600 - Product Requirements.

B. Immediately remove unspecified and unapproved coatings from the Project Site.

C. Deliver new, labeled, unopened containers:
1. Do not deliver materials after the 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.

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 the manufacturer allows a lower temperature.
b. Is less than 65 degrees Fahrenheit for clear finishes unless the manufacturer allows a lower temperature.
c. Exceeds 90 degrees Fahrenheit unless the manufacturer allows a higher temperature.
d. Exceeds the 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 in accordance with the 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. 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 generators.
    c. Locate engine generator outside hazardous classified areas in accordance with NFPA 820.
    d. Provide daily fuel service for generators for duration of use.
2. 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.
3. 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.
4. Filters:
    a. Use a filtration system for dust removal designed to not interfere with the 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.
5. 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 extra materials:
1. Minimum 1 gallon of each type and color of coating applied or provide additional quantities if specified in the Contract Documents:
    a. Deliver unopened factory-labeled cans when the manufacturer packages material in gallon cans.
    b. Deliver material in new gallon containers, properly sealed and identified with permanently affixed, durable, printed labels indicating brand, type, and color, when the manufacturer does not package material in gallon cans.

1.09 TECHNICAL REPRESENTATIVES' RESPONSIBILITIES

A. General:
   1. Attend pre-installation conference.
   2. Perform on-site application training.

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. 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.
   3. Provide special training as specified in the coating detail sheets.
   4. Visit the Site at the following intervals:
      a. On the first day of application of any coating system.
      b. As necessary during surface preparation and application to ensure installations are made in accordance with the manufacturer's recommendations.
      c. As required to resolve field problems attributed to or associated with the manufacturer's products.
   5. 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.
      a. Be on site to periodically observe and oversee:
         1) Coating application.
         2) End of surface preparation.
         3) During coating application.
         4) Post-cure inspection.
      b. Conduct final review of completed coating system installation and submit detailed report to the Engineer.

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 encounter water distributed as potable water shall be certified in accordance with NSF 61.

2.02 MATERIALS

A. General:
   1. 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. BG: Below grade or buried.
   b. BSC: Biogenic sulfide corrosion-resistant applications in wastewater.
   c. OZ: Organic zinc primer, epoxy polyurethane system.
   d. PWS: Potable water service applications (NSF-61 approved).
   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.
   2. Use clean white cloths and clean fluids in solvent cleaning.

PART 3 EXECUTION

3.01 GENERAL PROTECTION REQUIREMENTS

A. Protect adjacent surfaces from coatings and damage associated with coating work and repair any damage that occurs.

B. Place coating waste, cloths, and material that may pose a fire hazard in closed metal containers and remove daily from the Site.

C. 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.

D. Erect and maintain protective enclosures in accordance with SSPC-Guide 6.

E. 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.

3.02 GENERAL SURFACE PREPARATION REQUIREMENTS

A. Prepare surfaces in accordance with coating detail sheets in Attachment B - Coating Detail Sheets.
   1. Include coating and surface preparation requirements.
   2. CSM’s instructions will also have surface preparation requirements but follow the more stringent if information conflicts.

3.03 CLEANING OF NEW SURFACES

A. Complete final surface preparation before applying the new coating system in accordance with the manufacturers printed instructions.

3.04 PREPARATION REQUIREMENTS BY SURFACE TYPE

A. Galvanized steel and non-ferrous metal surfaces:
   1. Degrease or solvent clean (SSPC-SP 1) to remove oily residue.
   2. Abrasive blast clean in accordance with SSPC-SP 16.
      a. If abrasive blast cannot be performed, abrade in accordance with SSPC-SP 3.
   3. Apply metal pretreatment within 24 hours before coating galvanized surfaces that cannot be thoroughly abraded, such as bolts, nuts, or preformed channels.
   4. Test surface for contaminants using copper sulfate solution.

B. 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.

3.05 APPLICATION REQUIREMENTS

A. Apply coatings in accordance with the manufacturer’s instructions.

B. Empty aboveground piping to be coated of contents when applying coatings.

C. 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 the CSM-recommended amount.
   2. Equip spray equipment with properly sized mechanical agitators, pressure gauges, pressure regulators, and spray nozzles.

D. Where 2 or more coats are required, tint prime coat intermediate coats as necessary to distinguish each coating and to help indicate coverage.

E. Apply coating by brush, roller, trowel, or spray, unless a specific application method is required by the coating manufacturer’s instructions or these Specifications.
   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. After the prime coat dries, mark, repair, and retest pinholes and holidays before intermediate or topcoats are applied.

F. 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 a thickness no greater than recommended in the coating manufacturer's instructions.
   3. Use airless spray method unless air spray method is required by the CSM's instruction or these Specifications.
   4. Conduct spray coating under controlled conditions. Protect adjacent construction and property from coating mist, fumes, or overspray.

G. Brush, roll, trowel, or spray and back roll coats for concrete and masonry.

H. 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 the Engineer when requested.

I. Drying and recoating:
   1. Provide 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, the CSM's printed instructions before recoating.
   3. Use the CSM's printed instructions and the requirements specified in this Section to determine the minimum required drying time.
      a. Recoat coatings within time limits recommended by CSM.
      b. If time limits are exceeded, abrasive blast clean and de-gloss clean before applying another coat.
   4. Ensure primer and intermediate coats of coating are unscarred and completely integral when applying each succeeding coat.
   5. Touch up suction spots between coats and apply additional coats where required to produce finished surface of solid, even color, free of defects.
   6. Repair holidays in accordance with the requirements on pertinent Coating Detail Sheets or as recommended by the CSM.
   7. Sand and feather to a smooth transition and recoat scratched, contaminated, or otherwise damaged coating surfaces so repairs are invisible to the naked eye.

J. Workmanship:
   1. Ensure that coated surfaces are free from runs, drips, ridges, waves, laps, dry spray, and brush marks. Coats shall be applied to produce a smooth, even film of uniform thickness completely coating corners and crevices.
   2. Evenly apply each coat of material and sharply cut to a line created with masking tape or other suitable materials.
   3. 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.

4. Ensure that the finish coat, including repairs, has a uniform color and gloss.

K. Coating properties, mixing, and thinning:
   1. If maximum recoat time is exceeded, prepare surface with solvent washing, light abrasive blasting, sanding, or other procedures in accordance with the CSM's instructions.
   2. Allow adequate drying time between coats as instructed by the CSM, adjusted as necessary for the Site conditions.
   3. 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.
   4. Mix coatings with 2 or more components in accordance with the CSM's instructions.
   5. Where necessary to suit conditions of the surface, temperature, weather, and method of application, thin the coating in accordance with the 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.

L. 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 20 percent on the low end and 120 percent on the high end 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 thickness per coat.

M. 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.

N. 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 surfaces in contact with concrete.

3.06 COATING SYSTEMS

A. Attachment A - Schedule of Surfaces to be Coated specifies surfaces to be coated in the field with the coating systems required.

3.07 SURFACES NOT REQUIRING COATING

A. Galvanized structural steel framing, galvanized roof decking, galvanized pipe supports.

B. Copper and brass pipe, fittings, valves, etc.

C. Bronze valves, bearings, bushings, and fasteners.

D. Corrosion resistant special alloys: Inconel, Alloy 20, Hastelloy, etc.

3.08 QUALITY CONTROL

A. CSA to perform, or contract with an inspection agency to perform, quality control inspection and testing of the coating work covered by this Section. These inspections shall include the following:
    1. Prepare reports, after daily coating work ends, summarizing each day's test data, observations, drawings, and photographs.
    2. 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) 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 substrate profile (anchor pattern).
            5) Measure and record ambient air and substrate temperature.
            6) Measure and record relative humidity.
            7) Verify that mixing of coating system materials is in accordance with the CSM's instructions.
            8) Inspect, confirm, and record that the coating system materials' "pot life" is not exceeded during installation. Inspect to verify that recoat limitations for coating materials are not exceeded.

9) Perform adhesion testing.
10) Measure and record the coating system's thickness.
11) Verify proper curing of the coating system in accordance with the CSM's instructions.
12) Holiday or continuity testing in accordance with NACE SP0188 for coatings that will be immersed or exposed to aggressively corrosive conditions.
13) Prepare and submit written reports directly to the Owner's representative at the shift's end:
    a) Reports shall identify observations and testing relative to the quality of the surface preparation and painting/coatings work.
    b) Reports shall address any conditions observed which have the potential to adversely impact the finished painting/coating system integrity and performance.
    c) Any such findings shall be immediately repaired.

B. Owner-provided inspection or inspection by others does not limit the required Contractor's or CSA's responsibilities for quality workmanship or quality control. Owners' inspection is in addition to any inspection performed by the applicator.

3.09 CORRECTIVE MEASURES

A. Repair pinholes or holidays identified by holiday testing as follows:
1. Remove coating system at pinholes and holidays at least 2-inches diameter around the defect back to expose substrate.
2. 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 the CSM's recommendations.
3. Aggressively abrade or sand the intact coating system surfaces 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.
4. Remove dust, dirt, etc., leaving clean, sound surfaces.
5. Tape to mask the periphery of the prepared intact coating area to prevent coating repair application onto the prepared area.
6. 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.
7. Follow curing time between coats as specified by the CSM for the Site conditions. Solvent wash and abrasive blast in accordance with the CSM's instructions if the maximum recoat time is exceeded.
8. Apply coating at specified dry film thickness.

3.10 CLEANUP

A. Remove surplus materials, protective coverings, and accumulated rubbish after completing coating. Thoroughly clean surfaces and repair overspray or other coating-related damage.

3.11 FINAL INSPECTION

A. Conduct final inspection of coating system work to determine whether it meets specifications requirements.

B. Conduct subsequent final inspection with the Engineer to ensure Work is in accordance with Contract Documents requirements.

C. Mark any rework required.
   1. Re-clean and repair, as specified, at no additional cost to the Owner.

END OF SECTION

ATTACHMENT A - SCHEDULE OF SURFACES TO BE COATED

ATTACHMENT A
Schedule of Surfaces to be Coated

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

ACR-PVC-1	Chemical Feed Lines

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 SHEETS

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 09963

CORROSION PROTECTIVE COATING FOR CONCRETE STRUCTURES

PART 1 GENERAL

1.01 SUMMARY

A. Purpose
   1. This document is a specification requirement for coating systems selection, surface preparation, application, and quality control for new concrete and existing concrete with severe corrosion exposure.

B. Scope
   1. This document specifies industrial coatings for application in severe corrosion exposures for concrete containment and pads. Coating systems are selected for field painting new and maintenance or rehabilitation of existing concrete, described in the drawings and specification sections.

1.02 SUBMITTALS

A. Product Data: Manufacture's data, application, and SDS sheets for each product to be used, including:
   1. Surface preparation instructions and recommendations.
   2. Storage and handling requirements and recommendations.
   3. Application/Installation methods.

B. Qualifications:
   1. Five years minimum experience applying coatings like those specified.
   2. The personnel performing the work shall be knowledgeable and skilled. They shall have the required manufacture's training and certifications to apply the specified coatings in accordance with SSPC-PA1, "Shop, Field, and Maintenance Painting".

C. Manufacturer's certification of applicator.

D. Manufacturer's written warranty.

E. Contractor Certification Letter stating that:
   1. The Contractor accepts responsibility for products and the installation of the products as specified in this Section.

F. Applicator and superintendent qualifications.

1.03 CLEANING AND PREPARATION

A. The contractor shall inspect surfaces specified to receive coating system prior to surface cleaning and preparation.

B. Existing Coating Removal and Cleaning:
   1. Clean existing concrete prior to rehabilitation using high-pressure water jetting, as recommended by coating product manufacturer, and approved by the Engineer. Neutralize substrate and wash off residue when chemical cleaning to a pH 7.
   2. Entirely remove previously applied cured-in-place corrosion protective coatings using abrasive blasting prior to performing other surface preparation activities.

C. Surface preparation of concrete surface to be coated:
   1. Remove dust, loose particles, corroded or damaged materials, oils, grease, curing compounds, chemical contaminants, paints, prior to application of the approved coating.
   2. Caution: Cleaning and preparation activities (e.g., water blasting and/or abrasive blasting) may cause damage to certain materials and finishes.
      a. Contractor is solely responsible to protect portions of the concrete (including appurtenances and attachments) that are not slated for such cleaning and preparation activities from damage and shall be responsible to repair any damage caused by the cleaning and preparation activities.
   3. Additional concrete cleaning methods may be used, subject to the Engineer's approval, as necessary to thoroughly clean and prepare the concrete for the coating system.
      a. Other methods are high-pressure water jetting, shot blasting, grinding, mechanical removal methods, chemical cleaning, detergent cleaning, hot water blasting, and acid etching.
   4. Suitably prepared concrete surface:
      a. Loose, soft, discolored, or otherwise deteriorated material removed from the structures.
      b. Surface profile in accordance with ICRI Guideline No. 03732. Expose aggregate and obtain a uniform surface texture resembling an ICRI-CSP (Concrete Surface Profile) # 3-6 and in accordance with coating manufacturer's instructions for surface preparations.
      c. Engineer shall use one or more of the following observations/tests to determine the structure substrate preparation suitability:
         1) The visual appearance of sound concrete (or brick and/or mortar), free from discolored, white, chalky, and cracked areas.
         2) Aural observations – Exhibit the characteristic sound of solid, competent concrete (or brick) when struck with a metal hammer or similar metal tool. Care will be taken not to fracture sound concrete.
         3) Mechanical abrasion tests – Cannot be scraped off with the claw of a hammer or similar metal tool.
         4) pH testing – Minimum pH of 7 tested by applying wetted litmus paper to the surface of the substrate.
         1) Phenolphthalein testing – Concrete competency indicated by purple color when a few drops of phenolphthalein are applied to the surface of the concrete.

D. Debris Removal:
   1. Remove dirt, rocks, rust, spalled masonry (including mortar, concrete, and brick), roots, sludge, grease grit, and other deleterious materials and debris from the structures.

E. Defects:
    1. For existing concrete to be coated, restore the profile surface to original thickness and replace corroded or missing reinforcement prior to coating.
        a. Propose profile restoration and replacement procedures for Engineer review and approval.

1.04 COATING APPLICATION

A. Material application:
    1. Fill voids in existing damaged concrete material and restore surfaces to an even and uniform surface profile using approved underlayment materials prior to any surface coating work. The repair mortar and epoxy topcoat must be compatible to ensure a bond at the molecular level as directed by the Engineer.
    2. Install underlayment over a clean surface prepared in accordance with the requirements of this specification.
        a. Employ whatever means are necessary (e.g., humidity control, temperature control, additional blasting, mechanical surface preparation, etc.) to ensure proper curing of the underlayment layer, strong adherence of the underlayment layer to the prepared surface, and strong adherence to any layer installed over the underlayment layer.
        b. Provide installed underlayment free of trowel marks and irregularities. The finished surface profile shall be sufficient to create a mechanical bond and in accordance with the ICRI Concrete Surface Profiles CSP-3 or CSP-6, unless otherwise recommended by the manufacturer.

B. Surface coating application for new and existing concrete:
    1. Do not apply the finish coat until other work in the area is complete and until the previous primer and/or underlayment coat has been applied and inspected, unless otherwise specified.
    2. Apply coatings in strict accordance with the manufacturer’s requirements and recommendations and any specific Owner requirements.
    3. Ensure application equipment has been properly cleaned prior to application of coating.
    4. The equipment shall be specially designed to accurately ratio and apply the specified materials and shall be regularly maintained and in proper working order using a logbook.
    5. Test spray pattern for uniformity of distribution.
    6. Coating color:
        a. As chosen by the Engineer.
    7. Employ whatever means necessary (e.g., humidity control, temperature control, additional blasting, mechanical surface preparation, etc.) to ensure strong adherence of the surface coating layer to underlying and overlying layers and proper curing of the surface coating layer.
    8. Control time between applications of the various layers to ensure proper bond between layers if the surface coating is applied in two or more layers.
    9. Surfaces designated for lining/coating shall be lined with the epoxy system to provide the minimum dry film thickness specified.
        a. The cured surfacing shall be monolithic with proper sealing of connections to all uncoated surfaced areas and shall be placed and cured in one application if possible.

b. Engineers will measure and verify dry film thickness of individual coats and of total final build.

10. Remove trowel marks and other surface irregularities by using a short nap mohair paint roller dampened with water.
    a. Shake off excess water prior to use.
11. Protect surfaces from rapid drying due to heavy wind or hot sun.
12. Allow drying time between coats as recommended by manufacturer.
13. Cure coatings in strict accordance with the manufacturer's recommendations, prior to putting them into service.
14. Test prepared surfaces after cleaning but prior to application of the epoxy coating system to determine a neutral pH of 7 and moisture content of the concrete, as required according to manufacturer's recommendations.
15. Ensure that the moisture content of the surface is in accordance with the coating manufacturer's recommendations and/or requirements.
    b. If moisture content of the surface is not in accordance with the coating manufacturer's recommendations and/or requirements, bring surface up to the coating manufacture's recommendations and/or requirements at no additional cost to Owner.

1.05 QUALITY CONTROL

A. Prepare and submit coating system application plan, including the following information.
   1. Quality Control Procedures:
      c. Detailed duties of the applicator's superintendent.
      a. The training program outline qualifying personnel in the correct storage and handling of coating materials, and the necessary safety requirements.
      b. List of application and testing equipment to be used, including inspections confirming satisfactory condition of equipment.
      c. Detailed procedures and methods for surface preparation including repair and re-profiling if required, application of primer and/or underlayment (if needed), and final coating, and testing.
   2. Criteria for acceptance of the preparation of concrete surfaces.
   2. Detailed plan of surface preparation, including repair and re-profiling.
   3. Details of application of coats, including required curing times.
   4. Detailed environmental provisions such as shading from the sun.
   5. Detailed scheduling provisions for environmental considerations.
   6. Testing procedures:
      a. Dry film thickness testing per ASTM D 6132.
      b. Spark testing per ASTM D 4787.
      c. Adhesion testing per ASTM D 4541 and D 7234.
      d. Wet Film thickness per ASTM D 4414.
      e. Vacuum testing per ASTM C 1244.

B. Applicator qualifications.
   1. Provide coating manufacturer's certification that coating system applicator is trained and qualified to install the coating system specified in this Section.
      a. Provide evidence that the personnel performing the coating application on this Project received the manufacturer's training for certification for coating system, as specified in this Section.

b. Provide the names of applicator's superintendent who will take full responsibility for the quality of the work.
c. Approved applicator:
    1) Shall be approved by and have completed a training program by the manufacturer and have a minimum of 5 years application experience with the coating system as specified in this Section.
    2) Applicators shall initiate and enforce quality control procedures consistent with applicable ASTM and NACE standards together with pull testing and vacuum testing to assure a high-quality project.
    3) Applicators shall use an adequate number of skilled workers who are thoroughly trained and experienced in the necessary crafts. These workers shall be completely familiar with the specified requirements and the methods needed for proper performance of the work of this Section and have a minimum of 4 years' experience each in the epoxy restoration of underground structures. The superintendent must have a minimum of 5 years' experience in epoxy restoration. No more than one inexperienced apprentice will be allowed for each 4-man crew.
    4) Applicators shall use approved specialty equipment adequate in size, capacity, and number sufficient to accomplish the work of this Section in a timely manner.

C. Manufacturer's specification containing instructions and quality control procedures meeting the following requirements:
    1. Shall be written and published by the manufacturer for the purpose of giving complete instructions for the use and application of the proposed coating system for the conditions for which the coating is specified in this Section.
    2. Clearly and completely state limitations, exceptions, precautions, and requirements that may adversely affect the performance of the coating system.
        a. Temperature and humidity limitations for minimum and maximum conditions are to be included.
        b. If the manufacturer's requirements differ from the requirements specified in this Section, clearly note where deviations are.
            1) The engineer's acceptance of proposed deviations is required.

PART 2 PRODUCTS

2.01 PRODUCTS AND MATERIALS

A. COATING SYSTEMS
    1. Provide coating systems compatible with the concrete surface preparation methods specified in this Section.
    2. Apply epoxy-based coatings within a maximum of 2 months of manufacture date unless the manufacturer's requirements are more stringent or are otherwise approved in writing by the Engineer.
    3. Thicknesses specified in this Section are the minimum dry film thickness required and do not include the primer or resurfacing material thickness, unless otherwise noted.
        a. Minimum thickness as specified by the coating manufacturer.

b. Install individual coats of minimum and maximum thickness as recommended by the manufacturer to achieve full build thickness.

4. Apply primer as recommended by the manufacturer for each installation.
3. Provide a defect filler and repair materials as recommended by the manufacturer for each installation to ensure a bond of the coating system.

2.02 MANUFACTURERS

A. One of the following:
   1. Warren Environmental Inc. Epoxy
      a. S-301-14 Epoxy Spray System.
      b. M-301-18 Epoxy Trowel-on Mastic System.
   2. Raven Epoxy
      a. Raven 405
      b. Raven 405 Trowel
   3. Carboline Epoxy
      a. Semstone 110 primer
      b. Carboguard 510 plus Semstone 145
   4. Sherwin Williams Epoxy
      a. Corobond primer
      b. Dura-Plate 2300 plus CorCote VEN
   5. Sauereisen
      a. Sewergard 210S-Spray Applied
      b. Sewergard 210M – Towelable
   6. Tnemec Epoxy:
      a. Series 201 primer
      b. Series 218-1000 plus 239

B. Use trowel-on and/or spray-on systems together as recommended by the manufacturer to provide a suitable finished product.

2.03 ADHESION TESTING

A. Perform adhesion testing in-place and in accordance with ASTM D 7234 and as specified in this Section.

B. The Engineer will select structures to be subjected to adhesion testing and specific test locations within each structure.

C. The Engineer will be present to observe each adhesion test.

D. Perform adhesion testing at 2 different stages:
   1. Test adhesion of underlayment layer to underlying substrate before applying surface coating layer.
      a. Test after underlayment layer has cured for a minimum of 4 hours but before surface coating has been applied over underlayment layer.
   2. Test adhesions in the coating system after the surface coating layer has been applied.
      a. Test after finished coating system has adequately cured, as recommended by coating manufacturer, but no more than 4 days.

E. Testing frequency:
   Provide at least 3 adhesion tests on each rehabilitated structure.
   1. Provide at least 3 adhesion tests on each new structures receiving coating. Locations of adhesion test shall be at the discretion of the Engineer.
   2. Incomplete tests, described below, do not count in determining compliance with the minimum number of tests required.
      a. Adhesion test failure due to error in performance of adhesion testing (e.g., glue failure with dolly coming off prematurely).
      b. Failure in coating system before required full test pressure is applied (e.g., a "not pass" test result).
      c. Logbook for recording test data.
         1) Record date and time, structure location, test location in structure, coating thickness, pulling stress (psi), and failure mode.

F. Testing process
   1. Test to a minimum 200 pounds per square inch pulling stress for 30 seconds.
      a. Pulling Stress= Pulling Force (Test Sample Cross-Sectional Area Perpendicular to Applied Force).
      b. DeFelsko adhesion testing machine gauge will read 150 pounds per square inch, which when corrected for dolly diameter equates to 150 pounds per square inch pulling stress.
      c. If delamination or any other failure occurs, the sample failed.
      d. If the dolly comes off the surface of the coating and no other delamination or failure occurs between or within any of the coating system layers and/or the underlying concrete substrate, test is deemed incomplete and the test shall be repeated.
      e. After successful completion of minimum test, continue to raise applied pressure in increments of 50-100 psi, hold for 30 seconds and document data. Continue testing to failure and record failure mode and pressure.
      f. Engineer may require additional testing and/or remedial action on failed test at no additional cost to Owner.
         1) Remedial action may include removing the entire coating system, coating system components installed in structure to that point, re-cleaning of structure, re-application of coating system to all required surfaces, and re-testing.
   2. Mechanically grind down test locations to underlying substrate and re-apply the underlayment and/or coating system, whatever has been installed up to that point in the structure as specified in this Section, to patch the area. Wipe off dust and particulates, which function as a bond breaker.
      a. Do not use acetone, MEK or other chemical solvents to dissolve the underlayment or coating system as a substitute for mechanical grinding down of the test area.
   3. Contractor shall provide certification that the testing met the minimum requirements of 200 psi pulling stress.

2.04 SPARK TESTING

A. Perform spark testing on fully installed coating system in accordance with ASTM D 4787 on all coated surfaces of each structure.

B. The Engineer will be present to observe and approve each spark test.

C. Provide equipment and materials required for spark testing.
   1. Provide certification that spark tester equipment has a current calibration.

D. Testing process:
   1. Thoroughly clean and prepared structure.
   2. The Engineer will identify bolt installation location within the structure.
      a. Bolt will be used during the spark testing to provide grounding.
   3. Do not test with squeegee-type test wand or wet sponge.
   4. The Test with wire brush-type test wand with a minimum test voltage of 100 volts per mil (where 1 mil = 1/1000 inch) of finished surface coat thickness.
      a. For example, use minimum 12,500 volts for surface coat thickness of 1/8 inch (125 mils).
      b. Use installed stainless steel bolt as a grounding rod for the spark testing equipment.
   5. Spark test the entire coated surface of the structure.
   6. Treatment of imperfections found in the coating system using spark testing at no additional cost to Owner.
      a. Grind down and refill.
      b. Re-test repaired areas until all portions of structure pass the spark test as specified in this Section.
   7. Provide certification for each structure stating that the coating is free of holes or other imperfections.

2.05 VACUUM TESTING

A. Vacuum testing shall only be performed at the request of the Engineer.

2.06 DEFECT REPAIR

A. Repair surface defects.

B. Fill voids, holes, and rough or irregular surfaces as directed by the Engineer. Use epoxy mastic or concrete bonding agent as recommended by the manufacturer.

C. Use repair and fill material recommended by the coating manufacturer and approved by the Engineer.
   1. Propose repair method to Engineer for review and approval.
      a. Finish patches on exposed surfaces to match the adjoining surfaces after they have set.
      b. Provide finishes equal in workmanship, texture, and general appearance to that of adjacent undamaged concrete or brick.

2.07 CLEAN-UP

A. Remove surplus materials, protective coverings, and accumulated rubbish.

B. Thoroughly clean surfaces and repair overspray, splashes, splatters, or other coating-related damage.

C. Clean, repair, and refinish surfaces damaged by clean-up activities to the original or required condition.

2.08 BONDED WARRANTY

A. Provide a renewable maintenance Bond from Contractor to cover workmanship and materials for the structure coated with an approved corrosion protective coating renewed yearly for a period of not less than 1 years from the date of final acceptance of the project.
   1. Submit warranty to Engineer prior to and as a condition of Project final acceptance.
   2. Warranty also applies to repair materials, primers, or other products used in the application.
   3. The Bond shall also be unconditional in nature, covering any type of failure in the coating and agreeing to repair or replace it at no cost to the Owner at any point during the one-year period.

B. Coating failure is defined as blistering, cracking, embrittlement, softening, or failure to adhere to the substrate.

C. Testing performed during construction (e.g., spark testing, adhesion testing and/or other testing) does not in any way modify the warranty, nor relieve the Contractor's responsibility for responding to and correcting defects during the warranty period.

END OF SECTION

SECTION 11242

LIQUID CHEMICAL DIAPHRAGM-TYPE METERING PUMPS (OWNER PROVIDED)

PART 1 GENERAL

1.01 SUMMARY

A. The liquid chemical diaphragm-type metering pumps have been pre-purchased by the Owner. This includes a total of two skids for the following chemicals: 17.5% ortho/poly phosphate and 40% ferric chloride. The pump skids were manufactured by ProMinent and provided by Trinova. The Contractor shall be responsible for installing the two skids as indicated on the Drawing and as described herein.

B. A copy of the general arrangement drawings for the liquid chemical diaphragm-type metering pumps is provided in Appendix A for informational purposes.

C. Section includes:
   1. Description of and installation for positive displacement, diaphragm metering pumps; accessories, drives, and control panel requirements for pumping chemical solutions.

1.02 REFERENCES

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

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

C. Underwriters Laboratories, Inc. (UL).

1.03 SUBMITTALS

A. A copy of the general arrangement drawings for the liquid chemical diaphragm-type metering pumps is provided in Appendix A for informational purposes.

1.04 WARRANTY

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

PART 2 PRODUCTS

2.01 DESCRIPTION OF PUMP SKIDS

A. General: Mechanically actuated, positive displacement, diaphragm type chemical metering pumps, and accessories. Each chemical metering pump system includes, at a minimum, the following items.
   1. Pumps.

2. Motors.
3. Variable frequency drive (VFD).
4. VCPs.
5. Calibration columns.
6. Pulsation dampeners.
7. External pressure relief valves.
8. Diaphragm back pressure valves.

B. Fluid characteristics:
1. Ferric chloride:
a. Dry chemical formula: $2FeCl_3$.
b. Solution concentration: 40 percent by weight.
c. Solution pH: < 1.
d. Solution specific gravity: 1.4
2. Ortho/polyphosphate Blend:
a. Dry chemical formula: Blend.
b. Solution concentration: 17.5 percent by weight.
c. Solution pH: < 1.
d. Solution specific gravity: 1.38

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

2.02 VENDOR CONTROL PANELS AND ELECTRICAL CONNECTIONS

A. Connections and controls for the pump skids shall be as indicated on the drawings. Refer to Appendix A for location of panels on pump skids.

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 specified on approved anchoring designs.
3. Install anchors with embedment specified on approved anchoring designs.

3.02 INSTALLATION

A. Install the VCP in accordance with the accepted installation instructions and anchorage details.

3.03 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

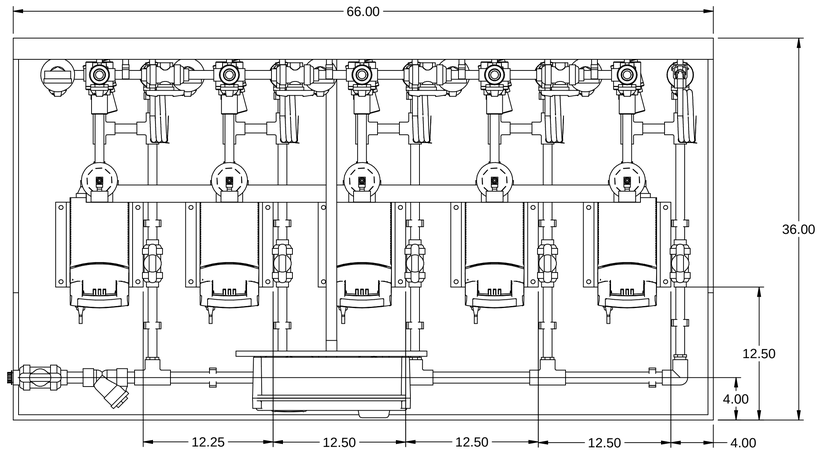
B. Installation Verification:
1. Furnish Manufacturer’s Certificate of Installation Verification.

C. Functional Testing:
   1. Equipment testing:
      a. As scheduled.
   2. System testing:
      a. As specified in Section 01756 - Commissioning, Attachment G.
      b. As specified in this Section.
   3. Furnish Manufacturer's Certificate of Functional Compliance.

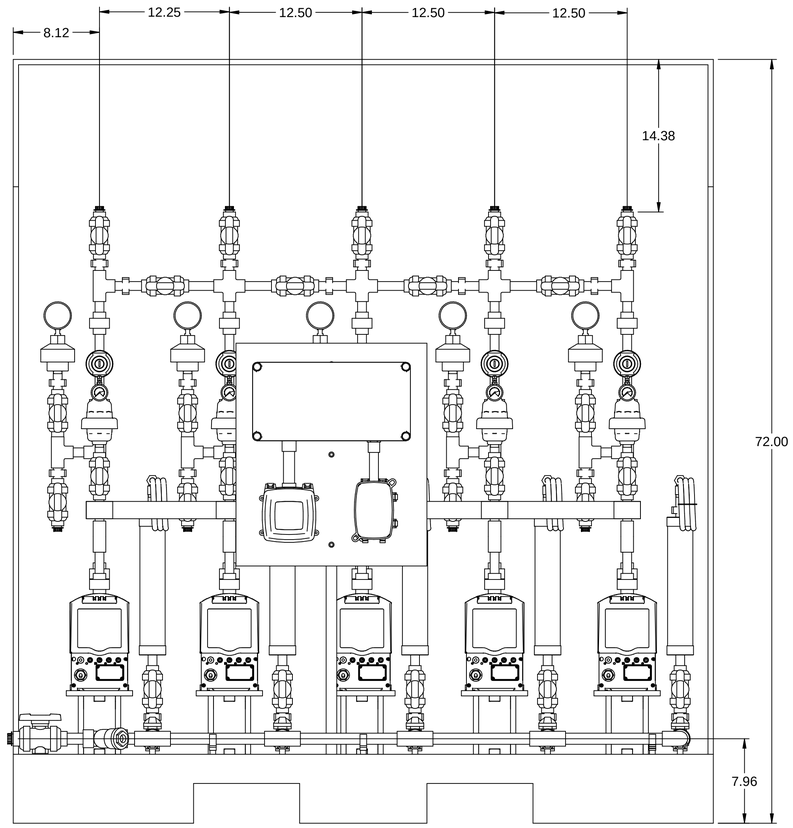
D. Owner Training:
   1. Perform Owner Training as specified in Section 01756 - Commissioning.
   2. Number of sessions:
      a. Operations 1.
      b. Maintenance 1.

END OF SECTION

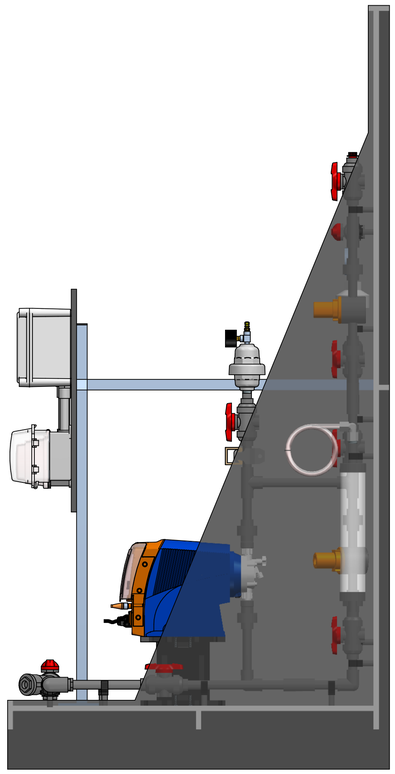
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PLAN VIEW



FRONT VIEW



SIDE VIEW

NOTES:

1. ALL PIPING AND FITTINGS SHALL BE 1/2" & 3/4" SCH. 80 PVC SOCKET WELD UNLESS OTHERWISE REQUIRED BY COMPONENTS.
2. SUCTION HEADER SHALL BE 3/4".
3. SEAL MATERIAL IS VITON UNLESS OTHERWISE SPECIFIED.
4. ALL MOUNTING HARDWARE IS 316SS UNLESS SPECIFIED BY CUSTOMER.
5. ALL PIPING AND COMPONENTS SHALL BE SECURED AT BUILDERS DISCRETION AS SEEN FIT.
6. ALL INTERCONNECTING PIPING, HARDWARE, GASKETS, SEALS, AND WIRING ARE DONE ON SITE BY OTHERS.
7. ALL INTERCONNECTING PIPING SHALL BE FULLY & INDEPENDENTLY SUPPORTED BY OTHERS.
8. TOLERANCE ON ALL TERMINATION POINTS ARE +/- 3/8" (10mm) UNLESS SPECIFIED BY OTHERS.
9. ESTIMATED WEIGHT: 475 LBS

TESTING:

-HYDROSTATIC TEST PRESSURE: 150 PSIG
-DESIGN OPERATING PRESSURE: 102 PSIG
-DESIGN FLOW TEST PRESSURE: 102 PSIG

TESTING CONDITIONS:

-TEST TYPE: HYDROSTATIC
-TEST MEDIUM: WATER
-TEST TEMPERATURE: AMBIENT 68F (20C)
-TEST DURATION: 30 MIN. (MINIMUM)

CHEMICAL SERVICE:

-FERRIC CHLORIDE

NETWORK NUMBERS:

-MECHANICAL: 1117131
-ELECTRICAL: 1117132

REV	DATE	DESCRIPTION	BY	APPD	REVD
B	08/11/23	CUSTOMER COMMENTS	REM		
A	07/19/23	FIRST ISSUE	REM		

REVISIONS

CUSTOMER: TRINOVA (CITY OF DELRAY BEACH)

JOB No: 3023800164 | PURCHASE ORDER No: 4024680

TITLE: P5_GXLA_PVC/VITON_050_FeCl3_FLOOR GENERAL ARRANGEMENT

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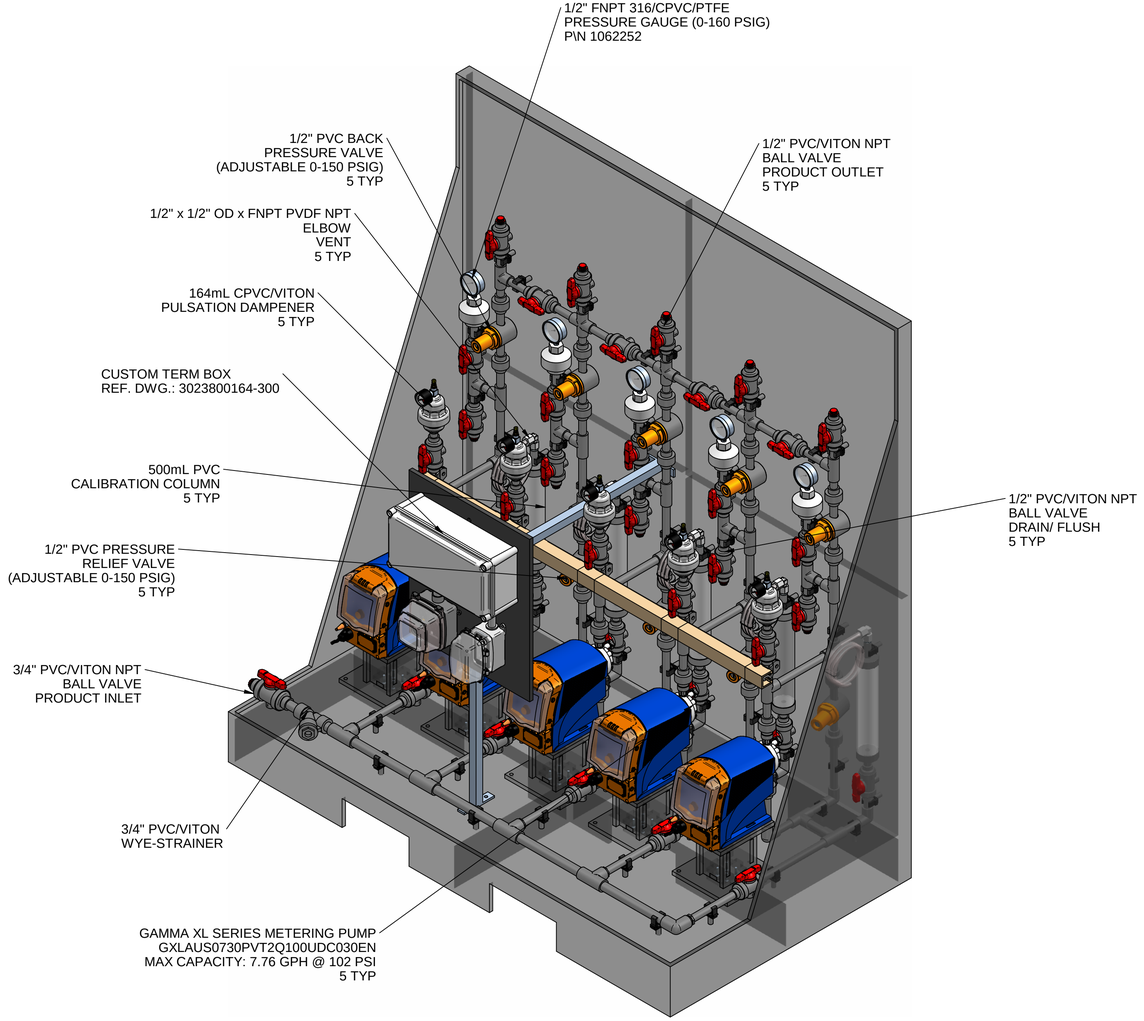
PROMINENT FLUID CONTROLS LTD.
490 SOUTHGATE DRIVE.
GUELPH, ONTARIO, CANADA
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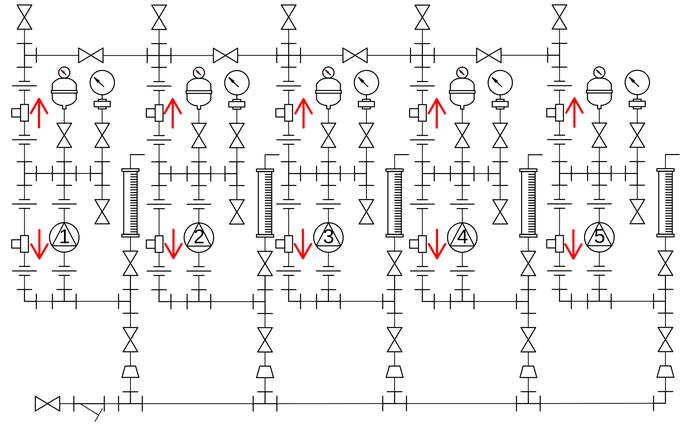
PROMINENT FLUID CONTROLS INC.
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136 INDUSTRY DRIVE,
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TEL. 412 787 2484 FAX. 412 787 0704

DESIGNED	TJB	APPROVED	TAU
DRAWN	REM	SCALE	N.T.S.
CHECKED	TJB	DATE	07/19/23

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DWG No	REV
3023800164-200	B





PIPING SCHEMATIC

REV	DATE	DESCRIPTION	BY	APPD	REVD
B	08/11/23	CUSTOMER COMMENTS	REM		
A	07/19/23	FIRST ISSUE	REM		

REVISIONS

CUSTOMER: TRINOVA (CITY OF DELRAY BEACH)

JOB No: 3023800164 | PURCHASE ORDER No: 4024680

TITLE: P5_GXLA_PVC/VITON_050_FeCl3_FLOOR GENERAL ARRANGEMENT

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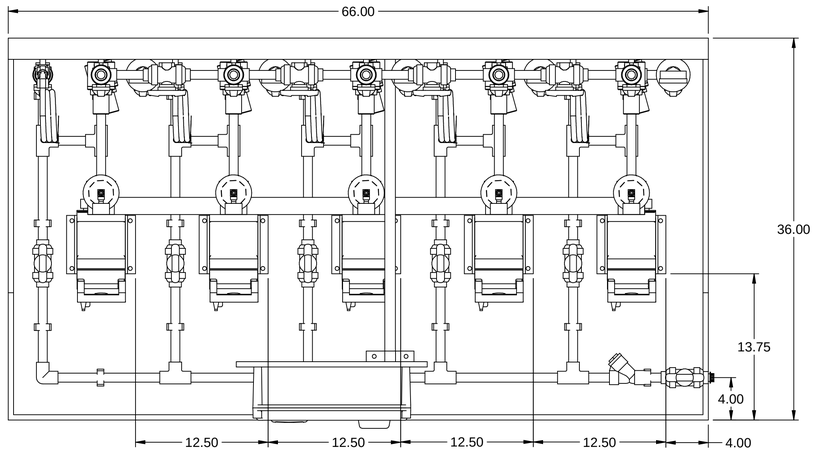
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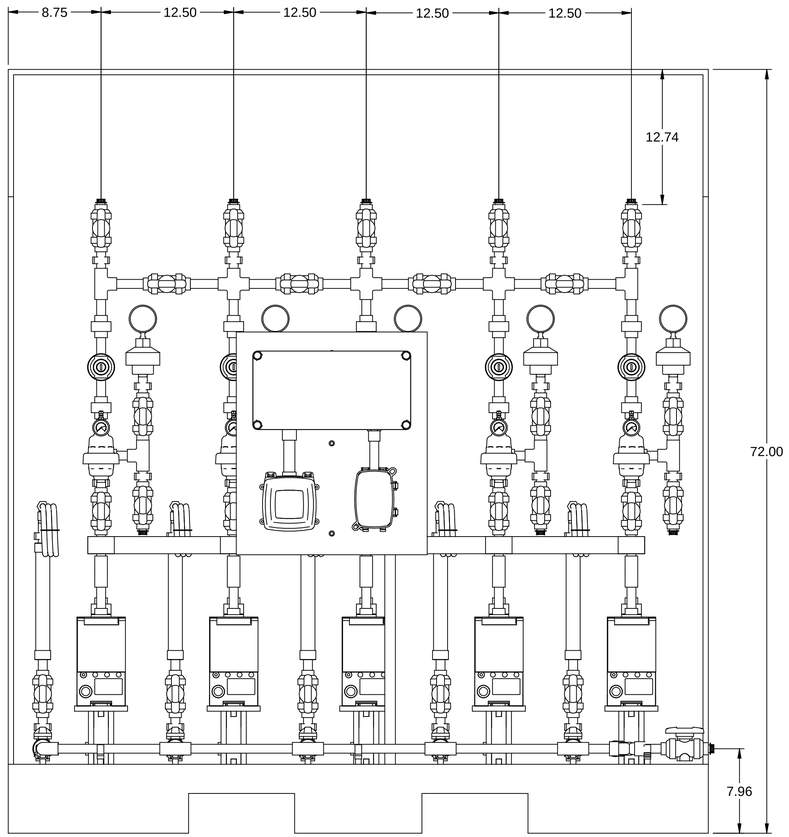
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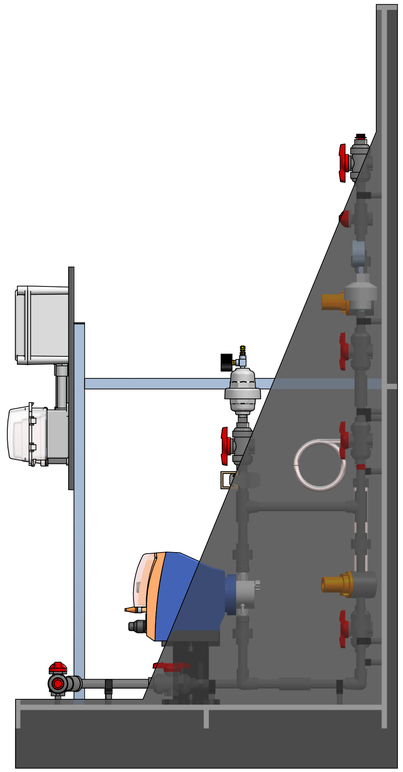
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PLAN VIEW



FRONT VIEW



SIDE VIEW

NOTES:

1. ALL PIPING AND FITTINGS SHALL BE 1/2" SCH. 80 PVC SOCKET WELD UNLESS OTHERWISE REQUIRED BY COMPONENTS.
2. SEAL MATERIAL IS VITON UNLESS OTHERWISE SPECIFIED.
3. ALL MOUNTING HARDWARE IS 316SS UNLESS SPECIFIED BY CUSTOMER.
4. ALL PIPING AND COMPONENTS SHALL BE SECURED AT BUILDERS DISCRETION AS SEEN FIT.
5. ALL INTERCONNECTING PIPING, HARDWARE, GASKETS, SEALS, AND WIRING ARE DONE ON SITE BY OTHERS.
6. ALL INTERCONNECTING PIPING SHALL BE FULLY & INDEPENDENTLY SUPPORTED BY OTHERS.
7. TOLERANCE ON ALL TERMINATION POINTS ARE +/- 3/8" (10mm) UNLESS SPECIFIED BY OTHERS.
8. ESTIMATED WEIGHT: 475 LBS

TESTING:

-HYDROSTATIC TEST PRESSURE: 150 PSIG
-DESIGN OPERATING PRESSURE: 150 PSIG
-DESIGN FLOW TEST PRESSURE: 145 PSIG

TESTING CONDITIONS:

-TEST TYPE: HYDROSTATIC
-TEST MEDIUM: WATER
-TEST TEMPERATURE: AMBIENT 68F (20C)
-TEST DURATION: 30 MIN. (MINIMUM)

CHEMICAL SERVICE:

-PHOSPHATE

NETWORK NUMBERS:

-MECHANICAL: 1117133
-ELECTRICAL: 1117134

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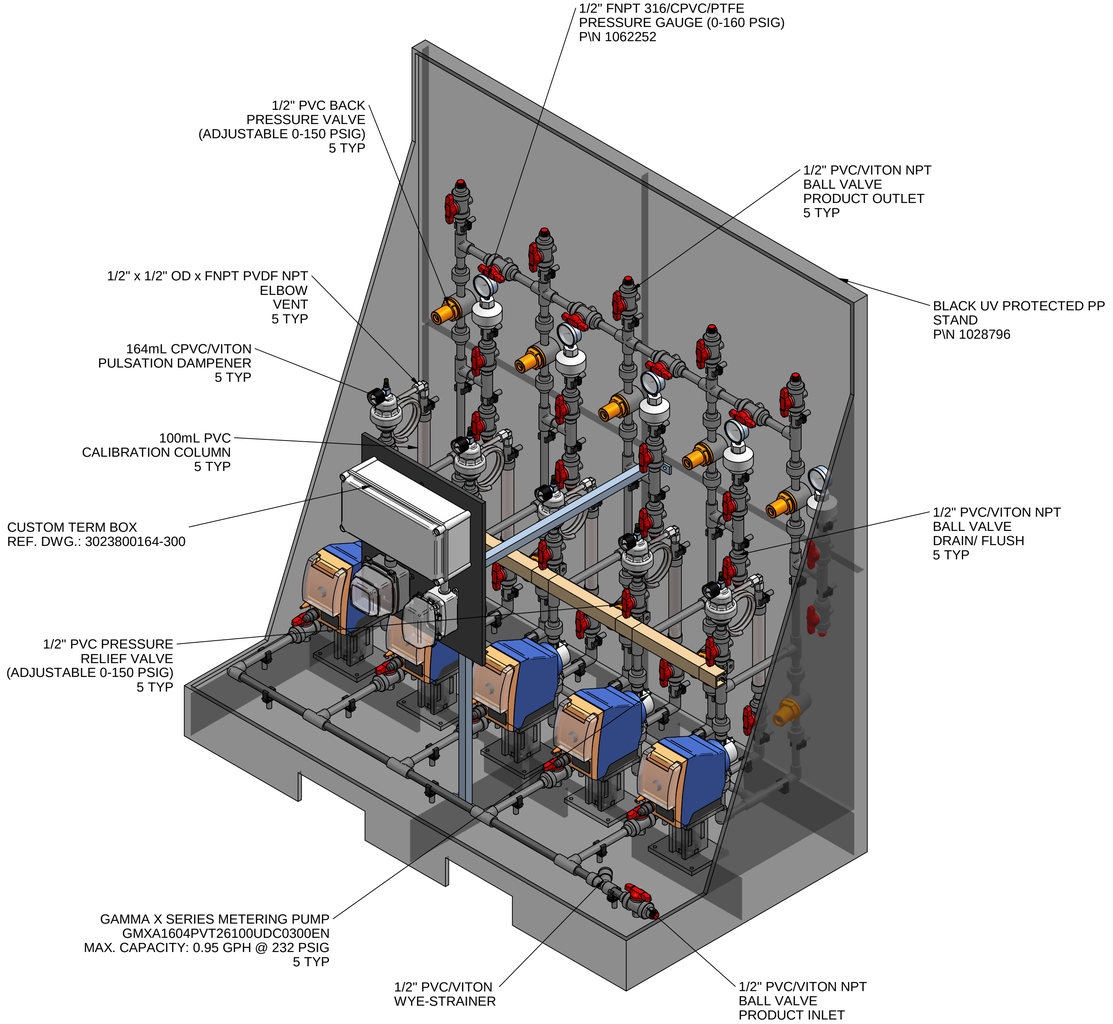
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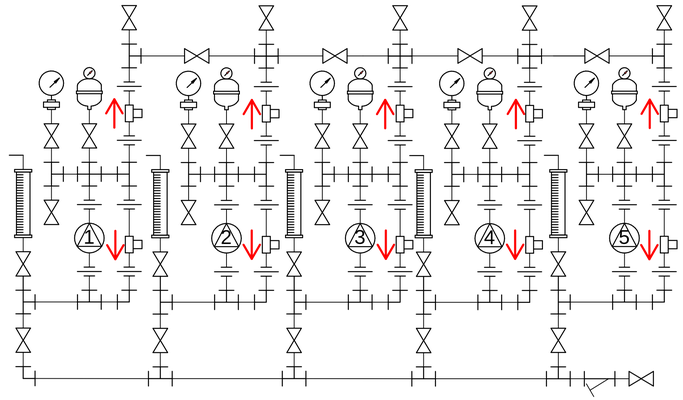
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PIPING SCHEMATIC

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SECTION 11242A

LIQUID CHEMICAL DIAPHRAGM-TYPE METERING PUMPS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Positive displacement, diaphragm metering pumps; accessories, drives, and skid-mounted local control panel requirements for pumping chemical solutions.
   2. Tag numbers:
      a. As specified in the Pump Schedule.

1.02 REFERENCES

A. National Electrical Manufacturers Association (NEMA):
   1. ANSI/NEMA EN 10250 - Enclosures for Electrical Equipment (1000 V Maximum).

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

C. Underwriters Laboratories, Inc. (UL).

1.03 DELEGATED DESIGN

A. As specified in Section 01357 - Delegated Design Procedures.

B. Anchoring and bracing.

1.04 SUBMITTALS

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

B. Product data:
   1. Design data, test reports, certificates, manufacturer's instructions, and the manufacturer's field reports:
      a. Chemical feed pumps:
         1) For each pump type, submit calibration charts and tables relating flow rate to stroke length setting and pump speed.
            a) Submit hydraulic modeling results for each pumping system.
         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 for each metering pump showing the suitability of each pump for the suction and discharge conditions of each application point.

4) Pump manufacturer shall recommend and size an accumulator to be piped to the suction side of each metering pump, when required based on calculations.
5) Submit calculations recommending dimensions of pulsation dampener.

2. Skid-mounted local control panel components.

C. Shop Drawings:
1. 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 setting and pump speed to flow rate shall be supplied.
9. Capacity control shall be 0 to 100 percent with delivery repeatable within 1 percent accuracy over at least a 10 to 1 range.
10. Skid-mounted local control panel:
a. Wiring schematics and local control panel layouts:
b. Scaled exterior front and side elevations with dimensional information.
c. Scaled interior layout showing terminal blocks, grounding provisions, wiring duct, and factory-wired terminations.
d. Bill of materials with detailed description of components.
e. Wiring schematics, including wire numbers and terminal numbers.
f. Power and signal wiring terminations; c
g. Control wiring, control logic, and instrumentation.

D. Delegated Design Submittals:
1. Provide project-specific calculations based on support conditions and requirements to resist loads specified in Section 01850 - Design Criteria.
a. To structures for skid-mounted local control panel installed in structures designated as seismic design category C, D, E, or F.

E. Quality Control Submittals:
1. Manufacturer's representative qualifications.
2. Manufacturer's Certificate of Source Testing as specified in Section 01756 - Commissioning.
3. Manufacturer's Certificate of Installation Verification as specified in Section 01756 - Commissioning.
4. Manufacturer's Certificate of Functional Compliance as specified in Section 01756 – Commissioning.

F. Owner Training Submittals:
   1. As specified in Section 01756 - Commissioning.

G. Operation and maintenance manuals:
   1. As specified in Section 01782 - Operation and Maintenance Manuals.
   2. Provide safety considerations relating to operations and handling of the associated chemical.
   3. Maintenance data shall include 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 the manufacturer and the manufacturer's local service representative.

1.05 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.

1.06 WARRANTY

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

1.07 MAINTENANCE

A. Spare parts:
   1. Furnish the following, packed and labeled for warehouse storage:
      a. Complete set of inlet and outlet ball check valves (balls, seats and gaskets) and a diaphragm for each pump.
      b. 1 complete spare parts kit for each pump provided.
      c. 1 spare parts kit for each size and type of backpressure and pressure relief valve.
      d. An initial supply of 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. Additional spare part requirements as specified in the Contract Documents.

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

PART 2 PRODUCTS

2.01 GENERAL

A. A single pump manufacturer shall furnish and coordinate 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. 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. 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 with variable AC frequency drives.
   3. Skid-mounted local control panel.
   4. Calibration columns.
   5. Pulsation dampeners.
   6. External pressure relief valves.
   7. Diaphragm back pressure valves.

B. Fluid characteristics:
   1. Sodium hypochlorite:
      a. Dry chemical formula: NaOCl.
      b. Solution concentration: 12.5 percent by weight.
      c. Solution pH: 9.
      d. Solution specific gravity: 1.21.

C. Design requirements:
   1. Pump:
      a. As specified in Pump Schedule in this Section.
      b. Dry self-priming, capable of being run dry without damaging effects to the pump.
   2. Motor characteristics:
      a. Driver horsepower shall be as specified in the Pump Schedule.
         (a)
   3. Pump and motor/drive arrangement shall be the pump manufacturer's standard close-coupled configuration suitable for the scheduled service.
         a) Supports:
      b. Provide pump and driver supported on a common base.
      c. Design anchor bolts to withstand a minimum of 1.5 times the maximum imposed operating loads or 1.0 times the imposed seismic loads, whichever is greater.

D. Performance requirements:

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

E. Product requirements:
   1. As specified in 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, and operation**.**

B. Equipment:
   1. Manufacturers: One of the following:
      a. Prominent Fluid Controls, Inc., Model Sigma X: Sigma/ 2 S2Cb

   2. Chemical proportioning pumps of the positive displacement diaphragm type.
   3. Materials:
      a. Metering pumps and their components and accessories shall be suitable for the following chemical concentrations, as scheduled in this Section:
         1) Sodium hypochlorite:
            a) Wetted parts shall be suitable for use with 0.8 to 12.5 percent sodium hypochlorite solution.
            b) Other non-specified materials are to be the manufacturer's standard for continuous service with 0.8 to 12.5 percent sodium hypochlorite solution. Brass and bronze components are not acceptable for contact with sodium hypochlorite.

      b. Diaphragm materials:
         1) Flat, composite, mechanically actuated diaphragms shall be Viton™, EPDM or PTFE faced as the 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 chemical proportioning pumps of the positive displacement type.
      b. Diaphragm shall be mechanically actuated.
      c. Liquid end:
         1) 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) Each metering pump shall include diaphragm failure detection. Upon actuation, the pump shall stop and provide local indication at the pump. The condition shall be reported to the plant control system through the common FAIL alarm signal shown on the Drawings.
            (a) Components:

d. Pump-mounted speed control furnished as part of the pump manufacturer's standard motor/drive assembly.
    1) Suction and discharge check valves.
e. 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.
f. Hydraulic make-up and air bleed valves.

5. Accessories: As indicated on the process and instrumentation Drawings, pumps shall be equipped with:
    a. Calibration column in suction piping.
    b. Diaphragm backpressure, pulsation dampener, and pressure relief valve in discharge piping.
6. Tests and inspections as scheduled in this Section.
7. Verification of performance.

2.04 PUMP GEARBOX DRIVE

A. Shall be constructed of steel and nodular iron and be water resistant and suitable for outdoor installation.
    1. Housing shall be coated in high-solids epoxy.

B. Oil bath lubricated.

C. Fasteners shall be Type 316 stainless steel.

2.05 MOTOR AND DRIVE

A. Type:
    1. Each chemical metering pump shall be furnished with the pump manufacturer's standard close-coupled motor and variable AC frequency drive assembly.
    2. Pump and motor/drive assembly shall be mounted on the skid or base furnished by the pump manufacturer.

B. Manufacturers: One of the following or equal:
        1) Dodge, Para-flex.
        2) Falk, Type WA.

C. Drives shall be variable AC frequency drives furnished as part of the pump manufacturer's standard pump/drive assembly.

D. Characteristics:
    1. AC motors and variable AC frequency drives shall be furnished by the pump manufacturer as an integrated pump/drive assembly and shall be coordinated with the requirements of the pumps.
    2. All operating parameters shall be made at the drive via the built-in display. The controller shall feature an intuitive menu system and shall not require additional hardware or software for programming.
    3. In the local mode the drive shall respond to local pushbuttons, which shall provide control from 0 to 100 percent as indicated on the display.

4. In remote mode, the drive shall respond to an external RUN command to start the pump and a 4 to 20 mA reference signal for 0 to 100 percent speed control.
5. The drive shall feature internal protection for over voltage, over current, under voltage, external trip, motor overload, over temperature, output shorted or ground. An LED indicator shall indicate a trip condition and a separate message and trace log shall be provided with the last 10 trips stored in memory.
6. Drive shall be rated for wash down environment.

2.06 LOCAL CONTROL PANEL

A. General:
1. Local control panel shall be a skid manufacturer-provided termination enclosure for skid 120 VAC power wiring and pump monitoring and control signal wiring.
2. Panel shall contain terminal blocks, grounding provisions, wiring duct, and other components required for terminating factory and field wiring.
3. Pump signal cables and skid-mounted 120 VAC receptacles shall be factory prewired to the local control panel.
4. Factory wiring shall be terminated on clearly identified terminal blocks such that field wiring only requires connections to terminals.
5. Provide terminal identification consistent with the pump monitoring and control signals indicated on the Drawings.
6. Enclosure type: NEMA Type 4X or IP66/IP67, high-grade LLDPE polyethylene or Type 316 stainless steel, suitable for sodium hypochlorite service and the installed environment.
7. Input voltage: 120 volts, 1-phase, 60 hertz.

B. Monitoring and control terminations:
1. Provide terminal connections for the following pump monitoring and control signals for each pump, as indicated on the Drawings:
   a. Speed setpoint: 4 to 20 mA.
   b. Speed feedback: 4 to 20 mA.
   c. REMOTE status dry contact.
   d. FAIL alarm dry contact.
   e. RUN command dry contact.

2.07 ACCESSORIES

A. Pulsation dampeners:
1. Manufacturers: One of the following or equal:
   a. Blacoh Fluid Controls, Inc.
   b. Kemlon Products.
   c. Pulsafeeder.
2. Furnished and installed on each chemical metering pump’s discharge lines as indicated on the Drawings and specified in this Section.
3. Materials:
   a. Hypalon diaphragms and CPVC, PVC, stainless steel, or lined cast iron chamber.

1) Compatible with the pumped liquid at the specified concentration and suitable for outdoor use and exposure.

4. Characteristics:
   a. Gas or air charged, diaphragm type complete with valved gas/air charge valve connection and pressure gauge graduated from 0 to 200 pounds per square inch.
   b. Shall allow no more than 6 percent discharge pressure fluctuation.
5. Shall be provided with a true-union ball valve for shutoff.

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

C. Characteristics:
   a. Furnish and install calibration columns, one for each chemical metering pump, on each chemical pump's inlet line as indicated on the Drawings and specified in this Section.
      1) Columns shall be translucent.
   b. Provide top cap threaded connection with vent piped to floor to prevent entry of foreign materials and to direct spillage or overflow.
   c. End connections shall be threaded.
   d. Capacities and graduations shall be as specified in the Pump Schedule in this Section.

D. 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:
   a. Griffco.
   b. Milton Roy Co.
   c. Pulsafeeder.
   d. Wallace and Tiernan.
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 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.
   c. Valves shall be furnished and installed on each chemical metering pump's discharge lines as indicated on the Drawings and specified in this Section.
   d. Adjustable spring range of 15 to 50 pounds per square inch, or as required by the pump manufacturer. Valves shall be factory adjusted for the backpressure recommended by the pump manufacturer.
   e. 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.

E. Additional accessories required for the system but not required to be supplied by the pump manufacturer include:
   1. Diaphragm seals as specified in Section 17401 - Pressure/Vacuum Measurement: Diaphragm and Annular Seals, except as modified in this Section.
      a. Materials shall be compatible with the pumped liquid at the specified concentration and suitable for outdoor use and exposure.
   2. Pressure gauges as specified in Section 17404 - Pressure/Vacuum Measurement: Gauges.
   3. Isolation valves as specified in Section 15111 - Ball Valves for suction and discharge piping as indicated on the Drawings. Ball valves for sodium hypochlorite service shall be vented.

F. Each chemical metering pump shall be provided with pump-mounted speed control capable of adjusting pump capacity from 0 to 100 percent while the pump is operating.
   1. Allow pump speed to be controlled remotely by a 4 to 20 mA signal originating from the programmable logic controller (PLC) and by local pump-mounted controls.
      a. Include pump-mounted display with indication of speed setting from 0 to 100 percent.
      b. Panel shall be rated in accordance with NEMA Type 4X enclosure.

2.08 FABRICATED PLASTIC SKID AND BASE

A. The chemical metering skids shall be constructed from PVC sheet with a minimum trade thickness of 1/2-inch. The design of the skid shall include gussets and supports as required for all components and shall be self-supporting. All components of the chemical metering system shall be contained within the skid. Each base shall provide a minimum of 1 foot of width for each pump with appurtenances. The skid shall incorporate spill containment capability and feature dual 1/2-inch FTP connections for containment drain piping. The skids shall be manufactured using continuous welding technology; bolted construction is not acceptable. Pedestals shall be provided to elevate the metering pumps above the skid base. The pedestals shall be bolted to the skid base with non-metallic bolts to allow for future pump/piping modifications.

B. The piping shall be attached to the chemical metering skid with a non-metallic corrosion resistant support system. All support channels shall be bolted to the skid with non-metallic, corrosion resistant fasteners. Tapped holes shall be provided for the support fasteners (no nuts shall be required), the tapped holes shall not penetrate the skid base in order to maintain containment integrity. The straps shall be removable and reusable to allow for servicing of the system. All inlet/outlet connections, valves, and pump accessories shall be clearly labeled on the skid for easy identification.

C. Fasteners for skids in sodium hypochlorite service shall be non-metallic or titanium. Titanium bolts shall be in accordance with ASTM F468, Grade Ti1, Ti2, or Ti7. Nuts shall conform to ASTM F467, same materials as the bolts.

D. All components on the skid shall be pre-wired.

E. The skid shall be pre-assembled and shall match the existing skid type for the owner-provided skids as shown in Section 11242 – Liquid Chemical Diaphragm-Type Metering Pumps (Owner Provided).

2.09 NAMEPLATES

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

2.10 SOURCE QUALITY CONTROL

A. Source Testing (Factory Acceptance Tests):
   1. As specified in Section 01756 - Commissioning.
   2. Not witnessed.
   3. Test as specified in Section 15958 - Mechanical Equipment Testing and the Pump Schedule.
   4. Furnish test reports and the Manufacturer's Certificate of Source Testing.

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 specified on approved anchoring designs.
   3. Install anchors with embedment specified on approved anchoring designs.

3.02 INSTALLATION

A. Install the skid-mounted local control panel in accordance with the accepted installation instructions and anchorage details.

B. Furnish Manufacturer's Certificate of Installation Verification.

3.03 FIELD QUALITY CONTROL

A. Functional Testing:
   1. Witnessed.
   2. Test as specified in Section 15958 - Mechanical Equipment Testing and the Pump Schedule.
   3. Furnish test reports and the Manufacturer's Certificate of Functional Compliance.

3.04 OWNER TRAINING

A. Perform Owner Training as specified in Section 01756 - Commissioning.
   1. Number of sessions:
      a. Operations: 1.
      b. Maintenance: 1.

3.05 SCHEDULES

A. Pumps:

Tag Number	PMP-050-533-61, PMP-050-533-71, PMP-050-533-81
Feed Point	East and West Clearwell
Service	Sodium Hypochlorite
Pump Type	Single Diaphragm
Number of Pumps	3
Named Manufacturer	Prominent
Rotodynamic Analysis	Not Required
Pump Characteristics:	
Design Conditions:	
Maximum Flow, (liters per hour)	352
Minimum Flow, (liters per hour)	3.5
Pump Stroke Range (strokes per minute)	0.25 to 200
Maximum Discharge Pressure (psig)	60
Minimum Suction Lift (feet)	10
Relief Valve Setting (psig)	80
Driver Characteristics:	
Driver Type	Motor with Variable AC Frequency
Drive Coupling	Close-coupled, Horizontal
Driver Horsepower	1/2
Maximum Driver Speed (rpm)	1,750
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 operating at full speed and the manufacturer's recommended stroke length setting.

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.

B. 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, Metric/Inch Standard.
   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 Fire Protection Association (NFPA):
   1. 70 - 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 in Section 01357 - Delegated Design Procedures.

B. Anchoring and bracing.

1.05 SUBMITTALS

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

B. As specified in Section 01600 - Product Requirements.
   1. Product data.
   2. Shop Drawings.
   3. Manufacturer's instructions.
   4. Schedules.

C. Delegated Design Submittals:
   1. Anchoring and bracing: Provide project-specific calculations based on support conditions and requirements to resist loads specified in Section 01850 - Design Criteria.
      a. For equipment installed outdoors.

D. Quality Control Submittals:
   1. Manufacturer's representative qualifications.
   2. Manufacturer's Certificate of Source Testing as specified in Section 01756 - Commissioning.
   3. Manufacturer's Certificate of Installation Verification as specified in Section 01756 - Commissioning.

4. Manufacturer's Certificate of Functional Compliance as specified in Section 01756 - Commissioning.

E. Owner Training Submittals:
   1. As specified in Section 01756 - Commissioning.

F. 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 PROJECT OR SITE CONDITIONS

A. As specified in Section 01850 - Design Criteria.

1.08 WARRANTY

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

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   1. Goulds Pump, Model 3298 1X1.5-6.
   2. Flowserve Polychem, M Series.
   3. Iwaki America, MDM Series.

2.02 DESIGN AND PERFORMANCE CRITERIA

A. 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 editions 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. All required conditions (flow/head) shall be within the pump manufacturer's Allowable Operating Region (AOR).
      c. 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. 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 PUMP CONSTRUCTION

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

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

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

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

E. 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.

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. Provide motors as scheduled and as specified in this Section:
   1. Revolutions per minute: As scheduled.
   2. Enclosure: As scheduled.
   3. Electrical characteristics: As scheduled.

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 MAINTENANCE

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.

2.14 SOURCE QUALITY CONTROL

A. Source Testing (Factory Acceptance Tests):
   1. As specified in Section 01756 - Commissioning.
   2. Not witnessed.
   3. Furnish test reports and the Manufacturer’s Certificate of Source Testing.

PART 3 EXECUTION

3.01 PREPARATION

A. Anchoring and bracing to structures:
   1. Prepare equipment anchor setting template(s) and use to position anchors during construction of supporting structure(s).
   2. Install anchors of type and material indicated on approved anchoring designs.
   3. Install anchors with embedment indicated on approved anchoring designs.

3.02 INSTALLATION

A. Install the equipment in accordance with the accepted installation instructions and anchorage details.

B. Furnish Manufacturer's Certificate of Installation Verification.

3.03 FIELD QUALITY CONTROL

A. As specified in Section 01756 - Commissioning.

B. Functional Testing:
   1. Witnessed.
   2. Furnish test reports and the Manufacturer's Certificate of Functional Compliance.

3.04 OWNER TRAINING

A. Perform Owner Training as specified in Section 01756 - Commissioning.
   1. Number of sessions:
      a. Operations: 1.
      b. Maintenance: 1.

3.05 PUMP SCHEDULE

Pump Identification	Ferric Chloride Transfer Pump	Phosphate Transfer Pump
General Characteristics:		
Service	Ferric Chloride, 40%	Ortho/Polyphosphate Blend, 17.5%
Quantity	2	2
First Named Manufacturer's Model	Goulds Pump Model 3298, 1X1.5-6	Goulds Pump Model 3298, 1X1.5-6
Minimum Pumped Fluid, degrees Fahrenheit	32	32
Normal Pumped Fluid, degrees Fahrenheit	80	80
Maximum Pumped Fluid, degrees Fahrenheit	100	100
Rotordynamic Analysis Level	None	None

Pump Identification	Ferric Chloride Transfer Pump	Phosphate Transfer Pump
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	1800	1800
Minimum Pump Revolutions per Minute	NA	NA
Suction Flange Size, minimum (in.)	1	1
Discharge Flange Size, minimum (in.)	1.5	1.5
Rated Design Point (at Maximum Revolutions per Minute):		
Flow, Gallons per Minute	40	40
Head, Feet	30	30
Required Condition 2 (at Maximum Revolutions per Minute):		
Flow, Gallons per Minute	50	50
Head, Feet	28	28
Required Condition 3 (at Maximum Revolutions per Minute):		
Flow, Gallons per Minute	15	15
Head, Feet	32	32
Other Conditions:		
Maximum Shut Off Head, Feet	38	38
Minimum Suction Static Head, Feet	2	12
Maximum Suction Static Head, Feet	2	12
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

Pump Identification	Ferric Chloride Transfer Pump	Phosphate Transfer Pump
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	1	1
Maximum Driver Speed, Revolutions per Minute	1800	1800
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	1	1
Vibration Test Level	None	None
Noise Test Level	None	None
Functional Testing:		
Performance Test Level	1	1
Vibration Test Level	1	1
Noise Test Level	1	1

END OF SECTION

SECTION 11317

SUBMERSIBLE MIXERS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Requirements for providing NSF 61 certified submersible mixers and accessory items required for a complete and operable system.

B. Mixers shall provide the specified turnover of water in the north segment of the east clearwell.

C. Mixers shall be stationary, and of type to produce horizontal flow mode.

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. Institute of Electrical and Electronics Engineers (IEEE):
   1. 112 - Standard Test Procedure for Polyphase Induction Motors and Generators.

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

1.03 SUBMITTALS

A. Submit the following for approval:
   1. NSF 61 listing for the proposed mixers.
   2. Manufacturer’s statement that the mixers will provide a complete turnover of water from the freshly filtered water entering the west portion of the clearwell to replace the entire volume of the north clearwell segment (103 feet long by 25 feet wide by 5 to 7 feet of water depth) over a 24 hour period.
   3. Shop drawings demonstrating compliance with the specification requirements, including:
      a. Manufacturer’s literature.
      b. Illustrations, specifications and engineering data including materials of construction, dimensions, weight, and performance data.
   4. An installation drawing showing the proposed location of the mixers within the clearwell, mounting method (if any), and location/elevation of the proposed cores through the north clearwell wall for the cable.
   5. Warranty.

B. Submit draft and final Operations and Maintenance Manual. Two copies of the draft and three copies of the final manual shall be submitted in addition to an electronic PDF version. The following sections shall be included:
   1. General equipment specifications and data sheets.
   2. Installation and start-up.
   3. Factory-recommended maintenance schedule.
   4. List of spare parts.
   5. List of equipment or tooling necessary for diagnostics, trouble-shooting, repair, or general maintenance.
   6. Electrical information:
      a. Wiring diagrams showing electrical connections to motor. Diagrams shall specify what electrical wiring needs to be done onsite during and prior to the installation, and by which responsible party.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Delivery materials to the site and unload in a location designated by the Owner.

B. Package materials to permit easy access for inspection and identification.

C. Keep steel members off ground, using pallets, platforms, or other supports.

D. Protect steel members and packaged materials from corrosion and deterioration.

1.04 SPARE PARTS AND MATERIALS

A. Provide one set of any special tools required for maintenance or operation.

B. Spare parts for each size or type of mixing unit.

C. Provide one-year supply of bearing grease or oil for all units furnished, including the lubricant changes after the initial run in period.

D. Box, tag, and clearly mark items.

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

F. Store spare parts, maintenance products, and special tools in enclosed, weather-proof conditions during the construction period.

G. Protect parts subject to deterioration, such as ferrous metal items and electrical components with appropriate lubricants, desiccants, or hermetic sealing.

H. Provide spare parts and special tools inventory list:
   1. Equipment manufacturer.
   2. Quantity.

I. Spare parts and special tools box:
   1. Wooden box:
      a. Size: 24 inches wide by 18 inches high by 36 inches long.

2. Hinged wooden cover:
    a. Strap type hinges.
    b. Locking hasp.
    c. Spare parts inventory list taped to underside of cover.
3. Clearly labeled:
    a. The words “Spare Parts and/or Special Tools”.
    b. Equipment tag number.
    c. Equipment manufacturer.

1.05 WARRANTY

A. Warranty: A written manufacturer's warranty shall be provided for the equipment specified in this Section. The Product shall be warranted to be substantially free from defects in material and workmanship for three (3) years from the date of delivery of all mixing equipment. This equipment warranty shall be directly from the manufacturer of the equipment to the Owner. Such warranty shall cover all defects or failures of materials or workmanship that occur as the result of normal operation and service.

PART 2 PRODUCT

2.01 MANUFACTURERS

A. One of the following or equal:
    1. Kasco.

2.02 GENERAL REQUIREMENTS

A. Owner shall furnish electrical service in conduit with disconnect switches. Contractor shall make the connection between the control panels and the disconnect switches using rigid aluminum conduit with 316 stainless steel supports (with insulation) at six foot intervals. Location of the disconnect switches is shown on the drawing in Appendix A of this specification.

B. The total horsepower of each mixer shall be less than 1.0 hp. Without exception, mixers with a horsepower over this horsepower shall not be accepted.

C. The mixer and any other components internal to the clearwell shall be NSF-61/ANSI 372 certified to conform with new lead content requirements for “lead-free” plumbing as defined by the US Safe Drinking Water Act.

D. Provide and install all accessories necessary for a complete and operational system.

E. Provide 316 stainless steel nameplates (for mixers and control panels giving the equipment manufacturer, model number, assembly weight, and representative contact information. Additional details to be included on the nameplate shall be coordinated with the Owner during shop drawing approval.

2.03 DESIGN AND PERFORMANCE CRITERIA

A. Mixer requirements:
   1. Capable of continuous submerged service in the City's clearwell without loss of watertight integrity.
   2. Mixers shall have the ability to function continuously on a 24-hour per day year-round basis, regardless of drain and fill cycles. Each mixer shall consist of a water-cooled submersible motor, an impeller and a non-submersible control center that houses all control electronics.
   3. Mixers shall be of one manufacturer.
   4. The mixers shall be capable of being installed through the only access into the clearwell, a 2'-6" by 2'-6" access hatch. From the hatch location, the mixer(s) shall be capable of being moved to their installed location by a diver with the clearwell in operation.

B. Mixer performance requirements:
   1. The existing east clearwell's northern segment has a "dead end" as depicted by the yellow zone in the following figure:

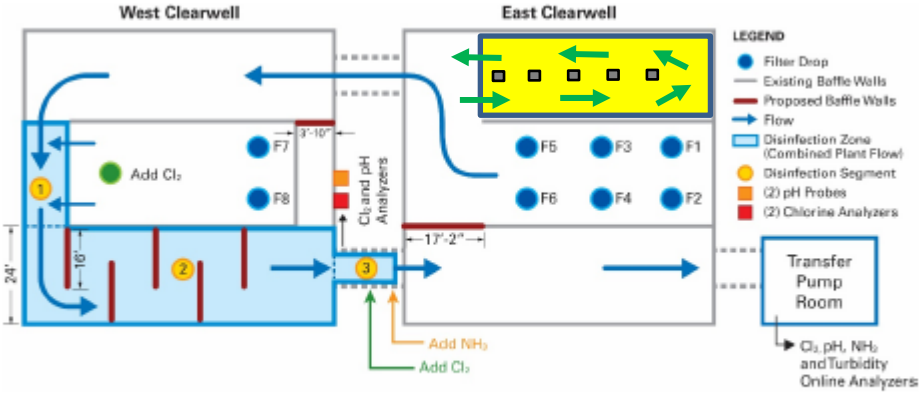


Figure 3 East and West Clearwell Modifications

   2. Two mixers shall be supplied to provide the desired mixing, MXR-050-224-11 and MXR-050-224-21.The mixers shall produce flow in a horizontal mode, vertical mode mixers will be rejected.
   3. Mixers shall be sized and oriented to provide a complete turnover of the water in the northern portion of the east clearwell over the course of 24 hours. Turnover shall consist of a complete change of water within the northern portion of the east clearwell. The northern portion of the east clearwell has a length of 103 feet, a width of 25 feet and a water depth that can vary between 5 and 7 feet, with columns along the centerline of the zone. Therefore, a minimum exchange flow of 0.21 cfs is needed through the zone for complete turnover. The green arrows in the above figure depicts the mostly likely flow pattern that will exchange water with the dominate flow path through the overall system. At the required minimum exchange flow, the area average minimum velocity into and out of the zone is 0.0024 ft/s. Columns are depicted in the drawing shown in Appendix A of this specification.

C. Service conditions
   1. The mixers and components shall be selected for continuous service and submergence in the following water quality:
      a. Effluent from the City's lime softening treatment plant. As a result, solids carryover from the softening process can be expected to enter the clearwell.
      b. Future effluent from a nanofiltration treatment plant.
      c. A range of 0 to 12 ppm chloramines.
      d. A pH range of 6 to 8.5.
      e. A temperature range of 40 to 120 degrees Fahrenheit.

2.04 SUBMERSIBLE MIXERS

A. Provide and install horizontal flow producing submersible mixers within the existing clearwell. Mixer control and operation shall be independent of tank drain and fill cycles to ensure constant mixing.

B. Each submersible mixer shall consist of the following components:
   1. Nozzle or Propeller:
      a. Composite or AISI Type 316 Stainless Steel.
      b. Electropolished to minimize surface corrosion.
   2. Mounting:
      a. Only stationary type mixers are acceptable.
      b. Mounting shall be mounted attached to a column. Columns are depicted in the drawing shown in Appendix A of this specification.
      c. All hardware shall be Series 300 stainless steel.
   3. Nozzle or Propeller Housing:
      a. AISI Type 316 Stainless Steel.
      b. Brush finish to minimize surface corrosion.
      c. Mechanism to keep nozzle or propeller pointing in design direction no matter the angle of the tank floor.
      d. Chlorine/chloramine resistant rubber foot pad to avoid scratching tank floor.
      e. Integrated power cable.
   4. Motor:
      a. Stainless Steel 304 body.
      b. Chlorine/Chloramine resistant rubber seals.
      c. Fully submersible.
      d. The motor shall be constructed with bearings providing a L-10 life of >200,000 service hours.
      e. Motors shall be single speed, oil cooled, Class B insulated, continuous duty rated, with built-in thermal overload protection.
      f. Motor size shall be indicated in the submittal.
   5. Lubrication:
      a. Mixer shall have food grade mineral oil lubrication.
   6. Power cable:
      a. The underwater power cable shall be UL, CSA, and NEC approved underwater rated, 3 conductor cable with open wires for hard wiring.

b. An underwater approved, potted, O-ring sealed quick disconnect shall be available on all cables with 12 gauge or larger cables approximately 30 inches from the motor housing. The quick disconnect shall be a UL and CSA recognized and IP68 rated connector.

C. Control Panel:
   a. Each mixer shall be provided with a control panel capable of disconnecting power to the mixer.
   b. Panel shall include a pad-lockable enclosure door.
   c. Panel shall be NEMA 4X UL Type rated control panel with integral mounting tabs.
   d. Mount control panel on clearwell wall using stainless steel Unistrut.
   e. Panel shall be UL 508A Listed industrial enclosed panel.
   f. Panel shall have an exterior mounted HOA switch, “RUNNING” indicator LED pilot light, and “FAULT” indicator LED pilot light all UL Type 4X rated.
   g. Panel shall allow for an automatic shut-off in the event of dry operation, such as a low water level.
   h. Panel shall include a circuit breaker for 120/240VAC, single-phase power.
   i. Panel shall have an operating temperature range -4 ºF to 129 ºF (-20 ºC to 54 ºC)

D. Spare Parts:
   1. Provide spare parts as recommended or supplied with this mixer assembly by the equipment manufacturer for five years of operation.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install equipment in accordance with manufacturer's printed installation instructions.

B. The manufacturer shall provide factory trained personnel experience with the installation of the mixer(s) to assist and direct during construction activities.

C. Install the mixer equipment through the hatch following disinfection of all equipment.

D. The power cable for each mixer shall exit the clearwell through a single cored hole on the north wall of the clearwell. Provide a linkseal or other approved fitting to seal the hole around the cable.
   1. Wall penetration is to be above clearwell overflow line, elevation 24.0.
   2. Linkseal or fitting shall prevent moisture or debris intrusion into clearwell.
   3. Linkseal or fitting shall be sufficient diameter to allow cable to pass through.
   4. Strain relief for power cable shall be part of supplied fitting.

E. The power cable for each mixer shall be hung from the ceiling of the clearwell using stainless steel pipe hangers. Hangers shall be spaced at even intervals with a maximum spacing of 7 feet.

F. Connect control panels to Owner supplied disconnect switches.

3.02 COMMISSIONING

A. Manufacturer services:
   1. Provide certificates:
      a. Manufacturer's Certificate of Installation and Functionality Compliance.
   2. Manufacturer's Representative onsite requirements:
      a. Installation: 1 trip, 2-day minimum each trip.
      b. Manufacturer's representative shall check and inspect the mixers before and after installation, place the mixers in operation, and make necessary adjustments including low water inhibit feature in control panel.

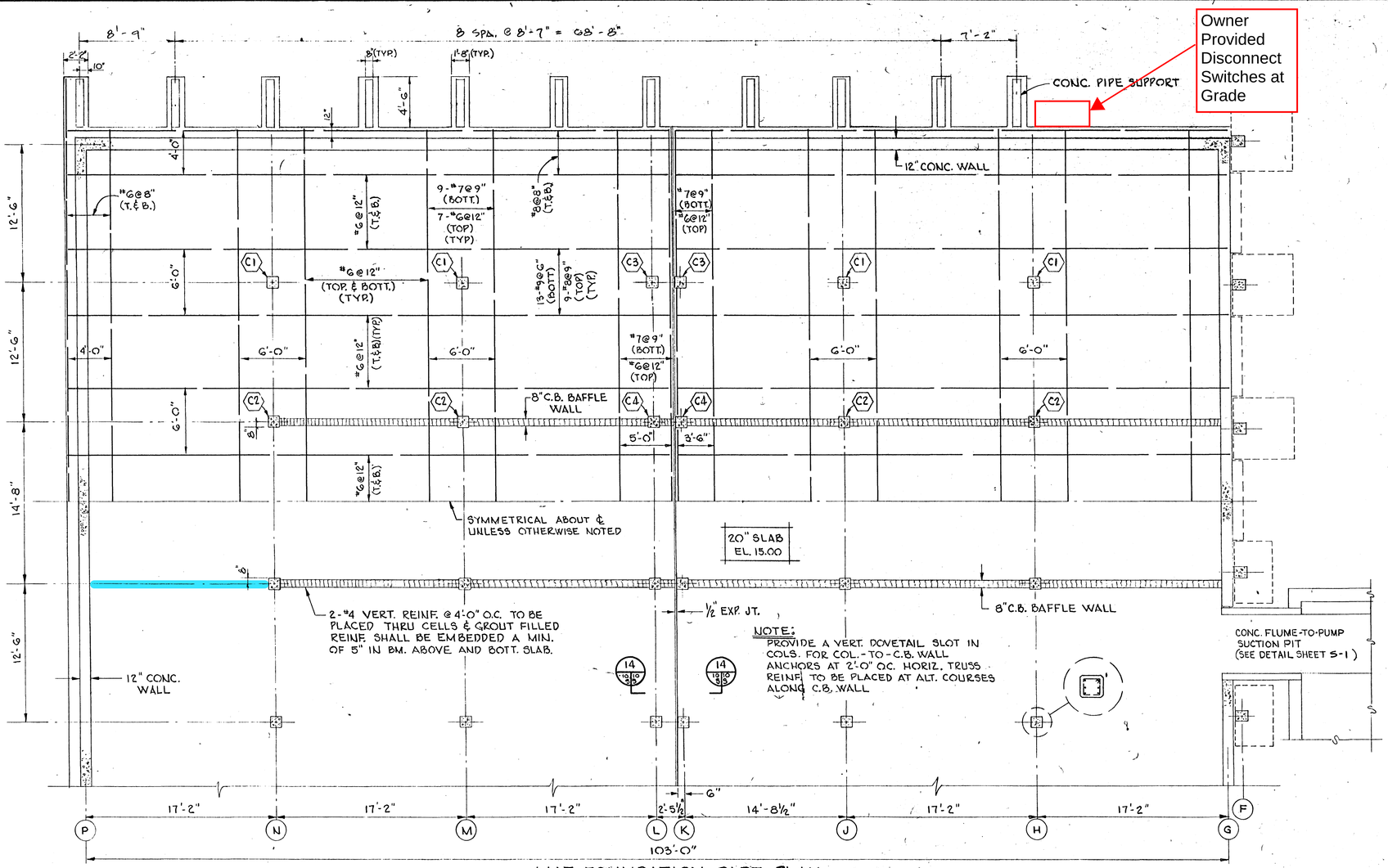
   3. Training:
      a. Maintenance: 3 hours per session, 2 sessions.
      b. Operation: 1 hours per session, 2 sessions.

B. Source testing:
   1. The mixer manufacturer shall perform source testing for each mixer prior to shipment from the factory.
   2. Mixer:
      a. Test witnessing: Unwitnessed.
      a. Mixer tests:
         i. Vacuum test each unit to establish sealing integrity.
         ii. Momentarily energize to determine correct rotation and current draw prior to immersion.
         iii. Run each mixer dry and immersed to determine correct shaft rotation, thrust direction, and power consumption.
         iv. After immersion testing, inspect each mixer for oil seepage, water infiltration, insulation defects, and motor resistance (Ohms).

C. Functional testing requirements:
   1. Control Panels:
      a. Demonstrate function of the control panels prior to installation of the mixers.
   2. Mixers:
      a. Demonstrate that power demand of each motor does not exceed nameplate horsepower or nameplate full load ampere rating.
      b. Demonstrate mixers are capable of operation without undue noise, vibration, or shaft whip prior to installing in the clearwell.
      c. Furnish necessary equipment required for testing, properly calibrated.
      d. Provide video of mixers to demonstrate operation of mixer (obtained by diver).
      e. Mixers shall demonstrate a continuous operation for a minimum of 7 days for acceptance.

APPENDIX A

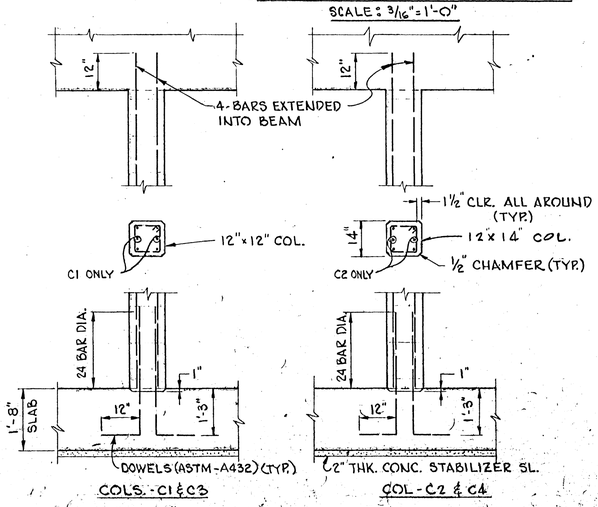
DRAWING SHOWING INTERIOR OF EAST CLEARWELL AND LOCATION OF OWNER PROVIDED DISCONNECT SWITCHES (TO BE AT GRADE ON EXTERIOR OF NORTH SIDE OF THE EAST CLEARWELL)



MAT FOUNDATION PART PLAN
CLEARWELL UNDER FILTER BLDG.

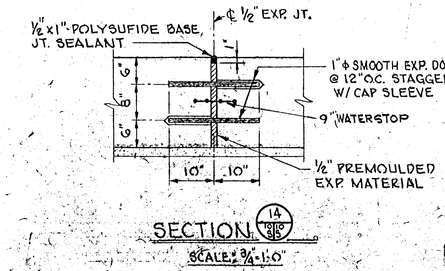
SCALE: 3/16"=1'-0"

COLUMN SCHEDULE - CLEARWELL				
COL. MARK	C1	C2	C3	C4
SIZE	12"×12"	12"×14"	12"×12"	12"×14"
REINF	6-#9	6-#8	4-#7	4-#7
TIES	#3@12"	#3@12"	#3@12"	#3@12"
DOWELS	6-#9	6-#8	4-#7	4-#7



COLUMN DETAILS

SCALE: ½"=1'-0"



SECTION 14/S10

SCALE: 3/4"=1'-0"

NOTES:

1. CONCRETE FOR COLUMNS SHALL HAVE A MINIMUM OF 4,000 P.S.I., AND ALL OTHER CONCRETE A MINIMUM OF 3,750 P.S.I. COMPRESSIVE STRENGTH IN 28 DAYS.
2. REINFORCING BARS FOR COLUMNS SHALL HAVE A MINIMUM YIELD STRENGTH OF 60,000 P.S.I. (ASTM-A615).
3. CONCRETE COVER:
   SLAB: 3" ON BOTT. & 2" ON SIDES.
   WALLS: 2"

RECORD DRAWING

DATE AUGUST, 1973 BY RLS

CK.

NO.	DATE	DESCRIPTION	BY	CKD.
2	8-6-73	PREPARE RECORD DRAWING RLS		
1	11-10-70	GENERAL REVISION	RJC	WDH

REVISIONS

RUSSELL & AXON,
Consulting Engineers, Incorporated
DAYTONA BEACH, FLA. ST. LOUIS, Mo.

WATER WORKS IMPROVEMENTS
SECTION I
FILTER BUILDING-STRUCTURAL
CLEARWELL MAT FOUNDATION & COLUMN DETAILS

DELRAY BEACH FLORIDA

DESIGNED BY	R. V. C.
DRAWN BY	R.V.C. / T.N.T.
CHECKED BY	WDH
DATE	JUNE, 1960
FILE NO.	6469-3
SHEET NO.	22
OF	74 SHEETS
SCALE:	AS SHOWN

SEAL: WALTER D. HAAS, CERTIFICATE No. 10876, STATE OF FLORIDA, PROFESSIONAL ENGINEER

S/10

K&E HERCULENE 74187

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.

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, seismic and wind load restraint systems, anchor bolts, and flange flexible connectors for complete installation in the positions and orientations indicated on the Drawings.

2.02 MANUFACTURERS

A. One of the following or approved equal:
   1. Poly Processing Co.
   2. Snyder Industries, Inc.

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 and seismic loading situations without tank damage.

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

L. Seismic and wind load restraint system:
    1. Wind design criteria: Design tank restraint system of outdoor or exposed tanks to meet the wind design criteria as indicated on the Drawings
    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 and seismic 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 316 stainless steel.

b. The Anchor bolts shall be supplied by the tank manufacturer.
c. The drawings and calculations for the seismic system shall be submitted for review.

2. Concrete anchors or flush shells shall not be used.

2.05 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. 1 minimum 2-inch flanged inlet nozzle entering the tank in the top near the wall.
2. 1 minimum 2-inch flanged outlet/drain nozzle, integrally molded with tank wall.
3. One 4-inch flanged overflow nozzle.
4. One 4-inch flanged roof nozzle for mounting of tank level sensor.
5. One 4-inch flanged roof nozzle for mounting of tank level gauge.
6. One mushroom vent as indicated in the drawings
7. One 24-inch flanged type or molded screw type manway lid on top of the tank.
a. Manway shall be sealed and shall be constructed of the same material as tank.
b. The bolts shall be stainless steel.
c. The gaskets shall be per tank manufacturer recommendation for the chemical stored.

2.06 ACCESSORIES

A. Ladder and platform:
   1. Provide a fiberglass reinforced plastic ladder and landing platform for each storage tank for access to the top manway.
   2. In accordance with OSHA standards.
   3. Provide handrail around the platform.
   4. Fasteners: Type 316 stainless steel.
   5. Anchor bolts: Type 316 stainless steel.
   6. Secure ladder to the tank using encapsulated stainless steel or Hastelloy bolts.
   7. Support ladder directly on the concrete foundation and from the tank wall.

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. 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	Phosphate Storage Tank
Service	Ortho and Poly Phosphate Blend
Chemical pH	< 1
Chemical Specific Gravity	1.38
Tank Design Specific Gravity	1.5
Number of Tanks	1
Usable Capacity, each	8,700 gal
Type of Tank	Linear HDPE
General Design	Flat bottom, dished top
Installation	Vertical
Diameter (feet)	12
Height (feet)	12 (max)
Inlet Nozzle Size (inches)	3
Outlet Nozzle Size (inches)	2
Drain Nozzle Size (inches)	3
Overflow Nozzle Size (inches)	3
Vent Nozzle Size (inches)	Indicated on Drawings
Roof Nozzle Size (inches)	2-inch nozzle for mounting ultrasonic level sensor
Bottom Manway (inches)	24
Top Manway (inches)	24
Ladder	Required
Lifting Lugs	Required
Level indicator	Required
Pipe and Conduit Supports	Required
Containment Wall Type (Double or Single)	Double Wall Tank

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. B1.1 - Unified Inch Screw Threads (UN, UNR, and UNJ Thread Forms).
   2. B18.2.1 - Square, Hex, Heavy Hex, and Askew Head Bolts and Hex, Heavy Hex, Hex Flange, Lobed Head, and Lag Screws (Inch Series).
   3. B18.2.2 - Nuts for General Applications: Machine Screw Nuts; and Hex, Square, Hex Flange, and Coupling Nuts (Inch Series).
   4. PCC-1 - Pressure Boundary Bolted Flange Joint Assembly.

B. American Water Work Association (AWWA):
   1. C110 - Ductile-Iron and Gray-Iron Fittings.
   2. C111 - Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
   3. C115 - Flanged Ductile-Iron Pipe with Ductile-Iron or Gray-Iron Threaded Flanges.
   4. C151 - Ductile-Iron Pipe, Centrifugally Cast.

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 Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.
   3. A307 - Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60,000 PSI Tensile Strength.
   4. A563 - Standard Specification for Carbon and Alloy Steel Nuts.
   5. B88 - Standard Specification for Seamless Copper Water Tube.
   6. D395 - Standard Test Methods for Rubber Property—Compression Set.
   7. D412 - Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers—Tension.
   8. D573 - Standard Test Method for Rubber—Deterioration in an Air Oven.
   9. D1149 - Standard Test Methods for Rubber Deterioration—Cracking in an Ozone Controlled Environment.
   10. D1330 - Standard Specification for Rubber Sheet Gaskets.
   11. D2513 - Standard Specification for Polyethylene (PE) Gas Pressure Pipe, Tubing and Fittings.
   12. F593 - Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.

13. F594 - Standard Specification for Stainless Steel Nuts.
14. 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 1. 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. Pipes:
1. Provide new pipe.
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 piece of pipe in accordance with applicable standards.

B. Materials in contact with drinking water:
1. As specified in Section 01410 - Regulatory Requirements.

C. Coatings and linings requirements shown 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.

2.03 FLANGE BOLTS AND NUTS

A. General:
1. Washer: Provide for each nut.
    a. Shall be of the same material as the nut.
2. Nuts: Heavy hex-head.
3. Cut and finish flange bolts to project:
    a. Face of the bolt shall exceed face of nut by 1/16-inch minimum.
    b. A maximum of 1/4 inch beyond outside face of nut after assembly.
4. Tap holes for cap screws or stud bolts when used.
5. Lubricant for stainless steel bolts and nuts:
    a. Chloride-free.
    b. Manufacturers: One of the following or equal:
        1) Huskey, FG-1800 Anti-Seize.
        2) Weicon, Anti-Seize High-Tech.

B. Ductile iron pipe:
1. On exposed pipes with pressures equal to or less than 150 pounds per square inch gauge (psig):
    a. Bolts: In accordance with ASTM A307, Grade B.
    b. Nuts: In accordance with ASTM A563, Grade A.
    c. Bolts and nuts: Hot-dip galvanized in accordance with ASTM F2329.
2. On exposed pipes with pressures greater than 150 psig:
    a. Bolts: In accordance with ASTM A193, Grade B7.
    b. Nuts: In accordance with ASTM A194, Grade 2H.
    c. Bolts and nuts: Hot-dip galvanized in accordance with ASTM F2329.
3. On underwater pipes and pipes adjacent to wet walls:
    a. Bolts: In accordance with ASTM A193, Grade B8M.
    b. Nuts: In accordance with ASTM A194, Grade 8M.

C. Plastic pipe:
1. On exposed pipes:
    a. Bolts: In accordance with ASTM A307, Grade B.
    b. Nuts: In accordance with ASTM A563, Grade A.
    c. Bolts and nuts: Hot-dip galvanized in accordance with ASTM F2329.
2. On underwater pipes and pipes adjacent to wet walls:
    a. Bolts: In accordance with ASTM A193, Grade B8M.
    b. Nuts: In accordance with ASTM A194, Grade 8M.

2.04 GASKETS

A. General.
   1. Suitable for the specific fluids, pressure, and temperature conditions.
   2. Capable of being applied on surface of piping with cavities to provide for an improved seal with the internal piping pressure.

B. For flanged joints in polyvinyl chloride and polyethylene piping:
   1. Suitable for pressures equal to and less than 150 pounds per square inch gauge, with low flange bolt loadings, temperatures equal to and less than 120 degrees Fahrenheit, and polymer, chlorine, caustic solutions, and other chemicals, except chemicals which liberate free fluorine, including fluorochemicals and gaseous fluorine.
   2. Material:
      a. Chemical systems: 0.125-inch thick Viton™ rubber.
      b. Sewer and water: 0.125-inch thick SBR.
   3. Manufacturers: One of the following or equal:
      a. Garlock.
      b. John Crane, similar product.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:
   1. Piping drawings:
      a. Except in details, piping is indicated diagrammatically. Not every offset and fitting, or structural difficulty that may be encountered has been indicated on the Drawings. Sizes and locations are indicated on the Drawings.
      b. Perform minor modifications to piping alignment where necessary to avoid structural, mechanical, or other type of obstructions that cannot be removed or changed.
         1) Modifications are intended to be of minor scope, not involving a change to the design concept or a change to the Contract Price or Contract Times.
   2. Piping alternatives:
      a. Provide piping as specified in this Section, unless indicated on the Drawings or specified otherwise.
      b. Alternative pipe ratings:
         1) Piping with greater pressure rating than specified may be substituted in lieu of specified piping without changes to the Contract Price.
         2) Piping of different material may not be substituted in lieu of specified piping.
      c. Valves in piping sections: Capable of withstanding specified test pressures
      d. 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.
        a. Seal openings around piping running through interior walls and floors of chlorine rooms and chlorine storage rooms gastight with synthetic rubber sealing compound.
    2. Provide flexibility in piping connecting to structures to accommodate movement due to soil settlement and earthquakes. Provide flexibility using details indicated on the Drawings.
    3. 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 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 after installing equipment and after piping and fitting locations have been determined.
    3. Route piping to preserve headroom, access space and workspace, and to prevent tripping hazards and clearance problems:
        a. Install piping so it does not interfere with the proper and safe operation of equipment and does not block or interfere with ingress or egress, including hatches.
    4. Support piping: As specified in Section 15061 - Pipe Supports, Section 15062 - Preformed Channel Pipe Support System, and Section 15063 - Non-Metallic Pipe Support System:
        a. Do not transfer pipe loads and strain to equipment.
    5. 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.
    6. 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. 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. 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. 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 the owner of the 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.

F. 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.

G. 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 15063

NON-METALLIC PIPE SUPPORT SYSTEM

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Pre-formed non-metallic pipe support systems.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. D635 - Standard Test Method for Rate of Burning and/or Extent and Time of Burning of Plastics in a Horizontal Position.
   2. E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.

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. Anchor: Elements (including hardware) connecting hangers and supports to the structure.
   2. Hardware: Nuts, bolts, straps, clamps, threaded rod, etc.
   3. Supports: Preformed channel or other structural member on which the pipe is mounted.

1.04 SUBMITTALS

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

B. Product data:
   1. Supports:
      a. Materials.
      b. Geometry.
      c. Manufacturer.
   2. Hardware:
      a. Materials.
      b. Manufacturer.

C. Shop Drawings.
   1. Dimensioned and scalable Shop Drawings of hangers and supports for piping.
   2. Complete details for:
      a. Member sizes and arrangement in hangers and support assemblies.
      b. Connections between members in hangers and support assemblies.
      c. Anchoring hangers and supports to structures.
      d. Bracing for hangers and supports and anchoring of bracing to structures.

3. Include data on connections, attachment hardware and construction to demonstrate that hangers and supports will satisfy the design loading, bracing, and anchoring criteria.

1.05 QUALITY ASSURANCE

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

PART 2 PRODUCTS

2.01 GENERAL

A. Mount pipes on Contractor-fabricated supports unless otherwise indicated on the Drawings.

2.02 DESIGN AND PERFORMANCE CRITERIA

A. Hangers and supports individually and as a system shall resist weights and code-required forces without deflections and deformations that would damage the supporting elements, the raceway or equipment supported, or the surrounding construction.
   1. Provide the necessary sway bracing to keep support structures from swaying due to lateral forces.
   2. Allowable column loads: As recommended by the manufacturer in published instruction for the column's unsupported height and "K" value for calculating effective column length of not less than 1.0.
   3. Lateral deflection at top of slab mounted supports shall not exceed support height divided by 240, unless otherwise approved by the Engineer.
   4. Spacing of supports: As required to comply with design requirements but not more than 3 feet.

2.03 MANUFACTURERS

A. One of the following or equal:
   1. Aickinstrut.
   2. Eaton B-Line.

2.04 MATERIALS

A. Fiberglass:
   1. Supports:
      a. Vinyl ester.
      b. Nominal dimensions: 1-5/8 inch by 1-5/8 inch.
      c. Flame spread rating of 25 or less in accordance with ASTM E84.
      d. Tested in accordance with ASTM D635.
   2. Hardware:
      a. Polypropylene.
      b. Thermal plastic elastomer.
      c. Fiberglass reinforced plastic.

B. Touch-up resin:
    1. As recommended by the manufacturer.

2.05 COMPONENTS

A. Channel framing:
    1. 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. For pipe less than 6 inches in diameter: Non-metallic and non-conductive.
        b. For pipe equal to and greater than 6 inches in diameter: Fiberglass.

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

D. 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. Add a cushion strip at each pipe support strap that meets these criteria.
        a. Manufacturers: One of the following or equal:
            1) Anvil, AS3792.
            2) Unistrut, P2600 Unicushion.

2.06 ACCESSORIES

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

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. Anchoring methods:
   1. Solid concrete:
      a. Anchor bolts, anchor rods, or post-installed anchors, as specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry.
   2. Metal surfaces: Machine screws or bolts.
   3. Hollow masonry units:
      a. Post installed anchors as specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry.
   4. Wood and metal studs:
      a. When supporting devices on metal or wood stud construction, bridge studs with preformed channel, and mount the devices to the channel.

B. Recoat or seal drilled holes, cut or scratched surfaces, with products recommended by the manufacturer.

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: Confirm final colors with Owner.

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.

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. Space solid-color bands along piping at 10-foot intervals.
   1. Do not apply bands to piping that is regularly submerged.

END OF SECTION

SECTION 15110

COMMON WORK RESULTS FOR VALVES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Basic requirements for valves.

1.02 REFERENCES

A. American Water Works Association (AWWA):
   1. C111/A21.11 - Standard for Rubber-Gasket Joints for Ductile-Iron Pressure Pipe Fittings.

B. ASTM International (ASTM):
   1. A126 - Standard Specification for Gray Iron Casting for Valves, Flanges, and Pipe Fittings.
   2. A480 - Standard Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip.
   3. A536 - Standard Specification for Ductile Iron Castings.

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

D. Society for Protective Coatings (SSPC):
   1. SP7 - Brush-Off Blast Cleaning.
   2. SP10 - Near-White Blast Cleaning.

1.03 SUBMITTALS

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

B. Product data:
   1. Submit the following information for each valve:
      a. Valve type, size, pressure rating, Cv factor.
      b. Coatings.
      c. Manual valve actuators:
         1) Information on valve actuator including size, manufacturer, model number.
      d. Certified drawings with description of component parts, dimensions, weights, and materials of construction.
      e. Certifications of reference standard compliance:
         1) Submit certification that the valves and coatings are suitable in potable water applications in accordance with NSF 61.
      f. Clearly mark submittal information to show specific items, materials, and accessories or options being furnished.

C. Provide vendor operation and maintenance manual as specified in Section 01782 - Operation and Maintenance Manuals.
   1. Furnish bound sets of installation, operation, and maintenance instructions for each type of manual valve 4 inches in nominal size and larger, and all non-manual valves. Include information on valve operators.

D. Provide Manufacturer's Certificate of Source Testing as specified in Section 01756 - Commissioning.

E. Provide Manufacturer's Certificate of Installation and Functionality Compliance as specified in Section 01756 - Commissioning.

1.04 QUALITY ASSURANCE

A. Manufacturer qualifications:
   1. Valves manufactured by manufacturers whose valves have had successful operational experience in comparable service.

1.05 DELIVERY STORAGE AND HANDLING

A. Protect valves and protective coatings from damage during handling and installation; repair coating where damaged.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

A. Pressure rating:
   1. Suitable for service under minimum working pressures of 150 pounds per square inch gauge.
   2. When a piping system is specified in the Piping Schedule to be tested at a pressure greater than 150 pounds per square inch gauge, provide valves for that piping system with design working pressure which is sufficient to withstand the test pressure.

B. Valve to piping connections:
   1. Metallic valves:
      a. Valves 3 inches nominal size and larger: Flanged ends.
      b. Valves less than 3 inches nominal size: Screwed ends.
   2. Plastic valves in plastic piping systems:
      a. Up to 4 inches: Provide solvent or heat welded unions, except for plastic butterfly valves.
         1) Plastic butterfly valves shall be flanged per Section 15112 - Butterfly Valves.
      b. 6 inches and above: Provide solvent or heat-welded flanges.

2.02 MATERIALS

A. Stainless steel: In accordance with ASTM A480, Type 316, or Type 304, UNS Alloy S31600 or S30400.

B. Valve and operator bolts and nuts (not including flange bolts and nuts, which are specified in Section 15052 - Common Work Results for General Piping):
   1. Fabricated of stainless steel for the following installation conditions:
      a. Submerged in sewage or water.
      b. In an enclosed space above sewage or water.
      c. In structures containing sewage or water, below top of walls.
      d. At openings in concrete or metal decks.
   2. Where dissimilar metals are being bolted, use stainless steel bolts with isolation bushings and washers.
   3. Underground bolts: Low-alloy steel in accordance with AWWA C111/A21.11.

C. Bronze and brass alloys: Use bronze and brass alloys with not more than 6 percent zinc and not more than 2 percent aluminum in the manufacture of valve parts; UNS Alloy C83600 or C92200 unless specified otherwise.

D. Cast iron valve bodies: In accordance with ASTM A126, Class 30 minimum.

E. Ductile iron valve bodies: In accordance with ASTM A536, Grade 65-45-12 minimum unless specified otherwise.

2.03 INTERIOR PROTECTIVE LINING

A. When specified in the particular valve specification, provide valves with type of protective lining specified in the particular valve Specification.

B. Apply protective lining to interior, non-working surfaces, except stainless steel surfaces.

C. Lining types:
   1. Fusion bonded epoxy:
      a. Manufacturers: The following or equal:
         1) 3-M Company, ScotchKote 134; certified to NSF 61 for drinking water use.
      b. Clean surfaces in accordance with SSPC SP 7 or SP 10, as recommended by epoxy manufacturer.
      c. Apply in accordance with manufacturer's published instructions.
      d. Lining thickness: 0.010 to 0.012-inch, except that:
         1) Lining thickness in grooves for gaskets: 0.005-inch.
         2) Do not coat seat grooves in valves with bonded seat.
      e. Quality control:
         1) Lining thickness: Measured with a non-destructive magnetic type thickness gauge.
         2) Verify lining integrity with a wet sponge-testing unit operating at approximately 60 volts, or as recommended by the lining manufacturer.
         3) Consider tests successful when lining thickness meets specified requirements and when no pinholes are found.
         4) Correct defective lining disclosed by unsuccessful tests, and repeat test.
         5) Repair pinholes with liquid epoxy recommended by manufacturer of the epoxy used for lining.

2. High solids epoxy:
    a. Product equivalent to high solids epoxy EPX-M-1-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 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. 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.

E. 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.

3.03 FIELD APPLIED COATING OF VALVE EXTERIOR

A. Match color and be compatible with manufacturer's coating system and as specified in Section 09960 - High-Performance Coatings.
   1. When shop applied finish coating matches field applied coating on adjacent piping, touch up shop coating in damaged areas in accordance with instructions recommended by the paint manufacturer.
   2. When shop applied coating does not match field coating on adjacent piping, or when damage has occurred to the shop applied coating that requires more than touchup, blast clean valve surfaces or utilize other surface preparation recommended by the manufacturer of the coating material and apply the coating system used for coating adjacent piping.

3.04 COMMISSIONING

A. As specified in Section 01756 - Commissioning and this Section.

B. Manufacturer services from each manufacturer for all valves supplied:
   1. Provide Manufacturer's Certificate of Source Testing.
   2. Provide Manufacturer's Certificate of Installation and Functionality Compliance.

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 in Section 01756 - Commissioning.

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. IPEX USA, LLC
   6. 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.
      b. CPVC piping systems: CPVC.
   2. Seats: PTFE (Teflon™).
   3. O-rings: EPDM

D. Valve actuator:
   1. Valves shall be quarter turn operated with valve seat adjustability.
   2. Manually operated valves: Lever.

E. Venting requirements:
   1. PVC and CPVC 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 Section 01756 - Commissioning and this Section.

B. Manufacturer services:
1. Provide certificates:
a. Manufacturer's Certificate of Installation and Functionality Compliance.

C. Functional testing:
1. Valves:
a. Test witnessing: Witnessed.

END OF SECTION

SECTION 15114

CHECK VALVES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Center guide (silent) check valves.
   2. Swing check valves:
      a. General swing check valves.
      b. Cushioned swing check valves.
   3. Dual flapper check valves:
      a. Metal hinge.
      b. Elastomer hinge.
   4. High-pressure gas check valves.
   5. Titling (slanting) disc check valves.
   6. Ball check valves:
      a. Metal body ball check valves.
      b. Plastic ball check valves.
   7. Angled disc rubber flapper 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. Quality Control Submittals
   1. Provide Manufacturer's Certificate of Installation Verification as specified in Section 01756 - Commissioning.

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 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. 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

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. 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.

PART 3 EXECUTION

3.01 INSTALLATION

A. Thermoplastic swing check valves:
    1. Install with proper orientation of flow direction arrow on valve body.
    2. Installation in a vertical pipeline shall only be allowed where pressurized flow direction is up, through the valve. Vertical installation in lines where pressurized flow direction is down shall not be allowed.

3.02 FIELD QUALITY CONTROL

A. Manufacturer services:
    1. Provide the Manufacturer’s Certificate of Installation Verification.

B. 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 in Section 01756 - Commissioning.

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 SERVICE

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 and compatible with chemical service.
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.

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 Section 01756 - Commissioning and this Section.

B. Manufacturer services:
1. Provide certificates:
    a. Manufacturer's Certificate of Installation and Functionality Compliance.

C. Functional testing:
1. Valves:
    a. Test witnessing: Witnessed.
    b. Conduct pressure and leak test as specified in Section 15110 - Common Work Results for Valves.

END OF SECTION

SECTION 15120

PIPING SPECIALTIES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Piping specialties, including:
      a. Flexible rubber connections.
      b. Pipe saddles.

1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):
   1. B16.5 - Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24, Metric/Inch Standard.

B. American Water Works Association (AWWA):
   1. C110 - Standard for Ductile-Iron and Gray-Iron Fittings.
   2. C151 - Standard for Ductile-Iron Pipe, Centrifugally Cast.

C. ASTM International (ASTM):
   1. A148 - Standard Specification for Steel Castings, High-Strength, for Structural Purposes.
   2. A193 - Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications.
   3. A194 - Standard Specification for Carbon Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.
   4. A536 - Standard Specification for Ductile Iron Castings.

D. NSF International (NSF):
   1. 61 - Drinking Water System Components - Health Effects, Includes Errata.
   2. 372 - Drinking Water System Components - Lead Content.

1.03 SUBMITTALS

A. Submit as specified in Section 01330 - Submittal Procedures and Section 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. Manufacturer's Certificate of Installation as specified in Section 01756 - Commissioning:
1. Provide as specified in this Section.

1.04 WARRANTY

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

PART 2 PRODUCTS

2.01 GENERAL

A. As specified in Section 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 PIPE SADDLES

A. For PVC 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**.**

2.04 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.

3.02 INSTALLATION

A. Pipe saddles:
   1. Coat threads on bolts with anti-gall coating prior to installation.

3.03 FIELD QUALITY CONTROL

A. Manufacturer services:
   1. 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 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. Product data.

B. Photographs and videos of the installation.

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. 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 1/2-inch, an ID of 0.375 inch.
      e. For NS 5/8-inch, an ID of 0.500 inch.
      f. For NS 3/4-inch, an ID of 0.600 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 resistant for long term contact with 12 percent sodium hypochlorite.
   7. Tubing shall be ultraviolet resistant.
   8. Tubing shall be NSF 61 certified.
   9. Tubing shall have a bending radius to allow insertion through the PVC sleeve piping with two standard 90 degree elbows that are in series as shown on the Drawings. Submit conformation that the application is suitable.
   10. Fittings:
      a. Compression fittings, Dekoron E-Z; or equal.
      b. Provide plug-in fittings for connection to instruments (brass quick-connect fittings).
   11. Manufacturers: The following or equal:
      1) Aetna Plastics Corp, HDPE Flexible Tubing.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install PE tubing in accordance with manufacturer's printed instructions, in neat straight lines, supported as shown on the Drawings.

B. For portions of the work interior to the clearwells, demonstrate proper installation complying to the Contract Documents through photographs and videos of the Polyethylene tubing installation, including the PVC carrier pipe and mounting brackets.

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.

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. All materials shall be NSF 61 certified.

B. 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.
    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: EPDM.
    3. Solvent cement:
        a. In accordance with ASTM D2564.
        b. 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. Locate unions where indicated on the Drawings, and elsewhere where required for adequate access and assembly of the piping system.

C. Solvent weld joints in accordance with ASTM D2855.

END OF SECTION

SECTION 15293

DOUBLE CONTAINMENT PIPING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Double contained piping systems and accessories.

1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):
   1. B31.3 - Process Piping Code.

B. ASTM International (ASTM):
   1. D2564 - Specification for Solvent Cements for Poly (Vinyl Chloride) (PVC) Plastic Piping Systems.
   2. D2837 - Standard Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials or Pressure Design Basis for Thermoplastic Pipe Products.
   3. D2855 - Practice for Making Solvent - Cemented Joints with Poly (Vinyl Chloride) (PVC) Pipe and Fittings.
   4. D2996 - Standard Specification for Filament-Wound Fiberglass (glass-fiber-reinforced thermosetting-resin) Pipe.
   5. F493 - Standard Specification for Solvent Cements for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe and Fittings.

C. German Institute for Standardization (DIN):
   1. PAS 1075 - Pipes Made from Polyethylene for Alternative Installation Techniques - Dimensions, Technical Requirements and Testing.

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

1.03 DEFINITIONS

A. PE 100-RC: High-density polyethylene with a cell classification of PE445584C.

1.04 SUBMITTALS

A. Product data.

B. Manufacturer’s published installation instructions.

C. Expansion joint design information.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

A. Materials:
   1. Compatible for continuous exposure to chemical service as specified in Section 15052 - Common Work Results for General Piping and maximum pressure equal to the test pressure.

B. Prefabricated fittings:
   1. Prefabricated fittings consisting of an inner (carrier) pipe elbow totally enclosed, secured, and spaced in an outer (containment) pipe elbow.
   2. Split fittings requiring field cutting, welding or joining shall not be used.

C. Spacers:
   1. Provide spacers on inner pipe to control sagging within containment pipe.
      a. Design and place spacers to withstand loads of the filled pipe and loads due to thermal expansion.
      b. Provide spacers free of sharp edges and attached to the carrier pipe.

D. Expansion loops:
   1. Provide expansion loops as required to compensate for expected thermal expansion for an ambient temperature range as specified in Section 01850 - Design Criteria.

E. Access ports:
   1. Provide access ports for ease of installation, start-up, and maintenance of piping.
   2. Access ports components:
      a. A tee fitting in the secondary containment piping.
      b. A 6-inch diameter riser pipe.
      c. A bolted blind flange cover.
   3. Locate access ports at each low point.

2.02 DOUBLE CONTAINMENT PVC PIPING SYSTEM

A. Manufacturers: One of the following or equal:
   1. Guardian Systems, a product of IPEX Inc.
   2. Pro-Lock by Asahi/America, Inc.

B. Materials:
   1. Compatible for continuous exposure to chemical service as indicated in the pipe schedule at ambient temperatures and maximum pressure equal to the test pressure.
   2. Prefabricated fittings:
      a. Prefabricated fittings consisting of an inner (carrier) pipe elbow totally enclosed and spaced in an outer (containment) pipe elbow.
      b. Split fittings requiring field cutting, welding or joining shall not be used.

3. Inner (carrier) pipe:
    a. Provide pipe as specified in Section 15052 - Common Work Results for General Piping and Section 15249 – Polyvinyl Chloride (PVC) Pipe: Schedule Type.
4. Outer (containment) pipe:
    a. Provide pipe as specified in Section 15052 - Common Work Results for General Piping and Section 15249 – Polyvinyl Chloride (PVC) Pipe: Schedule Type.

PART 3 EXECUTION

3.01 DELIVERIES, STORAGE AND HANDLING OF COMPONENTS

A. Manufacturer shall deliver piping components to arrive on-site wrapped or protected to avoid damage in shipping.

B. Deliver fittings and other components to arrive on-site in boxes.

C. Pipe, fitting and other components should be stored on elevated platforms in a dry location protected from the environment.

D. Lift, support, and transport components with due care to avoid damage.

3.02 INSTALLATION FOR PVC

A. Plastic piping systems:
1. Secondary containment joints solvent cemented using heavy body-slow set made in accordance with ASTM D2855.
    a. PVC cement: In accordance with ASTM D2564.
    b. CPVC cement: In accordance with ASTM F493.
2. Install and test in accordance with manufacturer's instructions.
3. Continuously slope piping to drain to a low point.
4. Buried double containment piping:
    a. Provide tee with minimum 3-inch riser pipe to grade for inspection and access at each low point.
    b. Provide threaded cap at top of riser pipe installed in a valve box.
5. Exposed double containment piping:
    a. Provide tee with minimum 2-inch drainpipe with ball valve at each piping low point.
6. Close ends of outer containment pipe.

3.03 INSTALLATION STEEL PIPING SYSTEMS:

A. Install and test in accordance with manufacturer's instructions.

3.04 PIPING SYSTEM TESTING

A. Inner containment pipe:
   1. Test as specified in Section 15956 - Piping Systems Testing.
      a. Outer containment pipe:
         1) Pneumatically test the pipe at a minimum of 5 pounds per square inch and a maximum of 10 pounds per square inch air pressure for 2-1/2 hours.
         2) Soap external joints and visually inspect for leaks.
         3) Repair leaks in accordance with manufacturer's recommendations.
         4) Purge containment pipe annular space with nitrogen to remove moisture containing air following leak test.

END OF SECTION

SECTION 15956

PIPING SYSTEMS TESTING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Test requirements for piping systems.

1.02 REFERENCES

A. American Water Work Association (AWWA):
   1. C600-17 - Installation of Ductile Iron Mains and Their Appurtenances.
   2. C605-21 - Underground Installation of PVC and PVCO Pressure Pipe and Fittings.

B. Underwriters Laboratories Inc. (UL).

1.03 TESTING REQUIREMENTS

A. General requirements:
   1. Testing requirements are stipulated in laws and regulations, specified in the Pipe Schedule in Section 15052 - Common Work Results for General Piping, 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 the Contract Documents, except where requirements of the 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. Air test of natural gas piping:
      a. For less than 125 pounds per square inch gauge working pressure, test in accordance with mechanical code, as specified in Section 01410 - Regulatory Requirements, or the National Fuel Gas Code, whichever is more stringent.
   5. Air test of digester gas piping shall not exceed 25 psi.
   6. 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 a 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. As specified in Section 01500 - Temporary Facilities and Controls.
      a. Use potable water for all potable waterlines.
      b. Use potable water for all other pipes.

D. Pipes to be tested:
   1. Test only those portions of pipes that have been installed as part of this Contract.
   2. Test new pipe sections prior to making final connections to existing piping.
   3. Furnish and install test plugs, bulkheads, and restraints required to isolate new pipe sections.
   4. Do not use existing valves as test plug or bulkhead.

E. Unsuccessful tests:
   1. 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:
   1. Dispose in accordance with requirements of federal, state, county, and city regulations governing disposal of wastes in the location of the Project and disposal site.
   2. Requirements and costs associated with notifications and obtaining any discharge permit or approvals shall be the responsibility of the Contractor.

1.04 SUBMITTALS

A. Furnish Submittals 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 the 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.

C. Pipe system test report:
   1. Submit a report for all piping tested. At a minimum, the test report shall include the following information:
      a. Description of piping being tested:
         1) Pipe material.
         2) Section of piping being tested:
            a) Date and time of pipe test.
            b) Name of person performing the pipe test.
            c) Specified test method and testing requirements (low-head, high-head, test pressure, test duration, etc.).
            d) Initial test pressure and time of pressure.
            e) Final test pressure and time of pressure.

f) Status of test: Pass or fail.
g) Signature of the Contractor and Owner's representative that witnessed the pipe test.

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 Pipe 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 -40 degrees Fahrenheit or less. Supply temporary air dryers as necessary.

C. Test at pressure as specified in the Pipe Schedule in Section 15052 - Common Work Results for General Piping:
    1. Provide temporary pressure relief valve for piping under test:
        a. Set at 110 percent of the test pressure.
    2. Gradually increase test pressure to an initial pressure of 1/2 the test pressure and inspect joint seals for leaks. If no leaks are found, gradually increase test pressure in 10 percent increments until target pressure is reached.
    3. At each step in the pressure, examine and test piping for leaks with soap solution.
    4. Consider examination complete when the 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 Pipe 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 a 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 the 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 polyvinyl chloride (PVC) gravity sewer pipe: 25 gallons per day per inch diameter per mile of piping under test.

d) 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 Pipe Schedule is 20 pounds per square inch gauge or greater, by the high head pressure test method, indicated with “HH” in the Pipe 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 a minimum of 2 hours for visible leaks test and a minimum of 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.
   2. Before pressurizing for the tests, retain water in piping under slight pressure for a water absorption period of a minimum of 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 in accordance with AWWA C605-21 or AWWA C600-17 by using the following formula:

$$L = \frac{\mathrm{SD}\sqrt{\mathrm{P}}}{148{,}000}$$

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 inch gauge, at the lowest point of the test section, corrected for elevation of the pressure gauge.

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 with “LH” in the Pipe 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 a minimum of 2 hours for visible leaks test and a minimum of 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 Pipe Schedule.
3. Before pressurizing for the tests, retain water in piping under slight pressure for the water absorption period of a minimum of 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 Pipe Schedule, the procedure shall be as follows:
    a. Allowed only for low head pressure piping.
    b. Does not replace and is not in lieu of any testing of the piping system or trust restraints.
2. 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 16050

COMMON WORK RESULTS FOR ELECTRICAL

PART 1 GENERAL

1.01 SUMMARY

A. Contract Drawings:
   1. Schematic diagrams:
      a. Controls are shown as de-energized.
      b. Add relays, where required, to provide necessary contacts for the control system or where needed to function as interposing relays for control voltage coordination, equipment coordination, or control system voltage drop considerations.
      c. Mount devices shown on motor controller schematic diagrams in the controller compartment enclosure, unless otherwise noted.
   2. Plan drawings:
      a. Electrical drawings show desired locations, arrangements, and components of the electrical Work in a diagrammatic manner.
      b. Locations and sizes of equipment are approximate only.
   3. Installation details:
      a. Contract Drawings include typical installation details the Contractor is to use to complete the electrical Work. For cases where a typical detail does not apply, develop installation details that may be necessary for completing the Work, and submit these details for review by the Engineer.
      b. Not all typical installation details are referenced within the drawing set. Apply and use typical details where appropriate.

B. Section includes:
   1. Requirements for electrical:
      a. Basic design and performance criteria.
      b. Prescriptive requirements for common components.
      c. Installation.

1.02 REFERENCES

A. Abbreviations:
   1. FAT: Factory acceptance test that is also referred to as source test.
   2. ICSC: Instrumentation and controls subcontractor.
   3. PCIS: Process control and instrumentation system.

B. Standards:
   1. National Electrical Manufacturers Association (NEMA):
      a. 250 - Enclosures for Electrical Equipment (1,000 V Maximum).
   2. National Fire Protection Association (NFPA):
      a. 70 - National Electrical Code (NEC).
   3. Underwriters' Laboratories, Inc. (UL).

1.03 TERMINOLOGY

A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
   1. LCP: Local control panel: Operator interface panel that may contain pilot type control devices, operator interface devices, control relays, etc., and does not contain a PLC or RIO.
   2. PCM: Process control module: An enclosure containing any of the following devices: PLC, RTU, or RIO.
   3. Space: That portion of the switchgear, motor control center, panelboard, switchboard, or control panel that does not physically contain a device but is capable of accepting a device with no modifications to the equipment, i.e., provide standoffs, bus, and hardware, as part of the space.
   4. Spare: That portion of the switchgear, motor control center, panelboard, switchboard, or control panel that physically contains a device with no load connections to be made.
   5. Unequipped space: That portion of the switchgear, motor control center, panelboard, switchboard, or control panel that does not physically contain a device, standoff, bus, hardware, or other equipment.
   6. Vendor control panel (VCP): Control panels that are furnished with particular equipment by a vendor other than the ICSC. These panels may contain PLCs, RIO, OIT, HMI, etc.

1.04 DELEGATED DESIGN

A. Requirements for Delegated Design are specified in the Technical Sections.

1.05 SUBMITTALS (NOT USED)

1.06 QUALITY ASSURANCE

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

1.07 DELIVERY, STORAGE, AND HANDLING

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

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 01850 - Design Criteria.

1.09 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
   1. Loop drawings:
      a. Provide electrical information required in the preparation of loop drawings, including, but not limited to:
         1) Conduit numbers and associated signal(s) contained within each conduit.
         2) Wire numbers.
         3) Equipment terminal numbers.
         4) Junction boxes and signal(s) contained within each junction box.
         5) Equipment power sources, and associated circuit numbers.
         6) As-built drawings detailing wiring.
   2. Roof penetrations:
      a. Show roof penetrations for electrical equipment and conduit on the roof drawing Submittal and include equipment information:
         1) Type.
         2) Size.
         3) Location.
         4) Configuration of individual penetrations or large penetrations for multiple conduits.
         5) Weight.
         6) Anchoring and support details.

B. Meetings:
   1. As specified in Section 01312 - Project Meetings.

C. Sequencing and scheduling:
   1. Equipment anchoring: Project construction schedule must include an event for obtaining the anchor layout drawings from equipment manufacturers in adequate time for templates to be constructed and anchors to be cast-in-place.

PART 2 PRODUCTS

2.01 GENERAL (NOT USED)

2.02 DESIGN AND PERFORMANCE CRITERIA

A. Provide field wiring and terminations.

B. Equipment mounting and anchoring:
    1. Design equipment anchorage, supports, and connections for dead load, running loads, loads during start-up, seismic load specified in Section 01850 - Design Criteria, and other loads as required for proper operation of equipment.
        a. For equipment with an operating weight of 400 pounds or greater and equipment that is supported higher than 4 feet above the floor, provide calculations for:
            1) Operating weight and location of the centroid of mass for the equipment.
            2) Forces and overturning moments.
            3) Shear and tension forces in equipment anchorages, supports, and connections.
            4) Design of equipment anchorage, supports, and connections based on calculated shear and tension forces.
    2. Anchorage of equipment to concrete or masonry:
        a. Perform calculations and determine number, size, type, strength, and location of anchor bolts or other connections.
        b. Unless otherwise indicated on the Drawings, select and provide anchors from the types specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry.
        c. Provide bolt sleeves around cast-in anchor bolts for 400 pounds or greater equipment.
            1) Adjust bolts to final location and secure the sleeve.
    3. Anchorage of equipment to metal supports:
        a. Perform calculations and determine number, size, type, strength, and location of bolts used to connect equipment to metal supports.

2.03 MANUFACTURERS (NOT USED)

2.04 MATERIALS

A. Enclosures:
    1. Provide enclosures for electrical, instrumentation, and control equipment, regardless of Supplier or Subcontractor furnishing the equipment, that meet the requirements of NEMA Standard 250.
        a. Provide metallic enclosures unless specifically indicated otherwise.

B. Stainless steel:
    1. Where stainless steel is indicated or used for any portion of the electrical Work, provide a non-magnetic, corrosion-resistant alloy, ANSI Type 316, satin finish.
    2. Provide exposed screws of the same alloys.
    3. Use stainless steel hardware, when chemically compatible, in all chemical areas or areas requiring NEMA Type 4X construction.
    4. Do not use stainless steel in any area containing chlorine, gas or solution, chlorine products or ferric chloride.

C. Plant area electrical Work requirements:
    1. Provide electrical materials in accordance with the following table, unless otherwise specifically indicated on the Drawings:
        a. Conduit installation requirements: As specified in Section 16130 - Conduits.

Table 1. Electrical Material Requirements				
Plant Area	**Environment: W = Wet D = Damp C = Clean/dry X = Corrosive H = Hazardous**	**NEMA Enclosure Type**	**Exposed Conduit Type (as specified in Section 16130 - Conduits)**	**Support Materials**
Electrical and Control Room	C	1,12	GRC	GALV STL
Chemical Building	W,X	4X SST	GRC	GALV STL
Lime Building	W,X	4X SST	GRC	GALV STL
Outdoor Areas	W,X	4X SST,7	PCS	SST
Notes: (1) Outdoor classified areas require dual rating of NEMA 4X and 7.				

PART 3 EXECUTION

3.01 EXAMINATION

A. Portions of this Project involve installation in existing facilities and interfaces to existing circuits, power systems, controls, and equipment:
   1. Perform and document comprehensive and detailed field investigations of existing conditions (circuits, power systems, controls, equipment, etc.) before starting any Work.
   2. Determine information necessary to document, interface with, modify, upgrade, or replace existing circuits, power systems, controls, and equipment.
   3. Provide and document interface with, modifications to, upgrades, or replacement of existing circuits, power systems, controls, and equipment.

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. Demolition:
   1. As specified in Technical Sections or as indicated on the Drawings.
   2. Disconnect utilities:
      a. Disconnect electrical equipment.
   3. Remove and dispose of conduit, wire, electrical equipment, controls, etc., associated with the items and/or areas to be demolished as indicated on the Drawings unless otherwise indicated.
   4. Salvage electrical equipment as specified in Section 01738 - Selective Alterations and Demolition.
   5. For each piece of equipment to be removed, remove ancillary components (e.g., instruments, solenoid valves, disconnect switches, etc.).
   6. Conduit:
      a. Where conduit removal, other than associated with equipment to be removed, is indicated on the Drawings:
         1) Remove exposed conduit to the point of encasement or burial.

2) Cut conduit flush and plug or cap encased or buried conduit.
b. Where conduits are to remain in place and removal is not indicated on the Drawings:
1) Cap conduit open ends.
2) Re-label empty conduits as spare.
7. Remove wire back to the source for conduits to be removed or abandoned in place.
8. Provide new nameplates for modified electrical distribution equipment, motor control centers etc., to identify equipment and circuits that are no longer used as spares.
9. Provide new typewritten schedules for modified panelboards.

B. Equipment:
1. Where the Drawings do not show dimensions for locating equipment, install equipment in the approximate locations indicated on the Drawings.

C. Provide NEC required working space in front of electrical equipment as if it could be worked on energized.

D. Circuits of different service voltage:
1. Voltage and service levels:
a. Medium voltage: Greater than 1.0 kV.
b. Low voltage:
1) Power and controls: 120 V to 480 V.
2) Instrumentation: Less than 50 VDC.
c. Fiber.
2. Install different service voltage circuits in separate raceways as well as underground manholes and hand holes.
3. Install different service voltage circuits in separate junction boxes and pullboxes or provide physical dividers where boxes can be divided.

E. Conductors shall not pass through equipment they are not terminating in unless indicated on the Drawings or approved by the Engineer.

3.04 COMMISSIONING

A. General:
1. As specified in Section 01756 - Commissioning, and Technical Sections.
2. Provide onsite assistance for troubleshooting and correcting electrical issues discovered during commissioning.

B. Functional Testing:
1. Inspection activities conducted during construction do not satisfy inspection or testing requirements as specified in Section 16950 - Field Electrical Acceptance Tests.

3.05 FIELD QUALITY CONTROL

A. Workmanship:
1. Leave wiring in panels, manholes, boxes, and other locations neat, clean, and organized:

a. Neatly coil and label spare wiring lengths.
b. Shorten, re-terminate, and re-label excessively used, as well as spare, wire and cable lengths, as directed by the Engineer.

3.06 ADJUSTING (NOT USED)

3.07 CLEANING

A. General:
1. Clean and vacuum enclosures to remove metal filings, surplus insulation and any visible dirt, dust, or other matter before energization of the equipment or system start-up:
a. Use of compressors or air blowers for cleaning is not acceptable.
2. Clean luminaries in the areas affected by the construction.

END OF SECTION

SECTION 16070

HANGERS AND SUPPORTS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Mounting and supporting electrical equipment and components.

1.02 REFERENCES

A. American National Standards Institute (ANSI).

B. ASTM International (ASTM):
   1. A123 - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
   2. A153 - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
   3. E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.

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. Anchor: Elements (including hardware) connecting hangers and supports to the structure.
   2. Hardware: Nuts, bolts, straps, clamps, threaded rod, etc.
   3. Supports: Preformed channel or other structural member on which the electrical equipment or raceway is mounted.

1.04 DELEGATED DESIGN

A. As specified in Section 01357 - Delegated Design Procedures.

B. Anchoring and bracing.

1.05 SUBMITTALS

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

B. Product data:
   1. Supports:
      a. Materials.
      b. Geometry.
      c. Manufacturer.

2. Hardware:
    a. Materials.
    b. Manufacturer.

C. Shop Drawings:
1. Dimensioned and scalable Shop Drawings of hangers and supports for distribution systems and equipment.
2. Complete details for:
    a. Member sizes and arrangement in hangers and support assemblies.
    b. Connections between members in hangers and support assemblies.
    c. Anchoring hangers and supports to structures.
    d. Bracing for hangers and supports and anchoring of bracing to structures.
3. Include data on connections, attachment hardware and construction to demonstrate that hangers and supports will satisfy the design loading, bracing, and anchoring criteria.

D. Delegated Design Submittals:
1. Hangers and supports - General:
    a. Locations and conditions:
        1) Hangers and supports inside structures.
        2) Hangers and supports that resist cable pulling/rigging loads.
    b. Required Submittals: Details with supporting calculations for:
        1) Support member arrangement, sizes, and connections.
        2) Bracing to resist cable pulling/rigging loads.
        3) Connections of hangers, supports, and bracing to the structure.
        4) Connections between supports and the equipment or raceway(s) thereon.
2. Hangers and supports - Exterior and seismic conditions:
    a. Locations and conditions:
        1) Hangers and supports at structures designated as Seismic Design Category (SDC) C, D, E or F in Section 01850 -Design Criteria.
        2) Hangers and supports for outdoor installations.
    b. Required Submittals:
        1) Interior: Bracing to resist seismic design loads specified in Section 01850 - Design Criteria.
        2) Exterior: Bracing to resist seismic, wind, and other environmental loads specified in Section 01850 - Design Criteria.
3. Hangers and supports anchored to concrete and masonry:
    a. Locations and conditions:
        1) Post-installed mechanical anchors in tension.
        2) Post-installed adhesive-bonded all-thread rods in tension.
    b. Required Submittals:
        1) Calculations demonstrating that anchors have a demand/capacity ratio (D/C) not greater than the following when anchor capacity is adjusted for moisture conditions, anchor spacing and edge distances, and sustained loading conditions present at the location of installation.
            a) Post-installed mechanical anchors maximum: 85 percent.
            b) Post-installed adhesive-bonded anchors maximum: 75 percent.

1.06 QUALITY ASSURANCE (NOT USED)

1.07 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 01850 - Design Criteria.

1.09 ADMINISTRATIVE REQUIREMENTS (NOT USED)

1.10 WARRANTY

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

PART 2 PRODUCTS

2.01 GENERAL

A. Mount raceways, cabinets, boxes, fixtures, instruments, and devices on Contractor-fabricated supports unless otherwise indicated on the Drawings.

2.02 DESIGN AND PERFORMANCE CRITERIA

A. Hangers and supports individually and as a system shall resist weights and code-required forces without deflections and deformations that would damage the supporting elements, the raceway or equipment supported, or the surrounding construction.
   1. Provide the necessary sway bracing to keep support structures from swaying due to lateral forces including wire and cable pulling forces.
   2. Lateral deflection at top of slab mounted supports shall not exceed support height divided by 240, unless otherwise approved by the Engineer.

2.03 MANUFACTURERS

A. One of the following or equal:
   1. Preformed channel:
      a. Cooper B-line.
      b. Power-Strut.
      c. Robroy.
      d. Thomas & Betts.
      e. Tyco.
      f. Unistrut.
   2. Nonmetallic cable rack:
      a. Underground Devices Inc.
      b. Hubbell.
      c. Unistrut.

2.04 MATERIALS

A. Hot dip galvanized steel:
   1. Supports:
      a. In accordance with ASTM A123 or A153.

b. Minimum zinc coating thickness of 2.5 mils.
c. Nominal dimensions: 1-5/8 inch by 1-5/8 inch.

2. Hardware:
   a. Electro-galvanized.
   b. In accordance with ASTM A153.

B. Stainless steel:
1. Supports:
   a. In accordance with ASTM A240.
   b. ANSI Type 316 material.
   c. Nominal dimensions: 1-5/8 inch by 1-5/8 inch.
2. Hardware:
   a. ANSI Type 316 material.

C. PVC coated galvanized steel:
1. Supports:
   a. Hot dip galvanized steel as specified in this Section.
   b. PVC coating thickness of 10 to 20 mils.
   c. Nominal dimensions: 1-5/8 inch by 1-5/8 inch.
2. Hardware:
   a. ANSI Type 316 material.

D. Non-metallic cable rack:
1. Consists of stanchions and cable support arms.
2. Stanchions:
   a. 50 percent glass reinforced nylon or other non-metallic material.
   b. Capable of supporting multiple arms.
   c. Recessed bolt mounting holes.
   d. Length as required.
3. Arms:
   a. 50 percent glass reinforced nylon or other non-metallic material.
   b. Size the arms based on the length and weight of the cable to be supported.
4. Stainless steel mounting hardware.

2.05 MANUFACTURED UNITS (NOT USED)

2.06 EQUIPMENT (NOT USED)

2.07 COMPONENTS

A. Fabricated metal supports: As specified in Section 05500 - Metal Fabrications.

2.08 ACCESSORIES

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

2.09 FABRICATION (NOT USED)

2.10 FINISHES

A. Paint and finish structures as specified in Section 09960 - High-Performance Coatings.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 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.

3.03 INSTALLATION

A. Use materials appropriate for the area as specified in Section 16050 - Common Work Results for Electrical.

B. General:
   1. Refer to the Drawings for details. equipment, cabinets, boxes, instruments, and devices in damp or wet locations on minimum of 7/8-inch preformed mounting channel.
   2. Mount channel vertically along the length of the device so that water or moisture may run freely behind the device.

C. Corrosion protection:
   1. Isolate dissimilar metals, except where required for electrical continuity.
      a. Use neoprene washers, 9-mil polyethylene tape, or gaskets for isolation.

D. Anchoring methods:
   1. Solid concrete:
      a. Anchor bolts, anchor rods or post-installed anchors as specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry.
   2. Metal surfaces: Machine screws or bolts.
   3. Hollow masonry units:
      a. Post installed anchors as specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry.
   4. Wood and metal studs:
      a. When supporting devices on metal or wood stud construction, bridge studs with preformed channel, and mount the devices to the channel.

E. Recoat or seal drilled holes, cut or scratched surfaces or with products recommended by the manufacturer.

F. Group raceway and position on racks to minimize crossovers.

G. Non-metallic cable rack:
   1. Install the non-metallic cable rack in accordance with the manufacturer's recommendations.
   2. Provide at least 2 stanchions and 2 arms at each installation.
   3. Mount the cable rack so that the supported cable does not interfere with access to manhole or handhole and so that the supported cable does not lie on the floor.
   4. Do not exceed the cable manufacturer's minimum bending radius.
   5. Use nylon cable ties to secure the cable to the supports.

3.04 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

END OF SECTION

SECTION 16075

IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Identification of electrical equipment, devices and components.
   2. Material, manufacturing and installation requirements for identification devices.

1.02 REFERENCES

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

B. National Fire Protection Association (NFPA):
   1. 70 - National Electrical Code (NEC).

C. Occupational Safety and Health Administration (OSHA).

1.03 DELEGATED DESIGN (NOT USED)

1.04 SUBMITTALS

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

B. Product data:
   1. Nameplates:
      a. Color.
      b. Size:
         1) Outside dimensions.
         2) Lettering.
      c. Material.
      d. Mounting means.
   2. Nameplate schedule:
      a. Show exact wording for each nameplate.
      b. Include nameplate and letter sizes.
   3. Wire numbers:
      a. Manufacturer’s catalog data for wire labels and label printer.

C. Record documents:
   1. Update the conduit schedule to reflect the exact quantity of wire numbers including spares and destination points for all wires.

1.05 QUALITY ASSURANCE (NOT USED)

1.06 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.07 PROJECT OR SITE CONDITIONS

A. As specified in Section 01850 - Design Criteria.

1.08 ADMINISTRATIVE REQUIREMENTS (NOT USED)

1.09 WARRANTY

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

PART 2 PRODUCTS

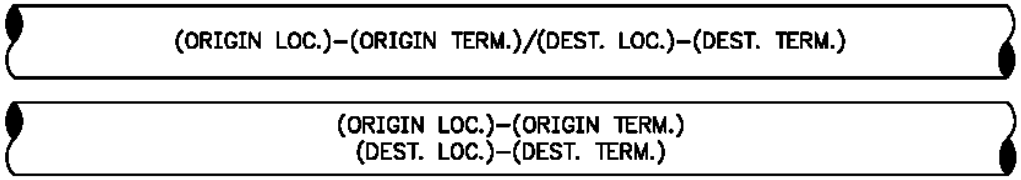
2.01 GENERAL

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

2.02 DESIGN AND PERFORMANCE CRITERIA

A. Nameplates:
   1. Provide for each piece of electrical equipment, device, control panel, and control panel components.
   2. Identical style, color, and material throughout the facility.
   3. Device nameplates information:
      a. Equipment tag number as indicated on the Drawings.

B. Wire numbers:
   1. Coordinate the wire numbering system with vendors of equipment so that every field wire has a unique number associated with it for the entire system:
      a. Correspond to the wire numbers on the control drawings or the panel and circuit numbers for receptacles and lighting.
      b. Correspond to the terminal block number to which they are attached in the control panel.
      c. Internal panel wires on a common terminal shall have the same wire number.
      d. Multi-conductor cables shall be assigned a cable number that shall be attached to the cable at intermediate pull boxes and stub-up locations beneath freestanding equipment. Multi-conductor and instrumentation cables shall be identified at pull points as described above:
         1) Label armored multi-conductor cable using the conduit number as indicated on the Drawings, following the requirements for conduit markers specified in Section 16130 - Conduits.
   2. Provide the following wiring numbering schemes throughout the project for field wires between process control module (PCM), vendor control panels (VCP), motor control centers (MCC), field starters, field instruments, etc.



OR:

Where:

ORIGIN LOC. = Designation for originating panel or device

ORIGIN TERM. = Terminal designation at originating panel or device

DEST. LOC. = Designation for destination panel or device

DEST. TERM. = Terminal designation at destination panel or device or PLC

3. I/O address at destination panel:
   a. Identify equipment and field instruments as the origin.
   b. PCMs are always identified as the destination.
   c. Location is the panel designation for VCP, LCP, or PCM. For connections to MCCs, location is the specific starter tag and loop number. Location is the tag and loop number for motor starters, field instruments and equipment. Any hyphen in the panel designation or tag and loop number shall be omitted.
   d. Terminal designation is the actual number on the terminal block where the conductor terminates at field devices and vendor control panels. For multi-conductor cables, all terminal numbers shall be shown, separated by commas.
   e. Terminal designations at motor leads shall be the motor manufacturer's standard terminal designation (e.g., T1, T2, T3, etc.).
   f. Terminal designations at PCMs where the field conductor connects to field terminal blocks for a PLC input or output shall be the PLC address (Note: The following PLC I/O numbering scheme is typical for Allen-Bradley. The numbering scheme should be modified to match that of the actual PLC manufacturer used for the Project):

      Discrete Point: W:X:Y/Z.

      Analog Point: W:X:Y.Z.

      Where:

      W = I for input, O for output.

      X = PLC number (1, 2, 3…)

      Y = Slot number (01, 02, 03…)

      Z = Terminal number (00, 01, 02…) for a discrete point or a word number for an analog point (1, 2, 3…)

   g. Terminal designations at PCMs where the conductor does not connect to a PLC I/O point shall be the terminal number with a "C" prefix (e.g., C0010). For common power after a fuse or neutrals after a switch, the subsequent points shall have and capital letter suffix starting with "A" (e.g., C0010A).

4. **Case 1**: Vendor control panel (VCP) to process control module (PCM):

   Field wire number/label: A-B/C-D:

   A = Vendor control panel number without hyphen (VCP#)

   B = Terminal number within VCP (manufacturer's or vendor's standard terminal number)

   C = Process control module number without hyphen (PCM#)

   D = Either the PLC address if the field terminal is connected directly to a PLC input or output point or the terminal number with a "C" prefix if not connected directly to a PLC I/O point (C0010)

   Examples:

   VCP#-10/PCM#-I: 1:01/01

   VCP#-10/PCM#-O: 1:10/07

   VCP#-10/PCM#-C0100

5. **Case 2**: Field instrument to process control module (PCM):

   Field wire number/label: E-F/C-D:

   C = Process control module number without hyphen (PCM#)

   D = Either the PLC address if the field terminal is connected directly to a PLC input or output point or the terminal number with a "C" prefix if not connected directly to a PLC I/O point (C0010)

   E = Field mounted instrument tag and loop numbers without hyphen (EDV#)

   F = Manufacturer's standard terminal number within instrument. Use both terminal numbers for analog points separated by a comma

   Examples:

   TIT#-2,3/PCM#-I: 1:01.1

   TSH#-1/PCM#-I: 2:01/00

6. **Case 3**: Motor control center (MCC) to process control module (PCM):

   Field wire number/label: G-B/C-D:

   B = Terminal number within Motor Control Center (manufacturer's or vendor's standard terminal number)

   C = Process control module without hyphen (PCM#)

   D = Either the PLC address if the field terminal is connected directly to a PLC input or output point or the terminal number with a "C" prefix if not connected directly to a PLC I/O point (C0010)

   G = Actual starter designation in the motor control center without hyphen (MMS#)

Examples:

MMS#-10/PCM#-I: 1:01/01

MMS#-10/PCM#-O: 1:10/07

MMS#-10/PCM#-C0100

7. **Case 4**: Motor control center (MCC) to vendor control panel (VCP):

   Field wire number/label: G-B/A-B:

   A = Vendor control panel number without hyphen (VCP#)

   B = Terminal number within motor control center or vendor control panel (manufacturer's or vendors standard terminal number)

   G = Actual starter designation in the motor control center without hyphen (MMS#)

   Example:

   MMS#-X2/VCP#-10

8. **Case 5**: Motor leads to a motor control center (MCC):

   Field wire number/label: H-I/G-B:

   B = Terminal number within motor control center (manufacturer's standard terminal number)

   G = Actual starter designation in the motor control center without hyphen (MMS#)

   H = Equipment tag and loop number without hyphen (PMP#)

   I = Motor manufacturer's standard motor lead identification (e.g., T1, T2, T3, etc.)

   Example:

   PMP-#-T3/MMS#-T3

9. **Case 6**: Remote or separately mounted starter or variable frequency drive (VFD) to process control module (PCM):

   Field wire number/label: J-B/C-D:

   B = Terminal number within starter or variable frequency drive (manufacturer's standard terminal number)

   C = Process control module number without hyphen (VCP#)

   D = Either the PLC address if the field terminal is connected directly to a PLC input or output point or the terminal number with a "C" prefix if not connected directly to a PLC I/O point (C0010)

   J = Starter or variable frequency drive tag and loop number without hyphen (MMS#)

   Examples:

   MMS#-10/PCM#-I: 1:01/01

   MMS#-10/PCM#-O: 2: 10/07

MMS#-10/PCM#-C0010

10. **Case 7**: Field bus trunk segment:

    Field cable number/label: C/K-L/M; C/K-L/H; C/K-L/J:

    C = Process control module without hyphen (PCM#)

    K = Field bus cable type

    L = Field bus segment number

    M = Field Bus field network component without hyphen (PTB1) or

    H = Equipment tag and loop number without hyphen (EMV#) or

    J = Starter or variable frequency drive tag and loop number without hyphen (VFD60.0112)

    Examples:

    PCM#/PA-1A/PTB1PTB1/PA-1B/PTB2

    PCM#/DN-1A/VFD#

    PCM#/DP-2A/ EMV#

11. **Case 8**: Field bus spur (drop):

    Field cable number/label: E/K-L/M:

    E = Field mounted instrument tag and loop numbers without hyphen (FIT#)

    K = Field bus cable type.

    L = Field bus segment number

    M = Field bus field network component without hyphen (PTB1), identify ports on the device.

    Examples:

    FIT#/PA-1C/PTB1-1

    FIT#/PA-1D/PTB1-2

12. Identify spare conductors as required for other field wires with an “S” prefix:

    Example:

    S MMS#-10/PCM#-C011

2.03 MANUFACTURERS

A. Nameplates and signs:
   1. One of the following or equal:
      a. Brady.
      b. Seton.

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

C. Conduit and raceway markers:
   1. Stainless steel: One of the following or equal:
      a. Panduit.

2.04 MATERIALS

A. Nameplates:
   1. Colors:
      a. Warning: White-center, red face.
      b. Other: Black-center, white face.
   2. Laminated plastic engraving stock:
      a. 3/32-inch-thick material.
      b. 2-ply.
   3. With chamfered edges.
   4. Lettering:
      a. Block style engraved characters of adequate size to be read easily from a distance of 6 feet:
      b. Minimum letter height: 1/8-inch.

B. Signs:
   1. Automatic equipment and high voltage signs:
      a. Suitable for exterior use.
      b. In accordance with OSHA regulations.

C. Conductor and cable markers:
   1. Lettering:
      a. Machine printed black characters on white tubing.
      b. Minimum letter height: 10-point type or larger.

D. Conduit and raceway markers:
   1. Stainless steel:
      a. Type 304 or 316.
      b. Minimum letter height: 3/16-inch.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. Nameplates:
   1. Attach to equipment with rivets, bolts, or sheet metal screws, approved waterproof epoxy-based cement or install in metal holders welded to the equipment.
   2. Provide for each disconnecting means with the following:
      a. Equipment served, voltage, and fuse size as required.
      b. Identification of the circuit source that supplies the disconnecting means.
   3. On NEMA Type 4, NEMA Type 4X, or NEMA Type 7 enclosures, use epoxy-based cement to attach nameplates.
   4. Aligned and level or plumb to within 1/64 inch over the entire length:
      a. Misaligned or crooked nameplates shall be remounted or provide new enclosures at the discretion of the Engineer.

B. Conductor and cable markers:
   1. Apply before termination.
   2. Heat-shrinkable tubing:
      a. Shrunk using a heat gun that produces low temperature heated air.
      b. Tight on the wire after it has been heated.
      c. Characters shall face the open panel and shall read from left to right or top to bottom.
      d. Marker shall start within 1/32 inch of the end of the stripped insulation point.

C. Conduit markers:
   1. Furnish and install markers for every conduit in the electrical system that is identified in the conduit schedule or part of the process system:
      a. Markings shall match the conduit schedule.
   2. Mark conduits at the following locations:
      a. Each end of conduits that are greater than 10 feet in length.
      b. The middle of conduits that are 10 feet or less in length.
      c. Where the conduit penetrates a wall or structure.
      d. Where the conduit emerges from the ground, slab, etc.
   3. Mark conduits after the conduits have been fully painted.
   4. Position conduit markers so that they are easily read from the floor.
   5. Attach stainless steel tags with stainless steel cable ties.
   6. Mark conduits before construction review by the Engineer for punch list purposes.
   7. Label intrinsically safe conduits in accordance with the requirements of the NEC.

D. Signs and labeling:
   1. Furnish and install permanent warning signs at mechanical equipment that may be started automatically or from remote locations:
      a. Fasten warning signs with round head stainless steel screws or bolts.
      b. Locate and mount in a manner to be clearly legible to operations personnel.
   2. Furnish and install permanent and conspicuous warning signs on equipment (front and back), doorways to equipment rooms, pull boxes, manholes, etc., where the voltage exceeds 600 volts.
   3. Furnish and install warning signs on equipment that has more than one source of power.
      a. Warning signs to identify every panel and circuit number of the disconnecting means of external power sources.
   4. Place warning signs on equipment that has 120 VAC control voltage source used for interlocking.
      a. Identify panel and circuit number or conductor tag for control voltage source disconnecting means.
   5. Label service entrance equipment, switchgear, switchboards, MCCs, panelboards, and transfer switches with the available short circuit current, equipment label, and date of application in accordance with NEC. Coordinate with the Owner for available fault current data.

3.04 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

3.05 FIELD QUALITY CONTROL

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

END OF SECTION

SECTION 16123

600-VOLT OR LESS WIRES AND CABLES

PART 1 GENERAL

1.01 SUMMARY

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

1.02 REFERENCES

A. Abbreviations:
   1. AWG: American wire gauge.
   2. BCCS: Bare copper-covered steel.
   3. CPE: Chlorinated polyethylene.
   4. FHDPE: Foam high-density polyethylene.
   5. FPE: Foam polyethylene.
   6. OD: Outside diameter.
   7. PVC: Polyvinyl chloride.
   8. XHHW: Cross-linked high heat water resistant insulated wire.

B. Standards:
   1. ASTM International (ASTM):
      a. B3 - Standard Specification for Soft or Annealed Copper Wire.
      b. B8 - Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.
   2. CSA International (CSA).
   3. Insulated Cable Engineer's Association (ICEA):
      a. S-90-661 - Individually Unshielded Twisted Pair Indoor Cables for Use in Communication Wiring Systems.
   4. National Electrical Code (NEC).
   5. National Electrical Manufacturers Association /Insulated Cable Engineers Association (NEMA/ICEA):
      a. NEMA WC 57/ICEA S-73-532 - Standard for Control, Thermocouple Extension, and Instrumentation Cables.
      b. NEMA WC 66/ICEA S-116-732 - Standard for Category 6 and 6A, 100 Ohm, Individually Unshielded Twisted Pairs, Indoor Cables (With or Without an Overall Shield) for Use in LAN Communication Wiring Systems.
      c. NEMA WC 70/ICEA S-95-658-1999 - Standard for Power Cables Rated 2,000 Volts or Less for the Distribution of Electrical Energy.
   6. National Fire Protection Association (NFPA):
      a. 262 - Standard Method of Test for Flame Travel and Smoke of Wires and Cables for Use in Air-Handling Spaces.
   7. Telecommunications Industry Association (TIA):
      a. 568.2-D - Balanced Twisted-Pair Telecommunications Cabling and Components Standard.

b. 569-B - Commercial Building Standards for Telecommunications Pathways and Spaces.

8. Underwriter's Laboratories Inc., (UL):
   a. 44 - Standard for Thermoset-Insulated Wires and Cables.
   b. 1569 - Standard for Metal-Clad Cables.
   c. 1666 - Standard for Test for Flame Propagation Height of Electrical and Optical-Fiber Cables Installed Vertically in Shafts.
   d. 2225 - Cables and Cable-Fittings for Use in Hazardous (Classified) Locations.

1.03 DELEGATED DESIGN (NOT USED)

1.04 SUBMITTALS

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

B. Product data:
   1. Manufacturer of wire and cable.
   2. Insulation:
      a. Type.
      b. Voltage class.
   3. AWG size.
   4. Conductor material.
   5. Pulling compounds.

C. Test reports:
   1. Submit test reports for meg-ohm tests.

D. Calculations:
   1. Submit cable pulling calculations to the Engineer for review and comment for cables that will be installed using mechanical pulling equipment. Show that the maximum cable tension and sidewall pressure will not exceed manufacturer recommended values:
      a. Provide a table showing the manufacturer's recommended maximum cable tension and sidewall pressure for each cable type and size included in the calculations.
      b. Submit the calculations to the Engineer a minimum of 2 weeks before conduit installation.

E. Cable lengths:
   1. Submit installed cable lengths using a conduit measuring tape for 3-phase circuits.
   2. Submit installed lengths of cable for the following single-phase circuits:
      a. Circuits feeding single-phase transformers.
      b. Circuits feeding single-phase panelboards.

1.05 QUALITY ASSURANCE

A. Wires and cables shall be UL listed and labeled.

1.06 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.07 PROJECT OR SITE CONDITIONS

A. General site and project conditions:
   1. As specified in Section 01850 - Design Criteria.

1.08 ADMINISTRATIVE REQUIREMENTS (NOT USED)

1.09 WARRANTY

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

PART 2 PRODUCTS

2.01 GENERAL

A. Color-coding:
   1. Color-coding shall be consistent throughout the facility.
   2. The following color code shall be followed for 240/120 volt and 208/120-volt systems:
      a. Phase A: Black.
      b. Phase B: Red.
      c. Phase C: Blue.
      d. Single phase system: Black for 1 hot leg, red for the other.
      e. Neutral: White.
      f. High phase or wild leg: Orange.
      g. Equipment ground: Green.
   3. The following color code shall be followed for 480/277-volt systems:
      a. Phase A: Brown.
      b. Phase B: Orange.
      c. Phase C: Yellow.
      d. Neutral: Gray.
      e. Equipment ground: Green.
   4. The following color code shall be followed for 120 VAC control wiring:
      a. Power: Red.
      b. Neutral: White.
   5. The following color code shall be followed for general purpose DC control circuits:
      a. Grounded conductors: White with blue stripe.
      b. Ungrounded conductors: Blue.
   6. Switch legs shall be violet. 3-way switch runners shall be pink.
   7. Wires in intrinsically safe circuits shall be light blue.
   8. Wire colors shall be implemented in the following methods:
      a. Wires manufactured of the desired color.
      b. Continuously spiral wrap the first 6 inches of the wire from the termination point with colored tape:
         1) Colored tape shall be wrapped to overlap half of the width of the tape.

2.02 DESIGN AND PERFORMANCE CRITERIA

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

2.03 MANUFACTURERS

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

2.04 MATERIALS

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

2.05 MANUFACTURED UNITS

A. General:
   1. Provide new wires and cables manufactured within 1 year of the date of delivery to the Site.
   2. Permanently mark each wire and cable with the following at 24-inch intervals:
      a. AWG size.
      b. Voltage rating.
      c. Insulation type.
      d. UL symbol.
      e. Month and year of manufacture.
      f. Manufacturer's name.
   3. Identify and mark wire and cable as specified in Section 16075 - Identification for Electrical Systems:
      a. Use integral color insulation for #2 AWG and smaller wire.
      b. Wrap colored tape around cable larger than #2 AWG.

B. 600-volt class wire and cable:
   1. Provide AWG or kcmil sizes as indicated on the Drawings or in the Conduit Schedules:
      a. When not indicated on the Drawings, size wire as follows:
         1) In accordance with the NEC:
            a) Use 75-degree Celsius ampacity ratings.
            b) Ampacity rating after derating factors, equal to or greater than rating of the overcurrent device.
         2) Provide #12 AWG minimum for power conductors.
         3) Provide #14 AWG minimum for control conductors.

2. Provide Class B stranding in accordance with ASTM B8:
    a. Provide Class C stranding where extra flexibility is required.
3. Insulation:
    a. XHHW-2.
    b. 90-degree Celsius rating.

C. Instrumentation class cable:
1. Type TC.
2. Suitable for use in wet locations.
3. Voltage rating: 600 volts.
4. Temperature rating:
    a. 90-degree Celsius rating in dry locations.
    b. 75-degree Celsius rating in wet locations.
5. Conductors:
    a. Insulation:
        1) Flame-retardant PVC, 15 mils nominal thickness, with nylon jacket 4 mils nominal thickness.
    b. #16 AWG stranded and tinned.
    c. Color code: ICEA Method 1:
        1) Pair: Black and white.
        2) Triad: Black, white and red.
        3) Multiple pairs or triads:
            a) Color-coded and numbered.
6. Drain wire:
    a. #18 AWG.
    b. Stranded, tinned.
7. Jacket:
    a. Flame retardant, moisture and sunlight resistant PVC.
    b. Ripcord laid longitudinally under jacket to facilitate removal.
8. Shielding:
    a. Individual pair/triad:
        1) Minimum 1.35-mil double-faced aluminum foil-polyester tape overlapped to provide 100 percent coverage.
    b. Multiple pair or triad shielding:
        1) Group shield: Minimum 1.35-mil double-faced aluminum foil-polyester tape overlapped to provide 100 percent coverage.
        2) Completely isolate group shields from each other.
        3) Cable shield: 2.35 mils double-faced aluminum and synthetic polymer backed tape overlapped to provide 100 percent coverage.
    c. Shielding to be in contact with the drain wire.

D. Network cables:
1. Copper Ethernet cable:
    a. Provide copper Ethernet cable types as indicated on the Drawings and Specifications.
    b. General requirements:
        1) Cables shall meet the standards set by TIA-568.2-D and verified by third-party testing laboratory.

2) Conductors:
   a) 4 balanced twisted pairs.
      (1) #22 to #24 AWG thermoplastic insulated solid copper conducts enclosed by a thermoplastic jacket. Copper clad aluminum is not allowed.
3) Insulation:
   a) Non-Plenum: Polyolefin.
   b) Plenum: Fluoropolymer.
4) Color coded per T568B.
5) Outer jacket with ripcord.
6) Shielding:
   a) Provide F/UTP cables with drain wire for cables inside any equipment or enclosure with 480 VAC and above, outdoor installations, and where indicated on the Drawings.
7) Voltage rating:
   a) At a minimum provide 300 VAC rated jacket.
   b) 600 VAC rated jacket when cables are inside equipment or enclosures that contain 480 VAC power.
8) Approvals and listings:
   a) Meets any necessary NEC and NFPA requirements for each application.
   b) Riser applications: CMR in accordance with UL 1666.
   c) Plenum applications: CMP in accordance with NFPA 262.
9) Certification:
   a) Provide Category 5e cables with ICEA S-90-661 certification.
   b) Provide Category 6 cables with NEMA WC 66/ICEA S-116-732 certification.
   c) Provide Category 6A cables with NEMA WC 66/ICEA S-116-732 certification.

2.06 EQUIPMENT (NOT USED)

2.07 COMPONENTS (NOT USED)

2.08 ACCESSORIES

A. Wire ties:
   1. One of the following, or equal:
      a. Panduit, cable ties.
      b. T&B, “Ty-Rap” cable ties.

B. Wire markers:
   1. As specified in Section 16075 - Identification for Electrical Systems.

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

A. Assembly and testing of cable shall comply with the applicable requirements of NEMA WC 70/ICEA S-95-658-1999.

B. Test Type XHHW-2 in accordance with the requirements of UL 44.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. Install conductors only after the conduit installation is complete, and enclosures have been vacuumed clean, and the affected conduits have been swabbed clean and dry:
   1. Install wires only in approved raceways.
   2. Do not install wire:
      a. In incomplete conduit runs.
      b. Until after the concrete work and plastering is completed.

B. Properly coat wires and cables with pulling compound before pulling into conduits:
   1. For #4 AWG and larger, use an approved wire-pulling lubricant while cable is being installed in conduit:
      a. Ideal Products.
      b. Polywater Products.
      c. 3M Products.
      d. Greenlee Products.
      e. Or equal, as recommended by cable manufacturer.
      f. Do not use oil, grease, or similar substances.

C. Cable pulling:
   1. Prevent mechanical damage to conductors during installation.
   2. For cables #1 AWG and smaller, install cables by hand.
   3. For cables larger than #1 AWG, power pulling winches may be used if they have cable tension monitoring equipment.
   4. Provide documentation that maximum cable pulling tension was no more than 75 percent of the maximum recommended level as published by the cable manufacturer. If exceeded, the Engineer may, at his discretion, require replacement of the cable.
   5. Ensure cable pulling crews have calculations and cable pulling limitations while pulling cable.
   6. Make splices or add a junction box or pullbox where required to prevent cable pulling tension or sidewall pressure from exceeding 75 percent of manufacturer’s recommendation for the specified cable size:
      a. Make splices in manholes or pull boxes only.
      b. Leave sufficient slack to make proper connections.

D. Use smooth-rolling sheaves and rollers when pulling cable into cable tray to keep pulling tension and bending radius within manufacturer’s recommendations.

E. Install and terminate wire in accordance with manufacturer's recommendations.

F. Neatly arrange and lace conductors in switchboards, panelboards, pull boxes, and terminal cabinets by means of wire ties:
   1. Do not lace wires in gutter or panel channel.
   2. Install wire ties with a flush cutting wire tie installation tool:
      a. Use a tool with an adjustable tension setting.
   3. Do not leave sharp edges on wire ties.

G. Terminate stranded conductors on equipment box lugs such that conductor strands are confined within the lug:
   1. Use ring type lugs if box lugs are not available on the equipment.

H. Lighting circuits:
   1. Each circuit shall have a dedicated neutral.

I. Apply wire markers to wires at each end after being installed in the conduit and before meg-ohm testing and termination.

J. Instrumentation class cable:
   1. Install instrumentation class cables in separate raceway systems from power cables:
      a. Install instrument cable in metallic conduit within non-dedicated manholes or pull boxes.
      b. Install cable without splices between instruments or between field devices and instrument enclosures or panels.
   2. Do not make intermediate terminations, except in designated terminal boxes as indicated on the Drawings.

K. Copper Ethernet cables:
   1. In accordance with TIA-568.2-D.
   2. Pathways:
      a. For initial installation, the maximum fill capacity for pathways (i.e., conduit, raceways, trays, baskets) is 40 percent. The maximum fill capacity of 60 percent is allowed to accommodate future additions after initial installation.
      b. Conduit should be run in the most direct route possible with no more than two 90-degree bends between pull boxes and serve no more than 3 outlet boxes.
   3. Cable bend radius:
      a. Proper cable bend radius control must be maintained throughout the pathways. Bend radius needs to be at a minimum 10 times the cable diameter.
   4. Cable pulling:
      a. Provide cable pulling swivel system to prevent winding and tangling of rope and cables during pull.

b. Maximum pulling tension is not to exceed manufacturer recommendations. Cable installation should not in any way deform the cable jacket.
c. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.

5. Cable management:
   a. Organize and manage cables for quick and easy moves, adds and changes.
6. Cable termination:
   a. Install equipment outlet connector hardware (e.g., RJ45, M12, etc.), and connect to field equipment outlet (e.g., instrument, VFD, actuator, etc.).
   b. Use shielded connectors as required by the installation.
   c. Coordinate cable termination at copper patch panels with ICSC and General Contractor.
7. Testing:
   a. Copper Ethernet cable testing requirements as specified in Section 16950 - Field Electrical Acceptance Tests.
8. Separation from EMI sources:
   a. Comply with TIA-569-B recommendations for separating unshielded copper voice and data communication cable from potential EMI sources, including electrical power lines and equipment.
   b. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:
      1) Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches.
      2) Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches.
      3) Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches.
   c. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:
      1) Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches.
      2) Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches.
      3) Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches.
   d. Separation between communications cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:
      1) Electrical Equipment Rating Less Than 2 kVA: No requirement.
      2) Electrical Equipment Rating between 2 and 5 kVA: A minimum of 3 inches.
      3) Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches.
   e. Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 48 inches.

L. Signal cable:
   1. Separate and isolate electrical signal cables from sources of electrical noise and power cables by minimum 12 inches.

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

3.04 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

B. Functional Testing:
   1. As specified in Section 16950 - Field Electrical Acceptance Tests.

END OF SECTION

SECTION 16125

FIBER OPTIC CABLE AND APPURTENANCES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Fiber optic cable.
   2. Fiber splices and terminations.
   3. Accessories.

1.02 REFERENCES

A. Abbreviations:
   1. N/Cm: Newtons per centimeter.
   2. OTDR: Optical Time Domain Reflectometer (Tier 2 test).
   3. OTLS: Optical Loss Test Set (Tier 1 test).

B. Standards:
   1. Bellcore Standards:
      a. GR-409 - Generic Requirements for Indoor Fiber.
   2. Electronic Industry Association (EIA):
      a. FOTP-25 - Impact testing of Fiber Optic Cables and Cable Assemblies.
      b. FOTP-33 - Fiber Optic Cable Tensile Loading and Bending Test.
      c. FOTP-41 - Compressive Loading Resistance of Fiber Optic Cables.
      d. FOTP-81 - Compound Flow (Drip) Test for Filled Fiber Optic Cable.
      e. FOTP-104 - Fiber Optic Cable Cyclic Flexing Test.
      f. FOTP-181 - Lightning Damage Susceptibility Test for Fiber Optic Cables with Metallic Components.
   3. Insulated Cable Engineer's Association (ICEA):
      a. S-83-596 - Optic Fiber Premises Distribution Cables.
      b. S-87-640 - Optic Fiber Outside Plant Communications Cable.
      c. S-104-696 - Indoor-Outdoor Optic Fiber Cable.
   4. TIA/EIA Standards:
      a. 598 - Optical Fiber Cable Color Coding.
      b. 11801 - Information technology - Generic cabling for customer premises.
   5. Underwriters Laboratories, Inc. (UL):
      a. 1666 - Test for Flame Propagation Height of Electrical and Optical-Fiber Cables Installed Vertically in Shafts.
      b. 1685 - Vertical-Tray Fire-Propagation and Smoke-Release Test for Electrical and Optical-Fiber Cables.

1.03 TERMINOLOGY

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

1.04 DELEGATED DESIGN (NOT USED)

1.05 SUBMITTALS

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

B. Product data:
   1. Complete manufacturer's brochures that identify materials and options.
   2. Completed datasheets, including catalog number and source for determining catalog number.
   3. Manufacturer's installation instructions.
   4. Include the following:
      a. Manufacturer's data on testing equipment used on this project.
      b. Manufacturer's specifications and datasheets for all fiber types.
      c. Manufacturer's specifications and datasheets for all connectors, bulkheads, splicing kits, breakout devices, and appurtenances used in connecting and terminating fiber spans.
   5. Catalog data on testing devices proposed for use plus certifications of accuracy, calibration, and traceability to standards of the NIST.
   6. Manufacturer's test procedures and quality assurance procedures:
      a. After review, Engineer may require that additional tests be performed before installation.

C. Shop Drawings:
   1. Interconnection cabling diagrams for the complete system including every fiber in each cable.
   2. Drawings indicating locations of all pull boxes including pull box identifiers and lengths.
   3. Submit optical power budget calculations for fiber segments. Include the following:
      a. Minimum transmit power of active devices.
      b. Minimum receive sensitivity.
      c. Available power, in dBm.
      d. Loss for each segment in dBm, including cable attenuation and connector losses. Use manufacturer's data for cable attenuation, at the wavelength to be used. Assume 0.5 dB per connector.
      e. Demonstrate that remaining power budget at each receiver is equal to or greater than 3.0 dBm.

D. Installation instructions:
   1. Submit a cable pulling and splicing work plan that includes the following:
      a. Pull tension calculations.
      b. Detailed description of pull operation methods for conduit runs.
      c. Tools and equipment to be used for cable installation and testing.
      d. Physical location of equipment setup and type.
      e. Exact locations of splice points.
      f. Safety and manual assist cable-pulling operations.
      g. Detailed schedule for pulling and testing cables.
      h. Name and qualifications of the supervisory personnel directly responsible for installation of the conduit system.

i. Sample fiber optic cable test sheets.
j. Signed test sheet results.

E. Commissioning Submittals:
1. As specified in Section 01756 - Commissioning, including the following:
a. Manufacturer's representative qualifications.
b. Certificates:
1) Requirements as specified in this Section.
c. Test Plans:
1) Test requirements as specified in this Section.
d. Test Reports.
e. Manufacturer's representatives field notes and data.

F. Operation and maintenance manuals:
1. Compile completed test reports, instruction manuals, and manufacturer's information into the operating manuals and submitted in accordance with Section 01782 - Operation and Maintenance Manuals.

G. Test reports:
1. Submit results of specified tests to the Engineer.
2. Submit 3 copies of test reports showing results of tests specified in this Section or in Section 16950 - Field Electrical Acceptance Tests:
a. Test forms shall include the following information at a minimum:
1) Test type.
2) Test location.
3) Test date.
4) Wavelength.
5) Index of refraction.
6) Cable identification.
7) Fiber type.
8) Fiber number.
9) Fiber color.
10) Result of the value of the tested parameter.
3. Furnish hard copy and electronic copy for OTDR traces.
4. Submit certification that the fiber optic cable has passed each testing stage:
a. Submit separate documentation for each testing stage result.

H. Record documents:
1. Furnish updated electrical drawings, network diagrams, and fiber cable block diagrams at the end of construction and submit as record drawings.

I. Calculations:
1. Cable pulling calculations for conduit runs:
a. Indicate on the Submittal any additional pull boxes that are required, including pull box identifiers and a written description of the location.

1.06 QUALITY ASSURANCE

A. Furnish cable and appurtenances manufactured within 1 year of installation.

B. Proof test optical fibers by the fiber manufacturer at a minimum load of 50 kpsi.

C. Provide 100 percent attenuation testing for optical fibers:
   1. Include with each cable reel the attenuation of each fiber.

D. Provide information on at least 5 successful fiber optic cable installations of comparable size and complexity in the past 3 years with name, address, and telephone number of facility owner, name of project with completion date, and type of conduit system and length of cable pulled.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Package cable for shipment on wooden reels:
   1. Seal both ends of cable to prevent ingress of moisture.
   2. Place fiber cable assemblies on reels such that both cable ends are available for testing.
   3. Weatherproof cable reel markings shall include the following:
      a. Manufacturer.
      b. Date of manufacture.
      c. Shipping date.
      d. Cable identification.
      e. Cable configuration/fiber count.
      f. Cable length.
      g. Gross weight.
      h. Cable test date.
      i. Handling instructions.
      j. Direction to unreel.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 01850 - Design Criteria.

1.09 ADMINISTRATIVE REQUIREMENTS

A. Sequencing:
   1. Submit a cable pulling and splicing work plan a minimum of 45 days before the planned initiation of cable pulling. Cable pulling and splicing work plan must be approved a minimum of 15 days before pulling cable.
   2. Testing sequence:
      a. Perform testing of each fiber in each cable as follows:
         1) At factory before shipment.
         2) At project site upon delivery.
         3) Submit copies of test results to the Engineer within 5 days after the delivery to the site.
         4) After installation, before breakout and terminations.
         5) After installation is complete.
      b. Submit test reports following each set of tests as specified in this Section.

B. Scheduling:
   1. Schedule Engineer, 5 days before installation, to witness cable installations.
   2. Notify the Engineer and Owner a minimum of 15 days before post-installation testing.

1.10 WARRANTY

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

PART 2 PRODUCTS

2.01 GENERAL

A. Furnish a complete fiber optic network as indicated on the Drawings.

2.02 DESIGN AND PERFORMANCE CRITERIA

A. Install fiber optic system components in accordance with the recommendations of the manufacturer.

2.03 MANUFACTURERS

A. Acceptable manufacturers are indicated with each component type as listed in the remainder of this Specification.

2.04 MATERIALS (NOT USED)

2.05 MANUFACTURED UNITS

A. General fiber cable requirements:
   1. Suitable for the installed environment.
   2. Color-coded fibers according to EIA/TIA-598.
   3. Color-coded buffer tubes according to EIA/TIA-598.
   4. Furnish buffer tubes of a single layer nylon construction or of a material with similar mechanical performance.
   5. Fillers may be included in the cable core to lend symmetry to the cable cross-section where needed.
   6. Apply binders with sufficient tension to secure buffer tubes to the central member without crushing the buffer tubes:
      a. Provide binders that are:
         1) Non-hygroscopic.
         2) Non-wicking (or rendered so by the flooding compound).
         3) Dielectric with low shrinkage.
   7. Provide a minimum of 1 ripcord under the cable sheath.
   8. Provide high tensile strength Aramid yarns, Kevlar, and/or fiberglass helically stranded evenly around the cable core:
      a. No metallic elements whatsoever are allowed in non-armored cable.
   9. Jacket or sheath shall be free of holes, splits, and blisters.
   10. Mark jacket or sheath with:
      a. Manufacturer's name.
      b. “Optical Cable”.
      c. Year of manufacture.
      d. Sequential meter marks.
      e. Repeat markings every 1-meter.
      f. Actual length of the cable to be within 1 percent of the length marking.

g. Marking must be in a contrasting color to the cable jacket.
h. Height of the marking:
1) Approximately 2.5 millimeters.

11. Shipping, storage, and operating temperature range of the cable shall be -40 degrees Celsius to +70 degrees Celsius.
12. General performance characteristics:
a. Rated tensile load of the cables:
1) Indoor/outdoor:
a) Short term: 1,330 N.
b) Long term: 400 N.
2) Outdoor:
a) Short term: 2,600 N.
b) Long term: 800 N.
b. Non-armored fiber optic cables: Compressive load withstand of 220 N/cm applied uniformly over the length of the cable.
c. Armored fiber optic cables: Compressive load withstand of 440 N/cm applied uniformly over the length of the cable.
d. Average increase in attenuation for the fibers: Less than or equal to 0.10 dB at 1,550 nm for a cable subjected to this load:
1) With no measurable increase in attenuation after load removal.
e. Test in accordance with EIA FOTP-41 except that the load must be applied at the rate of 3 millimeters to 20 millimeters per minute and maintained for 10 minutes.
f. Capable of withstanding 25 cycles of mechanical flexing at a rate of 30 within 1 cycles/minute.
g. Average increase in attenuation for the fibers: Less than or equal to 0.10 dB at 1,550 nm at the completion of the test.
h. For armored cables, any visible cracks causing separation of the armor and propagating more than 5 millimeters constitutes failure.
i. Outer cable jacket cracking or splitting observed under 10X times magnification, constitutes failure.

B. Indoor/outdoor cable:
1. Cable construction:
a. General:
1) Cable type: Indoor/Outdoor - Flame retardant, low smoke, zero halogen, UV resistant.
2) Fiber count: As indicated on the Drawings.
3) Fiber type: As indicated on the Drawings.
4) Buffer tube: Tight buffer.
5) Armoring: None.
6) Waterproofing: Water blocking layer.
7) Strength member:
a) Tight buffer: For cables with more than 12 fiber strands, utilize a central, nonmetallic strength member with a coefficient of thermal expansion similar to the fibers.
8) Approvals and listings: UL 1666 and UL 1685.
9) Design and test criteria: In accordance with ICEA S-104-696.
b. Testing:
1) Fibers in the cable:
a) Proof test of 100 kpsi.

b) Each optical fiber: Bellcore GR-409 strip force testing.
c) No gaps are allowed between the coating material and the buffer material visible under a 50-power microscope.

c. Outer jacket material:
1) Linear low-density polyethylene.
2) Meet requirements of the NEC for use in indoor/outdoor areas (excluding plenums) without being enclosed in conduit.
3) Flame retardant OFNR riser rated conforming to UL 1666.
4) Printed with necessary UL marks and manufacturer identification.
5) Sequential printing of footage in 2-foot increments.
6) With a ripcord incorporated under the cable jacket.

C. Single mode fibers:
1. Fibers in the cable must be usable fibers and meet required specifications.
2. Each optical fiber shall consist of a doped silica core surrounded by a concentric silica cladding.
3. Single mode fiber characteristics:
a. Category: OS2 compliant with ITU-G.657.A1.
b. Jacket color: Yellow.

D. Indoor/outdoor:
1. Tight buffer:
a. Corning Cable Systems, Freedm® One.
b. Optical Cable Corporation, DX-Series.
c. CommScope, LazrSPEED/TerraSPEED.

2.06 EQUIPMENT (NOT USED)

2.07 COMPONENTS (NOT USED)

2.08 ACCESSORIES

A. Patch cords:
1. General:
a. Connector types to match supplied equipment and patch panel terminations.
b. Maximum length of patch cords: 25 feet.
c. Provide 2 spare patch cords (or 1 duplex patch cord) of each type used at each PLC or network cabinet.
d. Factory assembled and optically tested.
e. Provide mode-conditioning cords for multimode fibers operating at 1,310 nm.
2. Manufacturers: One of the following or equal:
a. CommScope.
b. Corning Cable Systems.

B. Fiber connectors:
1. As specified in Section 17733 - Control Systems: Network Materials and Equipment.

C. Fiber optic identification/warning tags:
    1. Black letters on orange or yellow background.
    2. UV resistant polyethylene or other suitable material:
        a. Manufacturers: The following or equal:
            1) Almetek.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify the condition of the conduit system before installation of the fiber optic cable or inner duct.

B. Pass a test mandrel through fiber optic conduits prior to pulling fiber or installing inner duct.
    1. Run the mandrel in both directions.

C. Examine materials and equipment before installation and verify they are free from physical damage and defects.

3.02 PREPARATION

A. Equipment support and anchoring to structures:
    1. Prepare anchor setting template(s) and use to position anchors during construction of supporting structures.
    2. Install anchors of type and material indicated on approved anchoring designs.
    3. Install anchors with embedment indicated on approved anchoring designs.

B. Before fiber splicing terminating or testing activities, verify sufficient workspace is available to perform the activity without interferences from other trades.

C. Pre-installation test:
    1. Upon arrival at the site:
        a. Inspect the cable and reel for damage.
        b. Test fibers with an optical time domain reflectometer (OTDR) for fiber integrity.
        c. Verify that the fiber lengths are consistent with the cable manufacture.
        d. Verify that traces yield no point discontinuities.
    2. Complete test sequence and obtain approval from the Engineer of submitted test results before cable installation.

3.03 INSTALLATION

A. Install fiber optic patch cords in open network trays or in dedicated conduits no longer than 25 feet in length.

B. Install fiber optic cable in continuous lengths without intermediate splices, except where approved by the Engineer.

C. Cable installation:
   1. Properly attach the fiber optic cable's strength elements to a 600-pound breakaway swivel containing tension or shear pins using Kellums pulling grips that are a minimum of 18 inches long.
   2. Certify that cable tensile limits do not exceed cable pull tension and bend limits using tension monitoring devices.
   3. Leave an extra loop of fiber optic cable in each pull box.
   4. Conform with the cable manufacturer's specifications, practices, and the following requirements:
      a. When power equipment is used to install fiber optic cables, use low speeds and do not exceed a rate of 30 meters per minute.
      b. Do not exceed the tensile and bending limitation for fiber optic cables under any circumstances.
      c. Use large diameter wheels, pulling sheaves, and cable guides to maintain the specified bending radius.
      d. Use commercial dynamometers or load cells to monitor pulling tension.
      e. A nonfreezing type of swivel inserted between the pulling line and cable pulling grip to prevent twisting under strain.
      f. Cable to be installed using a breakaway swivel.
   5. Apply to conduits a lubricant at each conduit ingress and egress location during the pull operation:
      a. Pour or pump lubricant into the end of the conduit at the feed location at a nominal application rate of 3 gallons per 1,000 feet of cable.
      b. If the conduit is open at intermediate locations, then apply the appropriate proportion of lubricant at each opening.
      c. Continuously lubricate the cable as it is being pulled by pouring or pumping the lubricant into the conduit at the feed location and at each intermediate location.
      d. Station workers at each intermediate location as required.
      e. Remove excess lubricant that has collected.
      f. Remove and clean the surrounding area after cable installation.
   6. Install using a hydraulic capstan or winch equipped with a recording running line dynamometer graph which measures and records pulling tensions:
      a. Use pulling equipment with slip-load capability to allow the winch to maintain a constant pulling force without taking up the winch line.
      b. Use pulling equipment equipped with a hydraulic bypass set so that a maximum tension of 600 pounds is not exceeded.
      c. Use only equipment designed to prevent a preset pulling tension from being exceeded.
      d. Fiber optic cable manufacturer to provide the pulling tension setpoint.
      e. If during the pulling operation excessive tension is detected, cease operations and notify the Engineer.
   7. Position the cable reel at the feed point in alignment with the raceway and in such a position that the cable can be passed from the top of the reel in a long, smooth bend into the raceway system:
      a. Use of a cable feeder is required unless the cable is hand-pulled.
   8. Supply bull wheels, blocks, split wheels, cable feeders, and necessary equipment required to provide a clean and safe operation:
      a. Cable shall not be allowed to travel over any wheel or block that has a radius less than the minimum radius allowed by the cable manufacturer.

9. Minimize the use of snatch blocks and rollers to guide the cable into the conduit at the feed point:
    a. Slack feed by hand the cable into the feed point and raceway without the use of rollers.
10. Tend the cable reel at all times and turn by hand to provide the required cable slack:
    a. Under no circumstances shall the cable tension be allowed to turn the cable reel.
11. Use a rim roller, with a wheel radius greater than the minimum cable bending radius placed at the manhole or vault opening to prevent the cable from dragging on the manhole rim or steps.
12. Perform a continuous thorough visual inspection for flaws, breaks, and abrasions in the cable sheath as the cable leaves the reel and maintain a slow pulling speed to permit this inspection.
13. Damage to the sheath or finish of the cable is cause for rejecting the cable:
    a. Replace any cable damaged in any way during installation.
14. If the cable becomes damaged during installation, stop operations and notify the Engineer immediately:
    a. Engineer to determine whether to replace the entire reel of cable or to install a termination panel to eliminate the damaged section.
15. Document pulls by a graph which is annotated with the following information:
    a. Reel number.
    b. Pull point ID.
    c. Date and time.
    d. Explanations for abnormalities in readings or interruptions.
    e. Sign-off by Contractor and Engineer.
16. Under no conditions shall the fiber optic cable be left exposed or unattended.

D. After the cables are installed and spliced:
    1. Rack the cables:
        a. Loosely secure in racked position with wire ties.
        b. Attach imprinted plastic-coated cloth identification/warning tags to each cable in at least 2 locations in each handhole/manhole.

E. Ground armored fiber optic cables containing metallic members in accordance with NEC.

F. Splices:
    1. Provide field splices in a splice tray located in a waterproof splice enclosure:
        a. Manufacturers: The following or equal:
            1) Tyco/Raychem, FOSC style splice enclosure.
    2. Loop the individual fibers a minimum of 1 full turn within the splice tray to avoid macro/micro bending.
    3. After completion of cable terminations, neatly dress cables.
    4. Protect splices with a thermal shrink sleeve.
    5. Provide fusion type fiber optic cable splicing meeting the following requirements:
        a. Joins multimode or single mode fibers.
        b. Establishes a permanent fusion splice.
        c. Waterproof.
        d. Re-enterable, rearrangeable, and reusable.
        e. Splice loss less than 0.10 dB.

f. Protected by a splice enclosure.

6. Requirement for outdoor fiber splice enclosures:
   a. Seal.
   b. Bond.
   c. Anchor.
   d. Protect fiber optic cable splices.
   e. Stand-alone unit that does not require an outer enclosure.
   f. Provide for a maximum of 6 cable entries in a butt-end configuration.
   g. Used in aerial, underground, and direct buried applications.
7. Requirement for indoor fiber splice enclosures:
   a. Anchor.
   b. Protect fiber optic cable splices.
   c. Stand-alone unit that does not require an outer enclosure.
   d. Suitable for the minimum number of splices at that location plus additional capacity for reconfigurations.
8. Re-splice any splice that has a loss greater than 0.10 dB.
9. Leave a minimum of 20 feet of fiber optic cable at each end of splice.

G. Terminations:
1. Terminate fiber inside a patch panel:
   a. Direct landing to a switch, router hub, or PLC will not be allowed.
2. Terminate outdoor cables using a breakout kit that seals the cable and provides physical protection for the fiber strands.
3. Terminate indoor cables using factory assembled terminations pig tail spliced to the cable ends.
4. Labeling:
   a. Permanently label cable terminations. Use labels produced by a wire printer using pressure sensitive polyester labels.
   b. Label patch panels as specified in Section 16075 - Identification for Electrical Systems.

3.04 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

B. Source Testing:
1. Before shipment and while on the shipping reel, test 100 percent of fibers for attenuation:
   a. Copies of the results shall be:
      1) Maintained on file.
      2) Attached to the cable reel in a waterproof pouch.
      3) Submitted before the delivery of the cable to the job site to Engineer for approval.
2. Conduct the flex test in accordance with EIA FOTP-104 test condition I and III with a maximum sheave diameter of 20 times the cable OD.
3. Verify that the cable withstands 25 impact cycles with:
   a. Average increase in attenuation for fibers less than 0.20 dB at 1,550 nm.
   b. No evidence of cracking or splitting.
   c. Conduct test in accordance with EIA FOTP-25.

4. Certify that the cable withstands a tensile load of 2,700 N (600 pounds):
    a. Without exhibiting an average increase in attenuation of greater than 0.10 dB.
    b. Test in accordance with EIA FOTP-33 using a maximum mandrel and sheave diameter of 560 millimeters.
    c. Apply the load for 1 hour in Test Condition II.
5. Certify that the cable withstands a simulated lightning strike:
    a. Peak value of the current pulse greater than 105kA.
    b. Use a test current with a damped oscillatory maximum time-to-peak value of 15 µs (which corresponds to a minimum frequency of 16.7 kHz) and a maximum frequency of 30 kHz.
    c. Time to half-value of the waveform envelope 40 to 70 µs.
    d. Conduct the test in accordance with the EIA FOTP-181.
    e. In addition to the analysis criterion set forth in EIA FOTP-181, the integrity of the buffer tubes (or analogous loose tube, i.e., core tube) and strength members must be intact after removal of the cable specimens from the test box.
6. Furnish test reports and Manufacturer’s Certificate of Source Testing.

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

D. Functional Testing:
1. Conduct post-installation tests of the fiber optic system as specified in Section 16950 - Field Electrical Acceptance Tests.

3.05 FIELD QUALITY CONTROL

A. Utilize personnel certified by the manufacturer with specific knowledge of the cable manufacturer's recommended installation procedures.

B. General:
1. Test results shall meet or exceed manufacturer specifications:
    a. Test each fiber of each cable for breaks, abnormalities, and overall attenuation characteristics.
2. Pre-installation tests and post-installation tests to be witnessed and signed off by Engineer and Owner.
3. Perform OLTS test with equipment capable and calibrated to show anomalies of 0.1 dB as a minimum:
    a. Test multimode fibers at 850 nm and 1,300 nm.
    b. Test single mode fibers at 1,310 and 1,550 nm.
4. Perform OTDR tests on fiber cables less than 100 meters with the aid of a launch cable:
    a. Adjust OTDR pulse width settings to a maximum setting of 1/1,000th of the cable length or 10 nanoseconds.

3.06 ADJUSTING (NOT USED)

3.07 CLEANING

A. Clean fiber optic connectors after termination and before testing. After cleaning, cover unterminated connectors with a protective boot.

B. At the completion of construction, touch up the finish on fiber patch panels and enclosures.

3.08 PROTECTION

A. Protect the fiber system from physical damage and the encroachment of dust, before, during, and after installation.

3.09 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16130

CONDUITS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Metallic conduits.
   2. Nonmetallic conduits.
   3. Conduit bodies.
   4. Conduit fittings and accessories.
   5. Conduit installation.

1.02 REFERENCES

A. Abbreviations:
   1. GRC: Galvanized rigid steel conduit.
   2. PCS: Polyvinyl chloride (PVC) coated rigid steel conduit.
   3. PVC: Polyvinyl chloride rigid nonmetallic conduit.
   4. SLT: Sealtight-liquidtight flexible conduit.

B. Standards:
   1. American National Standards Institute (ANSI):
      a. C80.1 - Electrical Rigid Steel Conduit.
   2. National Electrical Code (NEC).
   3. National Electrical Manufacturer's Association (NEMA):
      a. RN-1 - Polyvinyl Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Steel Conduit.

1.03 UNDERWRITERS LABORATORIES (UL), INC.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. Conduit bodies: A separate portion of a conduit system that provides access through a removable cover to the interior of the system at a junction of 2 or more conduit sections. Includes, but not limited to, Shapes C, E, LB, T, X, etc.
   2. Conduit fitting: An accessory that primarily serves a mechanical purpose. Includes, but not limited to, bushings, locknuts, hubs, couplings, reducers, etc.

1.04 DELEGATED DESIGN

A. As specified in Section 01357 - Delegated Design Procedures and Section 16070 - Hangers and Supports.

1.05 SUBMITTALS

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

B. Product data:
   1. Furnish complete manufacturer's catalog sheets for every type and size of conduit, fitting, conduit body, and accessories to be used on the Project.
   2. Furnish complete manufacturer's recommended special tools to be used for installation, if required.
   3. Certified test results for PVC-coated metallic conduit showing the adhesive bond is stronger than the tensile strength of the PVC.

C. Shop Drawings:
   1. Furnish conduit routing plans for conduits before the installation of any conduit.
   2. Detail the intended routing of each conduit, conduit material and include supporting methods.
   3. Number conduits in accordance with the Contract Documents.
      a. Provide conduit labels as specified in Section 16075 - Identification for Electrical Systems.

D. Delegated Design Submittals:
   1. As specified in Section 16070 - Hangers and Supports.

E. Certifications:
   1. Furnish PVC-coated conduit manufacturer's valid, unexpired certification for each installer.

F. Record Documents:
   1. Incorporate changes in conduit routing on electrical plan drawings.
   2. Dimension underground and concealed conduits from building lines.
   3. Furnish hard copy drawings.

G. Installation drawings: Including individual conduit numbers, routing, sizes, cable sizes, and circuit numbers for each conduit.

1.06 QUALITY ASSURANCE

A. Conduits, conduit bodies, and fittings shall be UL listed and labeled.

B. Every installer of PVC-coated metallic conduit shall be certified by the manufacturer for installation of the conduit, and be able to present a valid, unexpired installer certification card prior to installation beginning.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Do not expose non-metallic conduit to direct sunlight.

B. Do not store conduit in direct contact with the ground.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 01850 - Design Criteria.

1.09 ADMINISTRATIVE REQUIREMENTS

A. Sequencing:

1.10 WARRANTY

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

PART 2 PRODUCTS

2.01 GENERAL (NOT USED)

2.02 DESIGN AND PERFORMANCE CRITERIA

A. Provide conduits, conduit bodies, fittings, junction boxes, and necessary components, whether or not indicated on the Drawings, as required, to install a complete electrical raceway system.

B. Provide location and protection of existing underground utilities, underground conduit trenching, conduit and backfill necessary for the complete installation of underground conduits.

2.03 MANUFACTURERS

A. Galvanized rigid steel conduit:
   1. One of the following or equal:
      a. Allied Tube and Conduit.
      b. Western Tube and Conduit.
      c. Wheatland Tube Co.

B. PVC-coated rigid steel conduit:
   1. One of the following or equal:
      a. Allied.
      b. Calbond.
      c. NEC, Inc. BlackGuard.
      d. Ocal, Inc.
      e. Robroy Ind.

C. Sealtight-liquidtight flexible conduit:
   1. One of the following or equal:
      a. AFC Cable Systems.
      b. Anaconda.
      c. Electri-Flex Co.
      d. Southwire.

D. Inner duct:
   1. One of the following or equal:
      a. Carlon.
      b. Endot Ind.
      c. MaxCell.

E. Fiberglass reinforced duct:
   1. One of the following or equal:
      a. Champion Fiberglass.
      b. FRE Composites.
      c. Smith Fiberglass.

F. Conduit bodies:
   1. One of the following or equal:
      a. Appleton.
      b. Calbond.
      c. Carlon.
      d. Crouse-Hinds.
      e. O-Z/Gedney.
      f. Ocal, Inc.
      g. Robroy Ind.

G. Joint compound:
   1. The following or equal:
      a. Thomas & Betts.

H. Galvanized rigid steel conduit expansion fittings:
   1. One of the following or equal:
      a. Appleton.
      b. Crouse-Hinds.
      c. O-Z/Gedney.

I. PVC-coated rigid steel conduit expansion fittings:
   1. One of the following or equal:
      a. NEC, Inc. BlackGuard.
      b. Ocal, Inc.
      c. Robroy Ind.

J. Conduit sleeve:
   1. One of the following or equal:
      a. Appleton.
      b. Crouse-Hinds.
      c. O-Z/Gedney.

K. Conduit seals:
   1. One of the following or equal:
      a. Appleton.
      b. Crouse-Hinds.
      c. O-Z/Gedney.

L. Conduit through wall and floor seals:
   1. The following or equal:
      a. O-Z/Gedney:
         1) Type “WSK.”
         2) Type “CSM.”

2.04 MATERIALS (NOT USED)

2.05 MANUFACTURED UNITS (NOT USED)

2.06 EQUIPMENT (NOT USED)

2.07 COMPONENTS

A. GRC:
   1. NPT standard conduit threads with a 3/4-inch taper per foot:
      a. Running conduit threads are not acceptable.
   2. Hot-dip galvanized inside and out:
      a. Ensures complete coverage and heats the zinc and steel to a temperature that ensures the zinc alloys with the steel over the entire surface.
      b. Electro-galvanizing is not acceptable.
   3. Manufactured in accordance with:
      a. UL-6.
      b. ANSI C80.1.

B. PCS:
   1. Steel conduit, before PVC coating, shall be new, unused, hot-dip galvanized material, in accordance with to the requirements for Type GRC.
   2. Coated conduit NEMA Standard RN-1:
      a. Galvanized coating may not be disturbed or reduced in thickness during the cleaning and preparatory process.
   3. Factory-bonded PVC jacket:
      a. Exterior galvanized surfaces shall be coated with primer before PVC coating to ensure a bond between the zinc substrate and the PVC coating.
      b. Nominal thickness of the exterior PVC coating shall be 0.040 inch except where part configuration or application of the piece dictates otherwise.
      c. PVC coating on conduits and associated fittings shall have no sags, blisters, lumps, or other surface defects and shall be free of holes and holidays.
      d. PVC adhesive bond on conduits and fittings shall be greater than the tensile strength of the PVC plastic coating:
         1) Confirm bond with certified test results.
   4. Urethane coating shall be uniformly and consistently applied to the interior of conduits and fittings:
      a. Nominal thickness of 0.002 inch.
      b. Conduits having areas with thin or no coating are not acceptable.
      c. Threads shall be coated with urethane.
   5. PVC exterior and urethane interior coatings applied to the conduits shall afford sufficient flexibility to permit field bending without cracking or flaking at temperature above 30 degrees Fahrenheit (-1 degree Celsius).
   6. PCS conduit bodies and fittings:
      a. Malleable iron.
      b. Conduit body, before PVC coating, shall be new, unused material and shall be in accordance with appropriate UL standards.
      c. PVC coating on the outside of conduit bodies shall be 0.040-inch thick and have a series of ribs to protect the coating from tool damage during installation.
      d. 0.002-inch interior urethane coating.

e. Utilize PVC coating as an integral part of the gasket design.
f. Stainless steel cover screw heads shall be encapsulated with plastic to ensure corrosion protection.
g. PVC sleeve extending 1 conduit diameter or 2 inches, whichever is less, shall be formed at each female conduit opening.
    1) Inside diameter of the sleeve shall be the same as the outside diameter of the conduit to be used.
    2) Sleeve shall provide a vapor- and moisture resistant seal at every connection.
    3) Fittings shall be Form 8 and supplied with plastic encapsulated stainless steel cover screws. Fittings shall be UL Type 4X. Fittings shall be from the same manufacturer as the conduit in order to maintain system continuity and warranty.

C. SLT:
1. Temperature rated for use in the ambient temperature at the installed location but not less than the following:
    a. General purpose:
        1) Temperature range: -20 degrees Celsius to +80 degrees Celsius.
    b. Oil-resistant:
        1) Temperature range: -20 degrees Celsius to +60 degrees Celsius.
2. Sunlight-resistant, weatherproof, and watertight.
3. Manufactured from single strip steel, hot-dip galvanized on all 4 sides before conduit fabrication.
4. Strip steel spiral wound resulting in an interior that is smooth and clean for easy wire pulling.
5. Overall PVC jacket.
6. With integral copper ground wire, built in the core, in conduit trade sizes 1/2 inch through 1-1/4 inch.

D. Inner duct:
1. HDPE and fabric inner duct are considered interchangeable.
2. HDPE inner duct:
    a. High-density polyethylene.
    b. Corrugated.
    c. Resin properties:
        1) Density, g/cm^3: 0.941 to 0.955.
        2) Melt index g/10-minute Condition E: 0.05 to 0.5.
        3) Flexural modulus, MPa (pounds per square inch): 80,000 minimum.
        4) Tensile strength at yield (pounds per square inch): 3,000 minimum.
        5) Environmental stress crack resistance condition B, F_{10}: 96 hours minimum.
        6) Brittleness temperature: -75 degrees Celsius.
    d. Size: 1.25 inch.
    e. Colors: orange.
3. Fabric inner duct:
    a. White polyester and nylon resin polymer textile.
    b. Standard outdoor textile inner duct:
        1) 3-inch multi-cell inner duct containing pull tape in each cell.
    c. Color-coded.

d. Pull tape:
    1) 1,250 pound.
    2) Synthetic fiber polyester, flat woven.
    3) Printed sequential footage marks.

E. Conduit bodies:
1. Material consistent with conduit type:
    a. Malleable iron bodies and covers when used with Type GRC.
    b. PVC bodies and covers when used with Type PVC.
    c. PVC-coated malleable iron bodies and covers when used with Type PCS.
2. Conduit bodies to be in accordance with to Form 8, Mark 9, or Mogul design:
    a. Mogul design in accordance with to NEC requirements for bending space for large conductors for conduit trade sizes of 1 inch and larger with conductors #4 AWG and larger, or where required for wire-bending space.
3. Gasketed covers attached to bodies with stainless steel screws secured to threaded holes in conduit body.

2.08 ACCESSORIES

A. Connectors and fittings:
1. Manufactured with compatible materials to the corresponding conduit.

B. Insulated throat metallic bushings:
1. Construction:
    a. Malleable iron or zinc-plated steel when used with steel conduit.
    b. Positive metallic conduit end stop.
    c. Integrally molded non-combustible phenolic-insulated surfaces rated at 150 degrees Celsius.
    d. Use fully insulated bushings on nonmetallic conduit system made of high-impact 150 degrees Celsius rated non-combustible thermosetting phenolic.

C. Insulated grounding bushings:
1. Construction:
    a. Malleable iron or steel, zinc-plated, with a positive metallic end stop.
    b. Integrally molded non-combustible phenolic-insulated surfaces rated at 150 degrees Celsius.
    c. Tin-plated copper grounding saddle for use with copper or aluminum conductors.

D. Electrical unions (Erickson Couplings):
1. Construction:
    a. Malleable iron for use with steel conduit.
    b. PVC-coated malleable iron for use with PCS conduit.
    c. Concrete tight, 3-piece construction.
    d. Rated for Class I Division 1 Group D in hazardous areas.

E. SLT fittings:
1. Construction:
    a. Malleable iron.
    b. Furnished with locknut and sealing ring.

c. Liquidtight, raintight, oiltight.
d. Insulated throat.
e. Furnish as straight, 45-degree elbows, and 90-degree elbows.
f. Designed to prevent sleeving:
1) Verify complete bonding of the raceway jacket to the plastic gasket seal.
g. Equipped with grounding device to provide ground continuity irrespective of raceway core construction. Grounding device, if inserted into raceway and directly in contact with conductors, shall have rolled-over edges for sizes under 5 inches.
h. Where terminated into a threadless opening using a threaded hub fitting, a suitable moisture-resistant/oil-resistant synthetic rubber gasket shall be provided between the outside of the box or enclosure and the fitting shoulder. Gasket shall be adequately protected by and permanently bonded to a metallic retainer.

2. Corrosion-resistant and outdoor SLT fittings:
a. Construction:
1) PVC-coated liquidtight fittings with a bonded 0.040-inch-thick PVC coating on the metal connector to form a seal around the SLT conduit.
2) Insulated throat and an integral sealing ring.

F. Hubs for threaded attachment of steel conduit to sheet metal enclosures:
1. Construction:
a. Insulated throat.
b. PVC-coated when used in corrosive areas.
c. Bonding locknut.
d. Recessed neoprene O-ring to ensure watertight and dusttight connector.
e. 1/2-inch through 1-1/4-inch steel zinc electroplated.
f. 1-1/2-inch through 6-inch malleable iron zinc plated.
2. Usage:
a. Conduits in damp, wet, outdoor, and corrosive areas shall use threaded hubs for connections to sheet metal enclosures.

G. Sealing fittings:
1. Construction:
a. 40-percent wire fill capacity.
b. PVC-coated when used in corrosive areas.
c. Malleable ductile iron with steel conduit.
d. Aluminum with aluminum conduit.
e. Type EYDX where drains are required.
f. Type EYSX where drains are not required.
g. UL 1203 listed for use in Class I, Division 1, Groups A, B, C, D; Class I, Division 2, Groups A, B, C, D; and Class II, Divisions 1 and 2, Groups E, F, and G.
2. Sealing compound:
a. Fiber filler and cement as recommended by the sealing fitting manufacturer.
b. Approved for the conditions and use.
1) Not affected by surrounding atmosphere or liquids.
c. Melting point shall be 200 degrees Fahrenheit minimum.

H. PVC fittings:
   1. Materials:
      a. Devices shall be made of PVC, using the same materials as used for Type PVC conduit.
      b. Metal hardware shall be stainless steel.

I. Through wall and floor seals:
   1. Materials:
      a. Body: Casting of malleable or ductile iron with a hot-dip galvanized finish.
      b. Grommet: Neoprene.
      c. Pressure rings: PVC-coated steel.
      d. Disc material: PVC-coated steel.

J. Expansion/deflection couplings:
   1. Use to compensate for movement in any directions between 2 conduit ends where they connect.
   2. Shall allow movement of 3/4 inch from the normal in all directions.
   3. Shall allow angular movement for a deflection of 30 degrees from normal in any direction.
   4. Constructed to maintain electrical continuity of the conduit system.
   5. Materials:
      a. End couplings: Bronze or galvanized ductile iron.
      b. Sleeve: Neoprene.
      c. Bands: Stainless steel.
      d. Bonding jumper: Tinned copper braid.

K. Expansion couplings:
   1. Shall allow for expansion and contraction of conduit:
      a. Permitting 8-inch movement, 4 inches in either direction.
   2. Constructed to maintain electrical continuity of the conduit system.
   3. Materials:
      a. Head: Malleable or ductile iron.
      b. Sleeve: Steel.
      c. Insulating bushing: Phenolic.
      d. Finish: Hot-dip galvanized.
      e. PVC-coated steel when used with Type PCS.

L. Inner duct couplings and fittings:
   1. HDPE inner duct:
      a. Couplings:
         1) Self-threading.
         2) Nonmetallic.
      b. Fittings:
         1) Multi-access fitting:
            a) 3-hole.
            b) Sized for conduit containing inner duct.
         2) Duct plugs:
            a) Sized for inner duct diameter.
            b) Install in both ends of unused ducts.
         3) Split plugs:
            a) Sized for inner duct and cable diameters.

b) Install at both ends of utilized ducts.

2. Fabric inner duct:
   a. Termination bags:
      1) Inflation-type bags for sealing and securing around 1 or more textile inner ducts and cables within 2-inch outside diameter or larger conduit.

M. Conduit markers:
   1. As specified in Section 16075 - Identification for Electrical Systems.

PART 3 EXECUTION

3.01 EXAMINATION

A. Before installing any conduit or locating any device box:
   1. Examine the complete set of Drawings and Specifications, and applicable Shop Drawings.

B. Verify all dimensions and space requirements and make any minor adjustments to the conduit system as required to avoid conflicts with the building structure, other equipment, or the work of other trades.

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. General:
   1. Conduit routing:
      a. Electrical drawings are diagrammatic in nature:
         1) Install conduit runs as specified with schematic representation indicated on the Drawings and as specified.
         2) Modify conduit runs to suit field conditions, as accepted by the Engineer:
            a) Make changes in conduit locations that are consistent with the design intent but are dimensionally different, or routing to bypass obstructions.
            b) Make changes in conduit routing due to the relocation of equipment.
            c) Install conduits and equipment in such a manner as to avoid obstructions and to preserve headroom and keep openings and passageways clear.
         3) Where the Drawings do not indicate the exact mounting and/or supporting method to be used, use materials and methods similar to the mounting details indicated on the Drawings.
         4) Electrical drawings do not indicate all required junction boxes and pull boxes:
            a) Provide junction boxes and pull boxes to facilitate wire pulling as required:
               (1) To meet cable manufacturer’s pulling tension requirements.
               (2) To limit total conduit bends between pull locations.

b) Install junction boxes and pull boxes at locations acceptable to the Engineer.

b. Contractor is responsible for any deviations in general location, conduit size, routing, or changes to the conduit schedule without the express written approval or direction by the Engineer:
   1) Engineer is the sole source in determining whether the change is constituted as a deviation.
   2) Perform any changes resulting in additional conduits, or extra work from such deviations.
   3) Incorporate any deviations on the Record Documents.

c. Owner reserves the right to deduct the amount of applicable reimbursement, equivalent to the cost of the engineering effort required to show those unauthorized changes on Record Drawings.

2. Use only tools recommended by the conduit manufacturer for assembling the conduit system.
3. Provide adequate clearances from high-temperature surfaces for conduit runs. Provide minimum clearances as follows:
   a. Clearance of 6 inches from surfaces 113 degrees Fahrenheit to 149 degrees Fahrenheit.
   b. Clearance of 12 inches from surfaces greater than 149 degrees Fahrenheit.
   c. Keep conduits at least 6 inches from the coverings on hot water and steam pipes, 18 inches from the coverings on flues and breechings, and 12 inches from fuel lines and gas lines.
   d. Where it is necessary to route conduits close to high-temperature surfaces, provide a high-reflectance thermal barrier between the conduit and the surface.
4. Support conduit runs on water-bearing walls a minimum of 7/8-inch away from wall on an accepted preformed channel:
   a. Do not run conduits within water-bearing walls unless otherwise indicated on the Drawings.
5. Do not install 1-inch or larger conduits in or through structural members unless approved by the Engineer.
6. Run conduits exposed to view parallel with or at right angles to structural members, walls, or lines of the building:
   a. Install straight and true conduit runs with uniform and symmetrical elbows, offsets, and bends.
   b. Make changes in direction with long radius bends or with conduit bodies.
7. Install conduits with total conduit bends between pull locations less than or equal to 270 degrees.
8. Route exposed conduits to preserve headroom, access space and workspace, and to prevent tripping hazards and clearance problems:
   a. Install conduit runs so that runs do not interfere with proper and safe operation of equipment and do not block or interfere with ingress or egress, including equipment-removal hatches.
   b. Route conduits to avoid drains or other gravity lines. Where conflicts occur, relocate the conduit as required.
9. Conduits may be run in concrete members or slabs with permission of the Engineer or as indicated on the Drawings:
   a. Refer to the typical details for conduit spacing and size requirements.

10. When installing conduits through existing slabs or walls, make provisions for locating any possible conflicting items where the conduit is to penetrate. Use tone signal or X-ray methods to make certain that no penetrations will be made into the existing conduits, piping, cables, post-tensioning cables, etc.
11. Plug conduits brought into pull boxes, manholes, handholes, and other openings until used to prevent entrance of moisture.
12. Install conduits through wall and floor seals where indicated on the Drawings.
13. For existing and new 2-inch and larger conduit runs, snake conduits with a conduit cleaner equipped with a cylindrical mandrel of a diameter not less than 85 percent of nominal diameter of the conduit:
    a. Remove and replace conduits through which mandrel will not pass.
14. Provide sleeves and openings required for the passage of electrical raceways or cables even when these openings or sleeves are not specifically indicated on the Drawings.
15. Install complete conduit systems before conductors are installed.
16. Provide metallic conduits terminating in transformer, switchgear, motor control center, or other equipment conduit windows with grounding bushings and ground with a minimum No. 6 AWG ground wire.
17. Underground conduits:
    a. Install underground conduits, including conduit runs below slabs-on-grade in concrete-reinforced duct bank construction:
        1) As specified in Section 16133 - Duct Banks.
    b. Make underground conduit size transitions at handholes and manholes.
    c. Install spare conduits in underground duct banks towards top center of runs to allow for ease of installation of future cables as conduits enter underground manholes and handholes.
    d. Seal around conduit penetrations of below grade walls with a mechanical seal.
18. Underground conduit trenching:
    a. Perform trenching as specified in Section 02318 - Trenching.
    b. Trench must be uniformly graded with the bottom, rock free and covered with select material.
    c. Damage occurring to existing ducts, conduits, cables, and other utilities during underground conduit installation shall be remediated to the satisfaction of the Owner.
    d. Whenever possible, use the walls of the trench as forms for concrete encasement:
        1) Forms are required where the soil is not self-supporting.

B. Equipment grounding conductors:
    1. Provide a separate, green insulated, grounding conductor in each raceway independent of raceway material:
        a. Multi-conductor power and control cables shall include an integral green insulated grounding conductor.
        b. Provide a separate grounding conductor in each individual raceway for parallel feeders.
    2. Conductors shall be the same type and insulation as the circuit conductors:
        a. Use 600-volt insulation for the equipment grounding conductors for medium voltage systems.
    3. Minimum size in accordance with the NEC.

C. Lighting and receptacle conduits:
   1. Provide conduit runs for lighting and receptacle circuits, whether or not indicated on the Drawings.
   2. Install conduits in accordance with the requirements of this Section unless otherwise indicated.
   3. Minimum conduit size:
      a. 3/4-inch for exposed conduits.
      b. 1-inch for underground or in-slab conduits.
   4. Provide conduit materials for the installed location as specified in Section 16050 - Common Work Results for Electrical.

D. Conduit usage:
   1. Exposed conduits:
      a. Rigid conduit:
         1) Install the rigid conduit type for each location as specified in Section 16050 - Common Work Results for Electrical.
         2) Minimum size: 3/4-inch.
      b. Flexible conduit:
         1) Use flexible conduit for final connections between rigid conduit and motors, vibrating equipment, instruments, control equipment, or where required for equipment servicing:
            a) Use Type SLT with rigid metallic conduit.
         2) Minimum size: 3/4-inch:
            a) 1/2 when required for connection to instruments.
         3) Maximum length:
            a) Fixed equipment:

Conduit Trade Size	Flexible Conduit Length (inch)
3/4	18
1	18
1-1/4	18
1-1/2	18
2	36
2-1/2	36
3	36
3-1/2	38
4	40

            b) Removable instruments or hinged equipment:
               (1) As required to allow complete removal or full movement without disconnecting or stressing the conduit.

   2. Concrete-encased and embedded conduits:
      a. Straight runs and bends less than 45 degrees:
         1) Type PVC Schedule 40.
      b. Bends with total deflection greater than 45 degrees:
         1) PCS.

c. Entering and exiting duct bank, underground or embedded conduit runs a minimum 12 inches above and below grade, finished floor, or entering equipment:
    1) PCS.
d. Minimum size:
    1) 2-inch in duct banks.
    2) 1-inch for in-slab conduits.
    3) Provide conduit fittings to enlarge the conduit from the exposed size in the conduit schedule as required.

3. Direct-buried and sand-bedded duct bank conduits:
    a. Type PCS.
    b. Minimum size: 1-inch.
4. PVC-coated rigid metallic conduit:
    a. Use specifically manufactured or machined threading dies to manufacturer's specifications to accommodate the PVC jacket.
    b. Repair damage to PVC coatings with manufacturer supplied touchup compound or PVC Coating Repair Kit for PVC Coated Raceway Systems.
5. Inner duct (applicable for fiber optic cable only):
    a. Install inner duct in conduits as indicated on the Drawings.
    b. Each inner duct conduit shall be a separate color.

E. Conduit joints and bends:
1. General:
    a. Where conduit is underground, under slabs on grade, exposed to the weather, or in NEMA Type 4 or NEMA Type 4X locations, make joints liquidtight.
    b. Keep bends and offsets in conduit runs to an absolute minimum.
    c. Bends shall be symmetrical.
    d. The following conduit systems shall use large-radius sweep elbows:
        1) Underground conduits.
        2) Conduits containing shielded cables.
        3) Conduits containing fiber optic cables.
    e. Provide large-radius factory-made bends for 1-1/4-inch trade size or larger.
    f. Make field bends with a radius of not less than the requirements found in the NEC:
        1) Minimum bending radius of the cable must be less than the radius of the conduit bend.
        2) Make field bends with power bending equipment or manual benders specifically intended for the purpose:
            a) Make bends so that the conduit is not damaged and the internal diameter is not effectively reduced.
            b) For the serving utilities, make bends to meet their requirements.
    g. Replace deformed, flattened, or kinked conduit.
2. Threaded conduit:
    a. Cut threads on rigid metallic conduit with a standard conduit-cutting die that provides a 3/4-inch per foot taper and to a length such that bare metal exposed by the threading operation is completely covered by the couplings or fittings used. In addition, cut the lengths of the thread such that joints become secure and wrench-tight just preceding the point where the conduit ends would butt together in couplings or where conduit ends would butt into the ends or shoulders of other fittings.

b. Thoroughly ream conduit after threads have been cut to remove burrs.
c. Use bushings or conduit fittings at conduit terminations.
d. On exposed conduits, repair scratches and other defects with galvanizing repair stick, Enterprise Galvanizing “Galvabar™,” or CRC “Zinc It.”
e. Coat conduit threads with an approved electrically conductive sealant and corrosion inhibitor that is not harmful to the conductor insulation:
    1) Apply to the male threads and tighten joints securely.
    2) Clean excess sealant from exposed threads after assembly.
f. Securely tighten threaded connections.
g. Any exposed threaded surfaces must be cleaned and coated with a galvanizing solution so that exposed surfaces have a galvanized protective coating.

3. PVC:
    a. Use approved solvent-weld cement specifically manufactured for the purpose. Spray-type cement is not allowed.
    b. Apply heat for bends so that conduit does not distort or discolor. Use a spring mandrel as required to ensure full inside diameter at bends:
        1) Utilize a heater specifically for PVC conduit as recommended by the conduit manufacturer.

F. Conduit sealing and drainage:
1. Other than required for hazardous and classified areas:
    a. Provide sealing and drainage in vertical drops of long (in excess of 20 feet), exterior, above-grade conduit runs at the points at which the conduit enters buildings, switchgear, control panels, lighting panelboards, and other similar enclosures.
    b. Provide seal fittings with drains in vertical drops directly above grade for exterior and above-grade conduit runs that are extended below grade.
    c. Provide conduit seals with drains in areas of high humidity and rapidly changing temperatures:
        1) Where portions of an interior raceway pass through walls, ceilings, or floors that separate adjacent areas having widely different temperatures.
    d. Provide conduit seals similar to O-Z/Gedney (Type CSM) on conduits between corrosive and non-corrosive areas.
    e. Seal 1 end only of underground conduits at highest point with O-Z/Gedney sealing (non-hazardous) filling, or equal.
2. Install seals with drains at any location along conduit runs where moisture may condense or accumulate. This requirement includes, but is not limited to, the following locations: Control panels, junction boxes, pullboxes, or low points of the conduit.

G. Hangers and supports:
1. General:
    a. Provide appropriate hangers, supports, fasteners, and seismic restraints to suit applications:
        1) As specified in Section 16070 - Hangers and Supports.
        2) Provide support materials consistent with the type of conduit being installed as specified in Section 16050 - Common Work Results for Electrical.

b. Support conduit at the intervals required by the NEC.
c. Perforated strap and plumbers' tape are not acceptable for conduit supports.

2. Finished areas:
   a. Above suspended ceilings:
      1) Support conduit on or from the structure. Do not support conduit from hanging wires or suspended ceiling grid.
   b. Concealed conduit on wood:
      1) Use 2-hole galvanized steel straps screwed or nailed to the wood or hammer-driven stamped galvanized-type supports having serrated or sawtooth edges on the driven portion and designed specifically for the size and type of conduit being supported. Drive these latter supports so that the conduit is tightly and rigidly supported. Replace any dented or damaged conduit.
   c. In steel-stud construction:
      1) Tie conduit at maximum 4-foot intervals with No. 16 gauge double-annealed galvanized wire or conduit clips so that conduit cannot move from vibration or other causes.
3. Conduit on concrete or masonry:
   a. Use 1-hole malleable iron straps with metallic or plastic expansion anchors and screws or support from preset inserts.
   b. Use preset inserts in concrete when possible.
   c. Use pipe spacers (clamp backs) in wet locations.
4. Suspended conduit:
   a. Use malleable-iron factory-made split-hinged pipe rings with threaded suspension rods sized for the weight to be carried (minimum 3/8-inch diameter), Kindorf, or equal.
   b. For grouped conduits, construct racks with threaded rods and tiered angle iron or preformed channel cross members. Clamp each conduit individually to a cross member. Where rods are more than 2-feet long, provide rigid sway bracing.
5. Supports at structural steel members:
   a. Use beam clamps.
   b. Drilling or welding may be used only as specified or with approval of the Engineer.

H. Expansion or expansion/deflection fittings:
1. General:
   a. Align expansion coupling with the conduit run to prevent binding.
   b. Follow manufacturer's instructions to set the piston opening.
   c. Install expansion fittings across concrete expansion joints and at other locations where necessary to compensate for thermal or mechanical expansion and contraction.
   d. Furnish fittings of the same material as the conduit system.
2. For metallic conduit, provide expansion or expansion/deflection couplings, as appropriate, where:
   a. Install expansion fittings a minimum of every 200 feet in straight conduit runs.

I. Empty conduits:
1. Provide a pull tape in each empty conduit more than 10 feet in length.

2. Seal ends of conduits with approved, manufactured conduit seals, caps, or plugs immediately after installation:
    a. Keep ends sealed until immediately before pulling conductors.

J. Miscellaneous:
1. Seal roof penetrations for raceways and other items that penetrate the roof in accordance with roofing manufacturer's instructions and as indicated on the Drawings.
2. Provide electrical unions at all points of union between ends of rigid conduit systems that cannot otherwise be coupled:
    a. Running threads and threadless couplings are not allowed.
3. Replace any conduits installed that the Engineer determines do not meet the requirements of this Specification.
4. Provide conduit housekeeping curb around embedded or below-grade conduits exiting or entering the slab, in accordance with the Typical Details.

3.04 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

END OF SECTION

SECTION 16134

BOXES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Device boxes.
   2. Raceway system boxes.

1.02 REFERENCES

A. Definitions:
   1. Arcing parts: Circuit breakers, motor controllers, switches, fuses, or any device intended to interrupt current during its operation.
   2. Raceway system boxes: Boxes that are used for wire and cable pullboxes, conduit junction boxes, or terminal boxes.

B. Standards:
   1. American Association of State Highway and Transportation Officials (AASHTO):
      a. Standard Specifications for Highway Bridges.
   2. ASTM International (ASTM):
      a. A47 - Standard Specification for Ferritic Malleable Iron Castings.
   3. Joint Industry Conference (JIC).
   4. National Electrical Code (NEC).
   5. National Electrical Manufacturers Association (NEMA):
      a. 250 - Enclosures for Electrical Equipment (1,000 V Maximum).
   6. Underwriters Laboratories, Inc. (UL).

1.03 DELEGATED DESIGN (NOT USED)

1.04 SUBMITTALS

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

B. Product data:
   1. Manufacturer.
   2. Materials.
   3. Dimensions:
      a. Height.
      b. Width.
      c. Depth.
      d. Weight.
      e. NEMA rating.
   4. Conduit entry locations.
   5. Catalog cutsheets.
   6. Installation instructions.

C. Shop Drawings:
   1. Include identification and sizes of pullboxes.

1.05 QUALITY ASSURANCE

A. Regulatory requirements:
   1. Outlet boxes shall comply with applicable standards of:
      a. JIC.
      b. NEC.
      c. NEMA.
      d. UL.

1.06 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.07 PROJECT OR SITE CONDITIONS

A. As specified in Section 01850 - Design Criteria.

1.08 ADMINISTRATIVE REQUIREMENTS (NOT USED)

1.09 WARRANTY

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

PART 2 PRODUCTS

2.01 GENERAL (NOT USED)

2.02 DESIGN AND PERFORMANCE CRITERIA

A. Provide outlet boxes for wiring devices, junction, and pullboxes for use in the raceway systems, etc.

B. Provide boxes as indicated on the Drawings or as needed to complete the raceway installation.

C. Size pullboxes in accordance with NEC requirements and to provide sufficient room for any future conduits, components, and cables as indicated on the Drawings.

D. Provide materials and construction suitable for environmental conditions at the location of the box as specified in Section 16050 - Common Work Results for Electrical.

E. For boxes not indicated:
   1. Provide types and mountings as required to suit the equipment and that will be consistent with the conduit system and environmental conditions as indicated in Section 16050 - Common Work Results for Electrical.

2.03 MANUFACTURERS

A. One of the following or equal:
   1. Pressed steel boxes and concrete boxes:
      a. Appleton.
      b. Crouse - Hinds.
      c. Thomas & Betts.
      d. Steel City.
   2. Plastic coated boxes:
      a. OCAL.
      b. Rob Roy.
   3. Cast device boxes:
      a. Appleton.
      b. Crouse - Hinds.
      c. O-Z/Gedney.
   4. Formed steel enclosures:
      a. Hoffman.
      b. Thomas and Betts.
      c. Stahlin.
      d. Rittal.
   5. Stainless steel enclosures:
      a. Hoffman.
      b. Rittal.
      c. Stahlin.

2.04 MATERIALS (NOT USED)

2.05 MANUFACTURED UNITS

A. Pressed steel boxes:
   1. 1-piece galvanized pressed steel.
   2. Knockout type boxes.
   3. Minimum size 4-inch square by 2-1/8-inch deep.

B. Concrete boxes:
   1. For outlets and pullboxes in concrete construction.
   2. Pressed steel or cast construction, concrete tight.
   3. Knockout sizes range from 1/2 inch to 1 inch.
   4. Depth as needed.
   5. Types:
      a. 4-inch octagon.
      b. 4-inch octagon ceiling boxes with hanging bars.
      c. Gangable masonry boxes:
         1) 3-1/2-inch deep, 3-3/4-inch high, length as required:
            a) 2-1/2-inch-deep boxes may be used where wall thickness precludes the use of the deeper boxes.
         2) With partitions as needed.

C. Cast device boxes:
   1. Construction:
      a. With internal green ground screw.

b. Furnished with a suitable gasketed cover.
c. With integral cast mounting lugs when surface mounted.
d. Conduit sizes range from 3/4 inch to 1 inch.
e. Tapered threaded hubs with integral bushing.

2. Aluminum (copper free) boxes:
   a. High strength copper free 4/10 of 1 percent maximum alloy for use with aluminum rigid conduit.
3. Malleable iron boxes:
   a. In accordance with ASTM A47 Grade 32510.

D. Plastic coated cast device boxes:
1. Construction:
   a. With internal green ground screw.
   b. Furnished with a suitable gasketed cover.
   c. With integral cast mounting lugs when surface mounted.
   d. Conduit sizes range from 3/4 inch to 1 inch.
   e. Double coated with a nominal 0.002-inch (2 mil) urethane on both the interior and exterior before application of PVC coating.
   f. With a minimum 0.040-inch (40 mil) PVC coating bonded to exterior.
   g. With pressure sealing sleeve to protect the connection with conduit.

E. Formed steel enclosures:
1. Steel:
   a. NEMA Type 12.
   b. Fabricated from 14-gauge steel, minimum.
   c. Seams continuously welded ground smooth.
   d. Door:
      1) Rolled lip around 3 sides.
      2) Attached to enclosure by means of a continuous stainless steel hinge and pin.
   e. Neoprene door gasket to provide a watertight, dusttight, oiltight seal:
      1) Attached with an adhesive.
      2) Retained by a retaining strip.
   f. Fabricate external removable hardware for clamping the door to the enclosure body from zinc-plated heavy gauge steel:
      1) With a hasp and staple for padlocking.
   g. Provide large enclosures with door and body stiffeners for extra rigidity.
   h. No holes or knockouts.
   i. Finish:
      1) ANSI-61 gray electrostatically applied polyester powder inside and out over cleaned and primed surfaces.
      2) White electrostatically applied polyester powder mounting plate.
   j. Heavy gauge steel external mounting brackets when surface mounted.
2. Stainless steel:
   a. NEMA Type 4X:
      1) Boxes in locations subject to flooding or temporary submersion:
         a) NEMA Type 6.
   b. Fabricated from 14-gauge Type 316 stainless steel.
   c. Seams continuously welded.
   d. Door:
      1) Rolled lip around 3 sides.

2) Attached to enclosure by means of a continuous stainless steel hinge and pin.

e. Neoprene door gasket to provide a watertight seal:
   1) Attached with an adhesive.
   2) Retained by a retaining strip.

f. Fabricate external removable hardware for clamping the door to the enclosure body from heavy gauge stainless steel:
   1) With a hasp and staple for padlocking.

g. Provide large enclosures with door and body stiffeners for extra rigidity.

h. No holes or knockouts.

i. Finish:
   1) Brushed.

j. Stainless steel external mounting brackets when surface mounted.

2.06 EQUIPMENT (NOT USED)

2.07 COMPONENTS (NOT USED)

2.08 ACCESSORIES

A. Fasteners:
   1. Electroplated or stainless steel in boxes with wiring devices.
   2. Screws, nuts, bolts, and other threaded fasteners:
      a. Stainless steel.

B. Provide breather and drain fittings where appropriate.

C. Internal panels:
   1. Provide internal panels where required for mounting terminal strips or other equipment.
   2. With plated steel shoulder studs.
   3. Steel with white polyester powder finish.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. General:
   1. Provide outlet box materials to match the conduit system:
      a. GRC - Cast ferrous boxes.
      b. PCS - PVC coated cast ferrous boxes.
      c. PVC - PVC boxes.
   2. Solid type gang boxes:
      a. For more than 2 wiring devices.
      b. For barriered outlets.

3. Support wall mounted NEMA Type 4 or NEMA Type 4X boxes to maintain a minimum of 7/8-inch free air space between the back of the enclosure and the wall:
    a. Use machined spacers to maintain air space; built-up washers are not acceptable.
    b. Use stainless steel or nylon materials for spacers.
4. Use cast malleable iron boxes when box must support other devices.
5. Boxes serving luminaires or wiring devices:
    a. Use as pullboxes wherever possible.
6. In finished areas:
    a. Provide specific pull or junction boxes only as indicated on the Drawings or as directed.
7. Fit cast boxes and pressed steel boxes for flush mounting in concrete with cast, malleable box covers and gaskets.
8. In terminal boxes, furnish terminals as indicated on the Drawings, with a minimum of 50 percent spare terminals:
    a. Furnish wireways for discrete and analog/DC wiring.
    b. Separate analog wiring from 120 V discrete or power wiring.
9. For fire-rated construction, provide materials and installation for use in accordance with the listing requirements of the classified construction.

B. Outlet boxes:
1. Locate outlet boxes as indicated on the Drawings:
    a. Adjust locations so as not to conflict with structural requirements or other trades.
2. Use deep threaded-hub malleable iron boxes:
    a. In hazardous areas.
    b. Where exposed to the weather.
    c. In unheated areas.
    d. Where subject to mechanical damage:
        1) Defined as exposed boxes less than 10 feet above the floor.
    e. To act as a pullbox for conductors in a conduit system.
    f. Accommodate wiring devices.
3. Use deep threaded-hub plastic coated malleable iron boxes in corrosive and NEMA Type 4X area and when the exposed conduit system is PVC coated steel.
4. Outlet boxes may be used as junction boxes wherever possible.

C. Pullboxes and junction boxes:
1. Install pullboxes such that access to them is not restricted.
2. Outlet, switch, and junction boxes for flush mounting in general purpose locations:
    a. One-piece, galvanized, pressed steel.
3. Outlet, switch, and junction boxes where surface mounted in exposed locations:
    a. Cast ferrous boxes with mounting lugs, zinc or cadmium plating finish.
4. Outlet, control station, and junction boxes for installation in corrosive locations:
    a. Fiberglass reinforced polyester, stainless steel, or plastic-coated steel to match the conduit system.
    b. Furnished with mounting lugs.
5. Fire rated construction: Use materials and methods to comply with the listing requirements for the classified construction.

3.04 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

END OF SECTION

SECTION 16140

WIRING DEVICES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Switches.
   2. Receptacles.
   3. Plates.

1.02 REFERENCES

A. Federal Specifications (FS):
   1. W-C 596 - Connector, Electrical, Power, General Specification for.
   2. W-S 896/2 - Switches, Toggle (Toggle and Lock), Flush Mounted (General Specification).

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

C. Telecommunications Industry Association (TIA):
   1. T568A - Eight-position jack pin/pair assignment.
   2. T568B - Optional eight-position jack pin/pair assignment.

D. Underwriters Laboratories, Inc. (UL):
   1. 20 - General Use Snap Switches.
   2. 498 - Standard for Attachment Plugs and Receptacles.
   3. 943 - Ground-Fault Circuit-Interrupters.

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. GFCI: Ground fault circuit interrupter.

1.04 DELEGATED DESIGN (NOT USED)

1.05 SUBMITTALS

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

B. Product data:
   1. Catalog cutsheets.

C. Shop Drawings:
   1. Engraving schedule:
      a. Furnish complete engraving schedule for engraved nameplates.

1.06 QUALITY ASSURANCE

A. Wiring devices shall be UL listed and labeled.

1.07 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 01850 - Design Criteria.

1.09 ADMINISTRATIVE REQUIREMENTS (NOT USED)

1.10 WARRANTY

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

PART 2 PRODUCTS

2.01 GENERAL (NOT USED)

2.02 DESIGN AND PERFORMANCE CRITERIA

A. Switches, receptacles, and plates as indicated on the Drawings, wired and operable to form a complete system.

2.03 MANUFACTURERS

A. Switches:
   1. One of the following or equal:
      a. Cooper Wiring Devices.
      b. Hubbell.
      c. Leviton.
   2. Occupancy sensor switches:
      a. One of the following or equal:
         1) Cooper Wiring Devices.
         2) WattStopper.
   3. Dimmer switches:
      a. One of the following or equal:
         1) Cooper Wiring Devices.
         2) Lutron.

B. Receptacles:
   1. General purpose:
      a. One of the following or equal:
         1) Cooper Wiring Devices.
         2) Hubbell.
         3) Leviton.

C. Plates:
1. General location:
a. One of the following or equal:
1) Cooper Wiring Devices.
2) Legrand.
2. Wet or corrosive areas:
a. One of the following or equal:
1) Cooper Wiring Devices.
2) Hubbell.
3) Pass and Seymour.
4) Thomas & Betts.
3. In-use covers:
a. One of the following or equal:
1) Cooper Wiring Devices.
2) Pass and Seymour.
3) TayMac.
4) Thomas & Betts.

D. Data and communications jacks:
1. Network jacks:
a. One of the following or equal:
1) Belden; REVConnect Connectivity System.
2) Hubbell.
3) Leviton; Quickport series.
4) Panduit.
2. Wall plates:
a. One of the following or equal:
1) Belden; REVConnect Connectivity System.
2) Leviton; Quickport series.
3) Optical Cable Corporation (OCC).
4) Panduit.

2.04 MATERIALS (NOT USED)

2.05 MANUFACTURED UNITS

A. Switches:
1. General:
a. 120 to 277 VAC.
b. 20-amp.
c. Listed in accordance with UL 20.
d. Designed and constructed in accordance with FS W-S-896/2.
e. Back and side wired unless otherwise indicated.
f. Integral grounding terminal.
g. Totally enclosed:
1) Color-coded body with color corresponding to amp rating.
h. Provide switches with the operator style and contact arrangement as indicated on the Drawings and as required for proper operation.
i. Color:
1) Ivory in finished areas.
2) Brown in all other areas.

2. General purpose switches:
    a. Toggle type.
3. Switches for office areas:
    a. Rocker type.
    b. Rectangular.
4. Switches for use with photocell:
    a. Maintained contact.
    b. 2 circuit.
    c. 3 position:
        1) Center off.
5. Occupancy sensor switches:
    a. Wall switch with dual-technology passive infrared and ultrasonic sensor.
        1) Configured such that lights turn on only when both infrared and ultrasonic sensors detect activity, but do not turn off as long as either sensor detects activity.
    b. Selectable “automatic-on” mode activated by sensors or “manual-on” mode activated by pushbutton.
    c. Adjustable 5- to 30-minute time delay.
    d. Selectable audible alert as a warning before lights turn off.
    e. Rated for fluorescent lighting loads of up to 800 W.
    f. True multi-way switching allowing identical controls at any location for multi-way switching applications.
6. Dimmer switches:
    a. Shall be rectangular design with LED light level indicators.
    b. Suitable for use with type of lamp switched.

B. Receptacles:
1. General purpose receptacles:
    a. Single or duplex as indicated on the Drawings.
    b. 125 VAC.
    c. 20 amp or as indicated on the Drawings.
    d. NEMA Type 5-20R configuration for 20 amp receptacles.
    e. Other NEMA configurations as indicated on the Drawings.
    f. Listed in accordance with UL 498.
    g. Designed and constructed in accordance with FS W-C-596.
    h. Back and side wired.
    i. 1-piece, rivet-less mounting strap.
    j. Color:
        1) Ivory in finished areas.
        2) Brown in all other areas.
        3) Orange when powered by a UPS.
2. Ground fault interrupter receptacles (GFCI):
    a. 125 VAC.
    b. 20 amp.
    c. Trip level 4 to 6 mA.
    d. Individual and feed through protection.
    e. UL 943 and UL 498 listed.
    f. NEMA Type 5-20R configuration.
    g. For damp or wet locations:
        1) Weather resistant, in accordance with UL 498.

C. Plates:
    1. General location:
        a. Type 302 or 304 stainless steel.
        b. Brushed satin finish.
        c. Minimum thickness: 0.032 inches.
        d. Rectangular or square shape.
        e. Engraving:
            1) Engrave each switch plate with the following:
                a) Area served.
                b) Panelboard and Circuit.
            2) Engrave each receptacle plate with the following:
                a) Panelboard and Circuit.
            3) Treat engraving to improve visibility.
            4) Characters shall be block letter pantograph engraved with a minimum character height of 1/8-inch.
        f. Coordinate the number of gangs, number, and type of openings with the specific location.
    2. Outdoor and wet areas requiring NEMA Type 4 or NEMA Type 4X enclosures:
        a. General:
            1) UL listed for wet locations.
            2) Gasketed.
            3) Die cast metal:
                a) Match material to box material.
        b. Switches:
            1) Lever operated:
                a) Provide toggle switch.
        c. Receptacles:
            1) Weatherproof in-use cover:
                a) Die cast metal construction with electrostatic powder coating for corrosion resistance.
                b) Gasketed.
                c) Lockable.
                d) UL listed and in accordance with NEC.
    3. Corrosive areas:
        a. Neoprene.
        b. Gasketed.
        c. Weatherproof.

D. Data and communications jacks:
    1. Process network jacks - conduit body mounted:
        a. Network jacks located in process areas shall have a NEMA Type 4 rating (with closure cap).
        b. Mounting of network jacks in conduit bodies adapter (with minifast connector) shall be accomplished using conduit body insert and environmental enclosure caps.
        c. PC board connections are not to be allowed.
        d. Furnish 10 RJ-45 to minifast connector patch cable 3 feet in length.
        e. Manufacturers: The following or equal:
            1) InterlinkBT.

2. Network/phone jacks:
    a. Meets or exceeds TIA standards for the Category of Ethernet cable connected.
    b. Accommodates TIA T568A and TIA T568B wiring schemes.
    c. UL listed or rated.
    d. Provide different colors for each network unless otherwise indicated on the Drawings.
    e. Power over Ethernet up to 100 watts.
    f. Interchangeable icons to identify function.
    g. Shall comply with NEC requirements.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. Mounting heights:
    1. Process and production areas:
        a. Switches and receptacles 48 inches from finished floor to top of plate.
    2. Offices and finished areas:
        a. Switches: 48 inches from finished floor to top of plate.
        b. Receptacles: 18 inches from finished floor to center of plate.

B. Switches:
    1. Over 300 volts:
        a. Where switches used in systems of more than 300 volts between conductors, are to be ganged in outlet boxes, provide switches having no exposed live parts or use barriers between the individual switches.

C. Receptacles:
    1. Provide GFCI receptacles as indicated on the Drawings.
        a. Provide weather resistant GFCI receptacles in wet or damp areas.
    2. Mount receptacles vertically:
        a. Ground slot down.
    3. 3-phase receptacles shall be consistent with respect to phase connection at the receptacle terminals. Correct errors in phasing at the source and not the receptacle.

D. Ensure plates make a firm seal with wall for recessed mounted devices:
    1. Outside edges of plates parallel with building lines.

3.04 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

END OF SECTION

SECTION 16150

LOW VOLTAGE WIRE CONNECTIONS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Wire connecting devices.
   2. Terminations.
   3. Splices.
   4. Power distribution blocks.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. D3005 - Standard Specification for Low-Temperature Resistant Vinyl Chloride Plastic Pressure-Sensitive Electrical Insulating Tape.

B. CSA International (CSA):
   1. C22.2 - No. 197-M1983 (R2208) - PVC Insulating Tape.

C. Underwriters Laboratories, Inc. (UL):
   1. 510 - Standard for Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape.
   2. 1953 - Outline of Investigation for Power Distribution Blocks.

1.03 DELEGATED DESIGN (NOT USED)

1.04 SUBMITTALS

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

B. Product data:
   1. Catalog cutsheets.
   2. Installation instructions.

1.05 QUALITY ASSURANCE

A. Materials shall be UL listed.

1.06 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.07 PROJECT OR SITE CONDITIONS

A. As specified in Section 01850 - Design Criteria.

1.08 ADMINISTRATIVE REQUIREMENTS

A. Sequencing:
   1. Conduct the initial fault current study and submit results for Engineer's review.
   2. After successful review of the initial fault current study, submit complete equipment submittal.

1.09 WARRANTY

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

PART 2 PRODUCTS

2.01 GENERAL (NOT USED)

2.02 DESIGN AND PERFORMANCE CRITERIA

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

2.03 MANUFACTURERS

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

2.04 MATERIALS (NOT USED)

2.05 MANUFACTURED UNITS (NOT USED)

2.06 EQUIPMENT

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

B. Joints, splices, taps, connections, and terminations:
   1. 600-volt conductors:
      a. Use solderless connectors.
      b. Copper pigtail adaptors.
         1) For use on select applications as approved by the Engineer.
         2) 600 volt, 90 degrees Celsius rated.
         3) UL 486A/B listed.

4) Manufacturers: The following or equal:
a) Burndy APY series.
b) ILSCO CPM series.

c. Use only plated copper alloy connectors or lugs:
1) Aluminum connectors or lugs are not acceptable for copper conductors.

d. Under those specific conditions where aluminum conductors have been allowed or are specified then the connectors for aluminum conductors shall be specifically designed for that purpose.

e. For wire Number 10 AWG and smaller, use compression splice caps, with insulating caps:
1) Manufacturers: The following or equal:
a) Buchanan, 2006S or 2011S, with 2007 or 2014 insulating caps.

f. For wire Number 8 AWG and larger, use heavy duty copper compression connectors:
1) Manufacturers: One of the following or equal:
a) Burndy.
b) Thomas & Betts.

g. Heat shrink tubing:
1) Suitable for indoors, outdoors, overhead, direct burial or submerged applications.
2) Minimum shrink ratio: 4 to 1.
3) Continuous operating temperature: -55 degrees Celsius to 110 degrees Celsius.
4) Internally applied adhesive sealant.
5) Cross-linked polyolefin:
a) Manufacturers: One of the following or equal:
(1) 3M, ITCSN.
(2) Thomas & Betts, Shrink-Kon.

2. Instrumentation class cable splices:
a. Suitable for indoor, outdoors, weather exposed, direct buried, or submersed applications.
b. Utilizing an epoxy, polyurethane, and re-enterable compounds.
c. For use with shielded or unshielded plastic- and rubber-jacketed, signal, control, and power cables rated up to 1 kilovolt.
d. Two-part mold body with tongue and groove seams and built-in spacer webbing.
e. Manufacturers: The following or equal:
1) 3M, Scotchcast 72-N.

C. Insulating tape:
1. General purpose insulating tape:
a. Minimum 7 mil vinyl tape.
b. Suitable for application in an ambient of -18 degrees Celsius (0 degrees Fahrenheit).
c. Operating range up to 105 degrees Celsius (220 degrees Fahrenheit).
d. Flame retardant, hot- and cold-weather resistant, UV resistant.
e. For use as a primary insulation for wire cable splices up to 600 VAC.
f. Meeting and complying with:
1) ASTM D3005 Type I.
2) UL 510.

3) CSA C22.2.
g. Manufacturers: The following or equal:
1) 3M, Scotch Number Super 33+.

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

D. Power distribution blocks:
1. UL 1953 listed.
2. Short circuit rating: Not less than the system maximum available fault current at the point of application.
3. Provide fuses or circuit breakers in enclosure as required to meet the fault current requirements.
4. Voltage rating: 600 VAC.
5. IP 20 finger safe enclosure.
6. Tin-plated aluminum or copper terminals suitable for copper conductors.
7. Manufacturers: One of the following or equal:
a. Eaton CHDB series.
b. Rockwell Automation 1492 PD series.
c. Schneider Electric LB series.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. Load connections:
   1. Connect loads to the circuits as indicated. Color-code branch circuits as specified in Section 16123 - 600-Volt or Less Wires and Cables.

B. Zero to 600-volt systems:
   1. Make connections with the proper tool and die as specified by the device manufacturer.
   2. Use only tooling and dies manufactured by the device manufacturer.
   3. Insulate connections and splices with Scotch 33+ tape and Scotchfill, or pre-molded plastic covers, or heat shrink tubing and caps.
   4. Number power and control wires before termination.

C. Motor connections (600 volts and below):
   1. Terminate leads and wires with compression type ring lugs.
   2. Terminations on motor leads, including leads that are connected together to accommodate the motor voltage, and the machine wires entering the motor terminal box from the power source, shall have ring type compression lugs.
   3. Cover bolted connectors with a heat shrinkable, cross-linked polyolefin material formed as a single opening boot:
      a. In damp and wet locations, use a complete kit containing mastic that shall seal out moisture and contamination.
      b. Shrink cap with low heat as recommended by manufacturer.
   4. Wire markers shall be readable after boot installation.
   5. Manufacturers: The following or equal:
      a. Raychem, MCK.

D. Power distribution terminal blocks:
   1. Connect fuses or circuit breakers on the line side of power distribution terminal blocks as required to meet short circuit requirements.

3.04 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

END OF SECTION

SECTION 16412

LOW VOLTAGE MOLDED CASE CIRCUIT BREAKERS

PART 1 GENERAL

1.01 SUMMARY

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

1.02 REFERENCES

A. National Fire Protection Association (NFPA):
   1. 70 - National Electrical Code (NEC).

B. Underwriter's Laboratories (UL):
   1. 489 - Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures.

1.03 DELEGATED DESIGN

A. As specified in Section 01357 - Delegated Design Procedures.

B. Anchoring and bracing.

1.04 SUBMITTALS

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

B. Product data:
   1. Catalog cutsheets.
   2. Manufacturer's time-current curves for molded case circuit breakers furnished.

C. Commissioning Submittals:
   1. As specified in Section 01756 - Commissioning, including the following:
      a. Owner Training.

D. Delegated Design Submittals:
   1. Anchoring and bracing: Provide project-specific calculations based on support conditions and requirements to resist loads specified in Section 01850 - Design Criteria.
      a. To structures for equipment installed in structures designated as seismic design category C, D, E, or F.
      b. For equipment installed outdoors.
      c. For wall mounted equipment weighing 125 pounds or more.

1.05 QUALITY ASSURANCE

A. Low voltage molded case circuit breakers shall be UL listed and labeled.

1.06 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.07 PROJECT OR SITE CONDITIONS

A. As specified in Section 01850 - Design Criteria.

1.08 ADMINISTRATIVE REQUIREMENTS (NOT USED)

1.09 WARRANTY

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

PART 2 PRODUCTS

2.01 GENERAL

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

2.02 DESIGN AND PERFORMANCE CRITERIA (NOT USED)

2.03 MANUFACTURERS

A. One of the following or equal:
   1. ABB.
   2. Eaton.
   3. Schneider Electric.

2.04 MATERIALS (NOT USED)

2.05 MANUFACTURED UNITS

A. General:
   1. In accordance with UL 489.
   2. Operating mechanism:
      a. Quick-make, quick-break, non-welding silver alloy contacts.
      b. Common Trip, Open and Close for multi-pole breakers such that all poles open and close simultaneously.
      c. Mechanically trip free from the handle.
      d. Trip indicating handle - automatically assumes a position midway between the manual ON and OFF positions to clearly indicate the circuit breaker has tripped.
      e. Lockable in the “OFF” position.
   3. Arc extinction:
      a. In arc chutes.
   4. Voltage and current ratings:
      a. Minimum ratings as indicated on the Drawings.
      b. Minimum frame size 100A.
   5. Interrupting ratings:
      a. Minimum ratings as indicated on the Drawings.

b. Not less than the rating of the assembly (panelboard, switchboard, motor control center, etc.).

B. Motor circuit protectors:
1. Instantaneous only circuit breaker as part of a listed combination motor controller.
2. Each pole continuously adjustable in a linear scale with 'LO' and 'HI' settings factory calibrated.

2.06 EQUIPMENT (NOT USED)

2.07 COMPONENTS

A. Terminals:
1. Line and load terminals suitable for the conductor type, size, and number of conductors indicated on the Drawings and in accordance with UL 489.

B. Case:
1. Molded polyester glass reinforced.
2. Ratings clearly marked.

C. Trip units:
1. Provide thermal magnetic or solid-state trip units as indicated on the Drawings.
2. Thermal magnetic:
a. Instantaneous short circuit protection.
b. Inverse time delay overload.
c. Ambient or enclosure compensated by means of a bimetallic element.
3. Solid state:
a. With the following settings as indicated on the Drawings:
1) Adjustable long time current setting.
2) Adjustable long time delay.
3) Adjustable short time pickup.
4) Adjustable short time delay.
5) Adjustable instantaneous pickup.
6) Adjustable ground fault pickup as indicated on the Drawings.
7) Adjustable ground fault delay as indicated on the Drawings.
b. Energy reducing maintenance switch on breakers 1,200 amps and above and on additional breakers as indicated on the Drawings.
1) Indication on the breaker.

D. Molded case circuit breakers for use in panelboards:
1. Bolt-on type:
a. Plug-in type breakers are not acceptable.
2. Ground fault trip devices as indicated on the Drawings.

2.08 ACCESSORIES

A. Undervoltage trip:
1. Electrically trips breaker when control circuit voltage falls to a preset voltage as indicated on the Drawings.

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

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

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

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION

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.

3.03 INSTALLATION

A. Install breakers to correspond to the accepted Shop Drawings.

3.04 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

B. Functional Testing:
   1. As specified in Section 16950 - Field Electrical Acceptance Tests.

3.05 FIELD QUALITY CONTROL (NOT USED)

3.06 ADJUSTING

A. Adjust trip settings in accordance with Protective Device Coordination Study as accepted by the Engineer and in accordance with manufacturer's recommendations.

B. Adjust motor circuit protectors in accordance with NEC and the manufacturer's recommendation based on the nameplate values of the installed motor.

END OF SECTION

SECTION 16494

LOW VOLTAGE FUSES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Fuses: 600-volt class and lower.

1.02 REFERENCES

A. As specified in Section 16050 - Common Work Results for Electrical.

1.03 DELEGATED DESIGN (NOT USED)

1.04 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 - Submittal Procedures.

B. Product data:
   1. Catalog cut sheets.
   2. Complete fuse schedule.
   3. Manufacturer original 11-inch by 17-inch, time current curves for all fuses furnished.

C. Shop drawings:
   1. Include drawings of spare fuse cabinets.

1.05 QUALITY ASSURANCE

A. All low voltage fuses shall be UL listed and labeled.

1.06 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.07 PROJECT OR SITE CONDITIONS

A. As specified in Section 01850 - Design Criteria.

1.08 ADMINISTRATIVE REQUIREMENTS (NOT USED)

1.09 WARRANTY

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

1.10 MAINTENANCE

A. Spare parts:
   1. Provide 3 spare fuses for each size and type used or supplied under any Section of the Contract Documents.
   2. Provide spare fuse cabinet(s):
      a. Metal cabinet with hinged door and shelves or fuse holders.
      b. Gray enamel finish.
      c. Mount near equipment and label "Spare Fuses" on face of cabinet.
      d. Suitable pocket inside door of each cabinet with typewritten spare fuse inventory in clear plastic protective insert.
      e. Provide as many cabinets as required to hold entire spare fuse inventory.

PART 2 PRODUCTS

2.01 GENERAL

A. Fuses for overcurrent protection and/or current limiting applications as indicated on the Drawings.

2.02 DESIGN AND PERFORMANCE CRITERIA (NOT USED)

2.03 MANUFACTURERS

A. One of the following or equal:
   1. Bussmann.
   2. Ferraz Shawmut.
   3. Littelfuse.

2.04 MATERIALS (NOT USED)

2.05 MANUFACTURED UNITS

A. General:
   1. Provide durable, readily visible label inside each fuse enclosure, clearly indicating the correct type, size, and ratings of replacement fuse:
      a. Label shall not cover or interfere with equipment manufacturer's instructions.
   2. Affix a label indicating recommended torque for fuse mounting bolts or studs to the inside of fuse access doors.
   3. To ensure selective coordination of protective devices:
      a. Provide fuses for new facilities by the same manufacturer.
      b. Provide fuses for renovations of the same manufacturer as existing fuses.
   4. Provide fuses rated for the voltage and available short circuit current at which they are applied.

B. Fuses for services, switchboard mains, feeders, and branch circuits:
   1. 600 amperes and less:
      a. Provide UL listed RK1 dual-element, time-delay fuses with ampere ratings as indicated on the Drawings except as may be modified by the Contract Documents.
   2. 601 to 6,000 amperes:
      a. Provide UL listed Class L fuses.

C. Fuses for motor branch circuits:
   1. Ampere ratings shall not exceed motor controller manufacturer's recommended values:
      a. If manufacturer does not have such standards, provide fuses as specified in this Section.
   2. Provide Class RK1 fuses or fuses as indicated on the Drawings and as specified in the Contract Documents, rated in accordance with the fuse manufacturer's recommendations for backup running protection of motor circuits containing overload relays.
   3. Determine fuse ratings for overload protection of motor branch circuits by actual full-load currents of motors provided.
   4. Fuses in motor control centers may be time-delay Class J or Class CC fuses, if MCC manufacturer's standard designs use these fuse types:
      a. Time-delay Class J fuse ratings shall not exceed 150 percent of motor full load current except as permitted.
      b. Follow fuse manufacturer's recommendations for Class CC fuses.
      c. A motor having starting duty or other special characteristics requiring larger fuses than specified above, may have branch circuit fuse ratings increased as necessary to meet motor's requirements, but no larger than maximum permitted by the NEC.
         1) Increased requirements for an individual motor shall not be cause for increasing size of all fuses.
   5. Provide Class L fuses for motor branch circuits requiring fuses over 600 amperes, sized at 150 percent of motor full load current except as permitted below:
      a. A motor having starting duty or other special characteristics requiring larger fuses than specified above, may have branch circuit fuse ratings increased as necessary to meet motor's requirements, but no larger than maximum permitted by the NEC.
         1) Increased requirements for an individual motor shall not be cause for increasing size of all fuses.

D. Fusing of control circuits:
   1. Provide:
      a. RK1 fuses installed in UL listed Class CC fuse blocks as specified in the Contract Documents.
   2. Provide minimum protection for control circuits in accordance with the latest revision of UL Standard 508 for Industrial Control.
   3. Fuse both the primary and secondary circuit of control power transformers:
      a. Fuse ratings shall be in accordance with NEC requirements.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. General:
   1. Install fuses properly aligned, electrically and mechanically secure.
   2. Evenly torque mounting bolts and nuts to ASTM recommendations for type and diameter of mounting bolts or studs provided.
   3. Paralleling of fuses is not permitted.
   4. Install fuses so that the fuse nameplate and rating are easily readable in the equipment.

B. Replace fuses, on all phases, for any fuses that opened during start-up and testing.

C. After completion of testing, deliver spare fuses in quantities specified:
   1. Fuses shall be new, in manufacturer's original packaging, and stored in a clean, dry location.

D. Install spare fuse cabinets where instructed by the Owner.

3.04 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

END OF SECTION

SECTION 16950

FIELD ELECTRICAL ACCEPTANCE TESTS

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PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Responsibilities for testing the electrical installation.
   2. Adjusting and calibration.
   3. Acceptance tests.

B. Copyright information:
   1. Some portions of this Section are copyrighted by the InterNational Electrical Testing Association, Inc. (NETA). See NETA publication ATS for details.

1.02 REFERENCES

A. Project references:
   1. Specification sections for the electrical equipment being tested.
   2. Electrical equipment Shop Drawings.

B. Standards:
   1. American National Standards Institute (ANSI).
   2. ASTM International (ASTM):
      a. D877 - Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes.
      b. D923 - Standard Practices for Sampling Electrical Insulating Liquids.
      c. D924 - Standard Test Method for Dissipation Factor (or Power Factor) and Relative Permittivity (Dielectric Constant) of Electrical Insulating Liquids.
      d. D971 - Standard Test Method for Interfacial Tension of Oil Against Water by the Ring Method.
      e. D974 - Standard Test Method for Acid and Base Number by Color-Indicator Titration.
      f. D1500 - Standard Test Method for ASTM Color of Petroleum Products (ASTM Color Scale).
      g. D1524 - Standard Test Method for Visual Examination of Used Electrical Insulating Liquids in the Field.
      h. D1533 - Standard Test Method for Water in Insulating Liquids by Coulometric Karl Fischer Titration.
      i. D1816 - Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using VDE Electrodes.
      j. D3612 - Standard Test Method for Analysis of Gases Dissolved in Electrical Insulating Oil by Gas Chromatography.
   3. Institute of Electrical and Electronics Engineers (IEEE):
      a. 43 - IEEE Recommended Practice for Testing Insulation Resistance of Rotating Machinery.
   4. Insulated Cable Engineer’s Association (ICEA).
   5. InterNational Electrical Testing Association (NETA).
      a. ATS- Standard for Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems.
   6. International Electrotechnical Commission (IEC).
   7. National Electrical Manufacturers Association (NEMA):
      a. MG1 - Motors and Generators.

8. National Fire Protection Association (NFPA):
    a. 70 - National Electrical Code (NEC).
    b. 110 - Standard for Emergency and Standby Power Systems.
9. National Institute of Standards and Technology (NIST).

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. Testing laboratory: Organization performing the acceptance tests.

1.04 DELEGATED DESIGN (NOT USED)

1.05 SUBMITTALS

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

B. Copper Ethernet test form:
    1. Cable test reports:
        a. Submit 3 copies of test reports showing the results of all tests specified in this Section:
            1) Test type.
            2) Test location.
            3) Test date.
            4) Cable number.
            5) Cable length.
            6) Certification that the cable meets or exceeds the specified standard.
        b. Furnish hard copy and electronic copy for all traces.

C. Manufacturers' testing procedures:
    1. Submit manufacturers' recommended testing procedures and acceptable test results for review by the Engineer prior to beginning testing.

D. Test report:
    1. Include the following:
        a. Summary of Project.
        b. Description of equipment tested.
        c. Description of tests performed.
        d. Test results.
        e. Conclusions and recommendations.
        f. Completed test forms.
        g. List of test equipment used and calibration dates.
        h. LAN cable test reports.

E. Test data records:
    1. Include the following:
        a. Identification of the testing organization.
        b. Equipment identification.
        c. Nameplate data.
        d. Humidity, temperature and or other conditions that may affect the results of the tests and or calibrations.

e. Dates of inspections, tests, maintenance and or calibrations.
f. Indication of the inspections, tests, maintenance, and or calibrations to be performed and recorded.
g. Expected results when calibrations are to be performed.
h. Indication of as-found and as-left results as applicable.
i. Indication of test results outside specified tolerances.

F. Testing laboratory qualifications:
1. Submit a complete resume and statement of qualifications from the proposed testing laboratory detailing their experiences in performing the tests specified:
a. This statement will be used to determine whether the laboratory is acceptable, and shall include:
1) Corporate history and references.
2) Resume of individual performing test.
3) Equipment list and test calibration data.

G. Division of responsibilities:
1. Submit a list identifying who is responsible for performing each portion of the testing.

1.06 QUALITY ASSURANCE

A. Testing laboratory qualifications:
1. May be qualified testing personnel from the electrical subcontractor's staff or an independent testing company.
2. NETA certification required.
3. Selection of the testing laboratory and testing personnel is subject to approval by the Engineer based on testing experience and certifications of the individuals and testing capabilities of the organization.

1.07 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 01850 - Design Criteria.

1.09 ADMINISTRATIVE REQUIREMENTS

A. General requirements:
1. Testing of electrical equipment installed under this Contract in accordance with the manufacturer's requirements and as specified in this Section.
2. Conduct tests in the presence of the Engineer or the Engineer's representative:
a. Engineer will witness visual, mechanical, and electrical tests, and inspections.
3. Testing and inspections shall verify that the equipment is operational within the tolerances required and expected by the manufacturer, and these Specifications.

B. Responsibilities:
1. Contractor responsibilities:

a. Ensure that resources are made available for testing and that testing requirements are met.

2. Electrical subcontractor responsibilities:
   a. Perform routine tests during installation.
   b. Demonstrate operation of electrical equipment.
   c. Commission the electrical installation.
   d. Provide the necessary services during testing, and provide these services to the testing laboratory, Contractor, and other subcontractors, including, but not limited to:
      1) Providing electrical power as required.
      2) Operating of electrical equipment in conjunction with testing of other equipment.
      3) Activating and shutting down electrical circuits.
      4) Making and recording electrical measurements.
      5) Replacing blown fuses.
      6) Installing temporary jumpers.
3. Testing laboratory responsibilities:
   a. Perform acceptance tests specified in this Section.
   b. Provide required equipment, materials, labor, and technical support during acceptance tests.

C. Sequencing:
1. Prior to testing:
   a. At least 30 days before commencement of the acceptance tests, submit the manufacturer's complete field testing procedures to the Engineer and to the testing laboratory, complete with expected test results and tolerances for equipment to be tested.
2. Perform testing in the following sequence:
   a. Perform routine tests as the equipment is installed, including:
      1) Insulation-resistance tests.
      2) Continuity tests.
      3) Rotational tests.
   b. Adjusting and preliminary calibration.
   c. Acceptance tests.
   d. Demonstration.
   e. Commissioning and plant start-up.

1.10 WARRANTY

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

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION

A. Test instrument calibration:
   1. Utilize a testing laboratory with a calibration program which maintains applicable test instrumentation within rated accuracy.
      a. Calibrating standard shall be of better accuracy than that of the equipment tested.
   2. Accuracy shall be traceable to the NIST in an unbroken chain.
   3. Calibrate instruments in accordance with the following frequency schedule:
      a. Field instruments: 6 months maximum.
      b. Laboratory instruments: 12 months maximum.
      c. Leased specialty equipment where the accuracy is guaranteed by the lessor (such as Doble): 12 months maximum.
   4. Dated calibration labels shall be visible on test equipment.
   5. Maintain an up-to-date instrument calibration record for each test instrument:
      a. Records shall show the date and results of each calibration or test.
   6. Maintain an up-to-date instrument calibration instruction and procedure for each test instrument.

B. Requirements prior to testing:
   1. Do not begin testing until the following conditions have been met:
      a. Instruments required are available and in proper operating condition.
      b. Required dispensable materials such as solvents, rags, and brushes are available.
      c. Equipment handling devices such as cranes, vehicles, chain falls, and other lifting equipment are available or scheduled.
      d. Instruction books, calibration curves, or other printed material to cover the electrical devices are available.
      e. Datasheets to record test results are available.

3.03 INSTALLATION

A. Test decal:
   1. Testing laboratory shall affix a test decal on the exterior of equipment or equipment enclosure of protective devices after performing electrical tests.
   2. Color coded to communicate the condition of maintenance of the protective. Color scheme for condition of maintenance of overcurrent protective devices shall be:
      a. White: Electrically and mechanically acceptable.
      b. Yellow: Minor deficiency not affecting fault detection and operation, but minor electrical or mechanical condition exists.
   3. Shall include the following information at a minimum:
      a. Testing organization.
      b. Project identifier.
      c. Test date.
      d. Technician identifier.

3.04 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

B. Functional Testing:
   1. Also called Field Acceptance Testing.

C. Panelboards:
   1. Cleaning:
      a. Visually inspect panelboard for evidence of discoloration, abnormal dust accumulation, metal shards, or any other indication of overheating, wear, or other abnormal conditions prior to cleaning.
      b. Clean cabinet with a brush, vacuum cleaner, or clean, dry, lint-free rags to remove any accumulation of dust, dirt, or other foreign matter. Do not use liquids, solvents or detergents when cleaning panelboards or components.
      c. Avoid blowing dust into panelboards. Do not use a blower or compressed air.
      d. Clean supports, terminals, and other major insulating surfaces with clean, dry, lint-free rags or soft bristled brushes.
      e. Remove dust, soot, grease, moisture, and foreign material from surface of circuit breakers.
   2. General:
      a. Compare equipment nameplate data with the Contract Documents.
      b. Check panelboard circuit schedule for accuracy.
      c. Verify appropriate anchorage, required area clearances, and correct alignment.
      d. Inspect overall general condition for physical damage.
         1) Check for broken studs and loose or damaged wires, connector, terminations, etc.
         2) Check bolts, nuts, washer, and pins for tightness.
         3) Tighten or use manufacturer’s replacement parts as required.
      e. Inspect cabinets for signs of rust, corrosion, or deteriorating paint. Inspect cabinets for evidence of localized heat damage to the paint. Investigate sources of heat. Repair painted surfaces.
      f. Check that covers are in place and fastened. Plug any open unused knockouts.
      g. Inspect panelboard for moisture. Seal off any cracks or openings which have allowed moisture to enter the cabinet. Inspect component devices. Replace any components that show evidence of damage from moisture.
      h. Look for any recent changes in sprinklers or other plumbing that might expose indoor panelboards to a source of liquids. Eliminate sources of water, moisture, or liquids, or provide adequate barriers to protect panelboards from sources of water, moisture, or liquids.
      i. Inspect panelboards and internal components for evidence of overheating, arc spatter, sooty deposits, and tracking.
         1) Investigate and correct sources of arcing or overheating.
         2) Consult the panelboard manufacturer for recommendations.
      j. Verify that fuse and/or circuit breaker sizes and types correspond to record drawings, if available, as well as to the circuit breakers’ address for microprocessor communications packages, if equipped.
      k. Set adjustable circuit breakers in accordance with engineering coordination study supplied by the Owner.
   3. Terminations, connections, and lugs:
      a. Inspect bolted electrical connections for high resistance using one of the following methods:

1) Use of low-resistance ohmmeter.
a) Compare bolted connection resistance values to values of similar connections:
(1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
2) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
a) Refer to the manufacturer's instructions for proper foot-pound levels or NETA ATS tables.

b. Inspect terminations, connection, and lugs for alignment, physical damage, burns, corrosion, discoloration, flaking, heat damage, arcing, pitting, melting, deterioration, carbonization, cracks, chips, breaks, partial discharge, or moisture. Investigate and eliminate sources of any damage.
c. Follow manufacturer recommendations for cleaning, repairing, and replacing damaged parts.
d. Replace overheated connections. Tighten connections to proper torque levels as specified above.

4. Conductors and raceways:
a. Inspect supply conductors and terminations for overheating, discoloration, and oxidation. Investigate and correct any deficiencies.
b. Ensure the conductors are protected within their ampacities.
c. Visually check panelboard, cables, and raceways for proper bonding and grounding. Correct improper bonding and grounding.
d. Inspect conductors for discoloration, arcing, pitting, melting, flaking of insulation and/or metal parts. Repair or replace damaged components in accordance with the manufacturer's recommendations.
e. Inspect for frayed or broken wires. Replace or repair damaged components in accordance with manufacturer recommendations.
f. Inspect for frayed or broken wires. Replace or repair conductors as necessary.
g. Inspect conduits for moisture. Seal conduits which are a source of moisture and provide means to drain moisture away from the panelboard.

5. Circuit breakers:
a. Perform visual and mechanical inspection as specified in this Section.
b. Operate several times in order to exercise the mechanisms and the contacts, and to ensure smooth operation. Do not oil or grease parts of molded case circuit breakers.
c. Visually check for evidence of overheating and thermal damage. Investigate and eliminate sources of overheating.
d. Check for visual defects, chipping, cracks, breaks, burns, and deterioration. Replace damaged circuit breakers.
e. Verify correct operation of any auxiliary features such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free, and antipump function.
f. Inspect interchangeable trip-unit circuit breakers for tightness of trip units.
g. Check terminals and connections for tightness as specified above.
h. Breakers rated 100 A and higher:
1) Perform electrical tests as specified in this Section.

D. Low voltage cables, 600 volt maximum:
1. Visual and mechanical inspection:

a. Compare cable data with the Drawings and Specifications.
b. Inspect exposed sections of cable for physical damage and correct connection as indicated on the Drawings.
c. Inspect bolted electrical connections for high resistance by one of the following methods:
    1) Use of low-resistance ohmmeter.
    2) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
        a) Refer to the manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
d. Inspect compression applied connectors for correct cable match and indentation.
e. Inspect for correct identification and arrangement.
f. Inspect cable jacket insulation and condition.

2. Electrical tests:
    a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
    b. Perform insulation resistance test on each conductor sized #8 AWG or larger with respect to ground and adjacent conductors:
        1) Applied potential shall be 500 volts DC for 300-volt rated cable and 1,000 volts DC for 600-volt rated cable.
        2) Test duration shall be 1 minute.
    c. Perform continuity tests on power and control conductors to ensure correct cable connection.
    d. Verify uniform resistance of parallel conductors.

3. Test values:
    a. Compare bolted connection resistance values to values of similar connections:
        1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
    b. Insulation-resistance values shall be in accordance with the manufacturer's published data:
        1) Refer to NETA ATS tables in the absence of the manufacturer's published data.
        2) Investigate values of insulation-resistance less than the allowable minimum.
    c. Cable shall exhibit continuity.
    d. Deviations in resistance between parallel conductors shall be investigated.

E. Low voltage molded case and insulated case circuit breakers:
1. Visual and mechanical inspection:
    a. Compare equipment nameplate data with the Contract Documents.
    b. Inspect physical and mechanical condition.
    c. Inspect anchorage and alignment.
    d. Verify the unit is clean.
    e. Operate the circuit breaker to ensure smooth operation.
    f. Inspect bolted electrical connections for high resistance by one of the following methods:
        1) Use of low-resistance ohmmeter.
        2) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:

a) Refer to the manufacturer's instructions for proper foot-pound levels or NETA ATS tables.

g. Perform adjustments for final protective device settings in accordance with the coordination study.

2. Electrical tests:
   a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
   b. For breakers 100 A and higher:
      1) Perform insulation-resistance tests for 1 minute on each pole, phase-to-phase and phase-to-ground with the circuit breaker closed and across each open pole:
         a) Apply voltage in accordance with the manufacturer's published data.
         b) Refer to NETA ATS tables in the absence of the manufacturer's published data.
      2) Perform a contact/pole-resistance test.
      3) Determine long-time pickup and delay by primary current injection.
      4) Determine short-time pickup and delay by primary current injection.
      5) Determine ground-fault pickup and delay by primary current injection.
      6) Determine instantaneous pickup value by primary current injection.
      7) Test functions of the trip unit by means of secondary injection.
      8) Perform minimum pickup voltage tests on shunt trip and close coils in accordance with the manufacturer's published data.
      9) Verify correct operation of any auxiliary features such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free, anti-pump function and trip unit battery condition:
         a) Reset trip logs and indicators.
      10) Verify operation of charging mechanism.
3. Test values:
   a. Compare bolted connection resistance values to values of similar connections:
      1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
   b. Bolt-torque levels shall be in accordance with the manufacturer's published data:
      1) Refer to NETA ATS tables in the absence of the manufacturer's published data.
   c. Insulation-resistance values shall be in accordance with the manufacturer's published data:
      1) Refer to NETA ATS tables in the absence of the manufacturer's published data.
      2) Investigate values of insulation-resistance less than the allowable minimum.
   d. Microhm or DC millivolt drop values shall not exceed the high levels of the normal range as indicated in the manufacturer's published data:
      1) If the manufacturer's data is not available, investigate any values which deviate from adjacent poles or similar breakers by more than 50 percent of the lowest value.
   e. Long-time pickup values shall be as specified, and the trip characteristic shall not exceed the manufacturer's published time-current characteristic tolerance band, including adjustment factors:

1) If the manufacturer's curves are not available, trip times shall not exceed the value shown in NETA ATS tables.

f. Short-time pickup values shall be as specified, and the trip characteristic shall not exceed the manufacturer's published time-current tolerance band.

g. Ground fault pickup values shall be as specified, and the trip characteristic shall not exceed the manufacturer's published time-current tolerance band.

h. Instantaneous pickup values shall be as specified and within the manufacturer's published tolerances:

1) Refer to NETA ATS tables in the absence of the manufacturer's published data.

i. Pickup values and trip characteristics shall be within the manufacturer's published tolerances.

j. Determine energy reducing maintenance switch pickup value by primary current injection.

k. Breaker open, close, trip, trip-free, anti-pump, and auxiliary features shall function as designed.

l. Charging mechanism shall operate in accordance with the manufacturer's published data.

F. Surge arresters, low-voltage:

1. Visual and mechanical inspection:

a. Compare equipment nameplate data with the Contract Documents.

b. Inspect physical and mechanical condition.

c. Inspect anchorage, alignment, grounding, and clearances.

d. Verify the arresters are clean.

e. Inspect bolted electrical connections for high resistance using one of the following methods:

1) Use of low-resistance ohmmeter.

2) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:

a) Refer to the manufacturer's instructions for proper foot-pound levels or NETA ATS tables.

f. Verify that the ground lead on each device is individually attached to a ground bus or ground electrode.

g. Verify that stroke counter is correctly mounted and electrically connected, if applicable.

h. Record stroke counter reading.

2. Electrical tests:

a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.

b. Perform an insulation-resistance test on each arrester, phase terminal-to-ground:

1) Apply voltage in accordance with manufacturer's published data.

2) Refer to NETA ATS tables in the absence of the manufacturer's published data.

c. Test grounding connection as specified in this Section.

3. Test values:

a. Compare bolted connection resistance values to values of similar connections:

1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.

b. Bolt-torque levels shall be in accordance with the manufacturer's published data:
    1) Refer to NETA ATS tables in the absence of the manufacturer's published data.
c. Insulation-resistance values shall be in accordance with the manufacturer's published data:
    1) Refer to NETA ATS tables in the absence of the manufacturer's published data.
    2) Investigate insulation values less than the allowable minimum.
d. Resistance between the arrester ground terminal and the ground system shall be less than 0.5 ohm.

G. Fiber-optic cables:
1. Visual and mechanical inspection:
    a. Compare cable, connector, and splice data with the Contract Documents.
    b. Inspect cable and connections for physical and mechanical damage.
    c. Verify that connectors and splices are correctly installed.
2. Optical tests:
    a. Perform cable length measurement, fiber fracture inspection, and construction defect inspection using an optical time domain reflectometer (OTDR):
        1) OTDR test performed on fiber cables less than 100 meters shall be performed with the aid of a launch cable.
        2) Adjust OTDR pulse width settings to a maximum setting of 1/1,000th of the cable length or 10 nanoseconds.
    b. Perform connector and splice integrity test using an optical time domain reflectometer.
    c. Perform cable attenuation loss measurement with an optical power loss test set:
        1) Perform attenuation tests with an optical loss test set capable and calibrated to show anomalies of 0.1 dB as a minimum.
        2) Test multimode fibers at 850 nanometer and 1,300 nanometer.
        3) Test single mode fibers at 1,310 nanometer and 1,550 nanometer.
    d. Perform connector and splice attenuation loss measurement from both ends of the optical cable with an optical power loss test set:
        1) At the conclusion of all outdoor splices at 1 location, and before they are enclosed and sealed, splices shall be tested with OTDR at the optimal wavelengths (850 and 1,300 for multimode, 1,310 and 1,550 for single mode), in both directions. Splices shall be tested for integrity as well as attenuation.
    e. Perform fiber links integrity and attenuation tests using each link shall be an OTDR and an optical loss test set:
        1) OTDR traces shall be from both directions on each fiber at the 2 optimal wavelengths, 850 nanometer, and 1,300 nanometer for multimode fibers.
        2) Optical loss testing shall be done with handheld test sets in 1 direction at the 2 optimal wavelengths for the appropriate fiber type. Test equipment shall equal or exceed the accuracy and resolution of Agilent/HP 8147 high performance OTDR.
3. Test values:

a. Cable and connections shall not have been subjected to physical or mechanical damage.
b. Connectors and splices shall be installed in accordance with industry standards.
c. Optical time domain reflectometer signal should be analyzed for excessive connection, splice, or cable backscatter by viewing the reflected power/distance graph.
d. Attenuation loss measurement shall be expressed in dB/km. Losses shall be within the manufacturer's recommendations when no local site specifications are available.
e. Individual fusion splice losses shall not exceed 0.1 dB. Measurement results shall be recorded, validated by trace, and filed with the records of the respective cable runs.

H. Copper Ethernet cable installation testing:
1. Pre-installation:
a. Immediately prior to installation, verify that cable to be installed matches that which was submitted.
b. Verify that no damage has been done to the cable during shipping or handling.
c. Inspect cable for physical and mechanical damage.
d. Engineer shall be notified if a cable fails to meet inspection and the cable shall not be installed unless otherwise directed by the Engineer.
2. Post-installation:
a. Prior to copper Ethernet cable termination, perform cable end-to-end continuity validation testing on installed cables, conductor pairs and cable shields using toner and probe kit. Any cable that fails testing shall be removed and replaced.
b. Inspect equipment outlet connectors for damage and ensure connectors hold tightly in field device ports.
3. Test equipment:
a. Certification equipment used for the testing shall be capable of verifying twisted pair cable installation with end-to-end continuity testing.
b. Use only test cords and adapters that are qualified by the test equipment manufacturer for channel or link test configuration.
c. Manufacturers: The following or equal:
1) Fluke Networks, IntelliTone Pro 200 Toner and Probe Kit, MT-8200-60-KIT.
d. Permanent link testing requirements: As specified in Section 17950 - Commissioning for Instrumentation and Controls.

3.05 FIELD QUALITY CONTROL (NOT USED)

3.06 ADJUSTING (NOT USED)

3.07 CLEANING

A. Dispose of testing expendables.

B. Vacuum cabinets.

C. Sweep clean surrounding areas.

END OF SECTION

SECTION 16990A

CONDUIT SCHEDULE

PART 1 GENERAL

1.01 SUMMARY

A. Conduit requirements:
   1. As defined in Section 16050 and Section 16130.

B. Cable requirements and definitions:
   1. As defined in Section 16050 and Section 16123.
   2. 2/CS#16: 2 conductor, 16 gauge, twisted shielded pair.
   3. */FO: Fiber optic (* indicates strand count).
   4. CAT6: Category 6 Ethernet cable.
   5. MFR: Manufacturer or vendor furnished cable.
   6. PULL: Pull Rope.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

3.01 CONDUIT SCHEDULE

A. Conduit Schedule is presented on the following pages.

CONDUIT SCHEDULE AREA

CLEARWELL AND CHEMICAL SYSTEM UPGRADES

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CONDUIT			CONDUCTORS			GROUND				
NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE	DESCRIPTION	CONNECTING SEGMENTS
C-50-102	10E01	0.75"	2	#14	XHHW-2	1	#14	XHHW-2	FR: LSH-050-514-01	C-50-103A
									TO: CONDUIT TEE	
									2 #14 >> LSH-050-514-01 CONTROL	C-50-101
C-50-103	10E01	0.75"	2	#14	XHHW-2	1	#14	XHHW-2	FR: LSH-050-534-51	C-50-103A
									TO: CONDUIT TEE	
									2 #14 >> LSH-050-534-51 CONTROL	
C-50-103A	10E01	0.75"	4	#14	XHHW-2	1	#14	XHHW-2	FR: CONDUIT TEE	C-50-104
									TO: CONDUIT TEE	
									2 #14 >> LSH-050-514-01 CONTROL	C-50-102
									2 #14 >> LSH-050-534-51 CONTROL	C-50-103
C-50-103B	10E01	1"	18	#14	XHHW-2	1	#14	XHHW-2	FR: LCP-050-533-02	C-50-104
									TO: CONDUIT TEE	
									18 #14 >> LCP-050-533-02 CONTROL	
C-50-104	10E01	1.5"	22	#14	XHHW-2	1	#14	XHHW-2	FR: CONDUIT TEE	
									TO: PCM-050-500-01	
									2 #14 >> LSH-050-514-01 CONTROL	C-50-103A
									2 #14 >> LSH-050-534-51 CONTROL	C-50-103A
									18 #14 >> LCP-050-533-02 CONTROL	C-50-103B
C-50-111	10E01	1"	18	#14	XHHW-2	1	#14	XHHW-2	FR: LCP-050-543-01	
									TO: CONDUIT TEE	
									18 #14 >> LCP-050-543-01 CONTROL	
C-50-112	10E01	1"	18	#14	XHHW-2	1	#14	XHHW-2	FR: LCP-050-513-01	
									TO: CONDUIT TEE	
									18 #14 >> LCP-050-513-01 CONTROL	
C-50-114	10E01	1.5"	36	#14	XHHW-2	1	#14	XHHW-2	FR: CONDUIT TEE	C-50-116
									TO: CONDUIT TEE	
									18 #14 >> LCP-050-543-01 CONTROL	C-50-113
									18 #14 >> LCP-050-513-01 CONTROL	C-50-113
C-50-115	10E01	1"	18	#14	XHHW-2	1	#14	XHHW-2	FR: LCP-050-533-01	C-50-116
									TO: CONDUIT TEE	
									18 #14 >> LCP-050-533-01 CONTROL	
C-50-116	10E01	2"	54	#14	XHHW-2	1	#14	XHHW-2	FR: CONDUIT TEE	
									TO: PCM-050-500-01	
									18 #14 >> LCP-050-543-01 CONTROL	C-50-114
									18 #14 >> LCP-050-513-01 CONTROL	C-50-114
									18 #14 >> LCP-050-533-01 CONTROL	C-50-115
C-50-117	10E01	1"	18	#14	XHHW-2	1	#14	XHHW-2	FR: LCP-050-522-11	C-50-120
									TO: JUNCTION BOX	
									18 #14 >> LCP-050-522-11 CONTROL	
C-50-118	10E01	1"	18	#14	XHHW-2	1	#14	XHHW-2	FR: LCP-050-522-21	C-50-120
									TO: JUNCTION BOX	
									18 #14 >> LCP-050-522-21 CONTROL	
C-50-119	10E01	1"	18	#14	XHHW-2	1	#14	XHHW-2	FR: LCP-050-522-31	C-50-120
									TO: JUNCTION BOX	
									18 #14 >> LCP-050-522-31 CONTROL	
C-50-120	10E01	2"	54	#14	XHHW-2	1	#14	XHHW-2	FR: JUNCTION BOX	C-50-122
									TO: CONDUIT TEE	
									18 #14 >> LCP-050-522-11 CONTROL	C-50-117
									18 #14 >> LCP-050-522-21 CONTROL	C-50-118
									18 #14 >> LCP-050-522-31 CONTROL	C-50-119
C-50-121	10E01	1"	18	#14	XHHW-2	1	#14	XHHW-2	FR: LCP-050-522-41	C-50-122
									TO: JUNCTION BOX	
									18 #14 >> LCP-050-522-41 CONTROL	
C-50-122	10E01	2"	72	#14	XHHW-2	1	#14	XHHW-2	FR: CONDUIT TEE	
									TO: PCM-050-500-01	
									18 #14 >> LCP-050-522-11 CONTROL	C-50-120
									18 #14 >> LCP-050-522-21 CONTROL	C-50-120
									18 #14 >> LCP-050-522-31 CONTROL	C-50-120
									18 #14 >> LCP-050-522-41 CONTROL	C-50-121
C-50-140	10E01	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: FV-050-512-15	C-50-142
			4	#14	XHHW-2				TO: CONDUIT TEE	
									4 #14 >> FV-050-512-15 CONTROL	
									2 #12 >> FV-050-512-15 POWER	
C-50-141	10E01	0.75"	2	#14	XHHW-2	1	#14	XHHW-2	FR: LSHH-050-512-31	C-50-142
									TO: CONDUIT TEE	
									2 #14 >> LSHH-050-512-31 CONTROL	

CONDUIT SCHEDULE AREA

CLEARWELL AND CHEMICAL SYSTEM UPGRADES

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CONDUIT			CONDUCTORS			GROUND							
NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE			DESCRIPTION		CONNECTING SEGMENTS
C-50-142	10E01	0.75"	2 6	#12 #14	XHHW-2 XHHW-2	1	#12	XHHW-2	FR: TO: 4 2 2	 #14 #12 #14	CONDUIT TEE LCP-050-500-02 >> FV-050-512-15 CONTROL >> FV-050-512-15 POWER >> LSHH-050-512-31 CONTROL		 C-50-140 C-50-140 C-50-141
C-50-150	10E01	0.75"	2 4	#12 #14	XHHW-2 XHHW-2	1	#12	XHHW-2	FR: TO: 4 2	 #14 #12	FV-050-542-15 CONDUIT TEE >> FV-050-542-15 CONTROL >> FV-050-542-15 POWER		C-50-152
C-50-151	10E01	0.75"	2	#14	XHHW-2	1	#14	XHHW-2	FR: TO: 2	 #14	LSHH-050-542-31 CONDUIT TEE >> LSHH-050-542-31 CONTROL		C-50-152
C-50-152	10E01	0.75"	2 6	#12 #14	XHHW-2 XHHW-2	1	#12	XHHW-2	FR: TO: 4 2 2	 #14 #12 #14	FV-050-512-31 CONDUIT TEE >> FV-050-542-15 CONTROL >> FV-050-542-15 POWER >> LSHH-050-542-31 CONTROL		 C-50-150 C-50-150 C-50-151
C-50-160	10E01	2"	48	#14	XHHW-2	1	#14	XHHW-2	FR: TO: 48	 #14	LCP-050-500-02 PCM-050-500-01 >> LCP-050-500-02 CONTROL		
C-50-200	30E01	0.75"	1	PULL	ROPE				FR: TO: 1	 PULL	CARB-050-553-11 CONDUIT TEE >> SPARE FOR CARB-050-553-11 CONTROL		C-50-204
C-50-201	30E01	0.75"	2	#14	XHHW-2	1	#14	XHHW-2	FR: TO: 2	 #14	CARB-050-553-21 CONDUIT TEE >> SPARE FOR CARB-050-553-21 CONTROL		C-50-203
C-50-202	30E01	0.75"	2	#14	XHHW-2	1	#14	XHHW-2	FR: TO: 2	 #14	CARB-050-553-31 CONDUIT TEE >> SPARE FOR CARB-050-553-31 CONTROL		C-50-203
C-50-203	30E01	0.75"	4	#14	XHHW-2	1	#14	XHHW-2	FR: TO: 2 2	 #14 #14	CONDUIT TEE CONDUIT TEE >> SPARE FOR CARB-050-553-21 CONTROL >> SPARE FOR CARB-050-553-31 CONTROL		C-50-204 C-50-201 C-50-202
C-50-204	30E01	0.75"	4 1	#14 PULL	XHHW-2 ROPE	1	#14	XHHW-2	FR: TO: 1 2 2	 PULL #14 #14	CONDUIT TEE PCM-050-550-01 >> SPARE FOR CARB-050-553-11 CONTROL >> SPARE FOR CARB-050-553-21 CONTROL >> SPARE FOR CARB-050-553-31 CONTROL		 C-50-200 C-50-203 C-50-203
L-50-010	01E01	1.5"	14 2	#12 #14	XHHW-2 XHHW-2	1	#12	XHHW-2	FR: TO: 14 2	 #12 #14	SP-050-225-01 PCM-050-220-01 >> SP-050-225-01 POWER >> FSL-050-225-21 CONTROL		
L-50-020	01E01	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: TO: 2	 #12	PCM-050-145-11 LP-050-145-11 >> PCM-050-145-11 POWER		
L-50-030	01E01	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: TO: 2	 #12	PCM-050-185-01 EXISTING PANEL-7 >> PCM-050-185-01 POWER		
L-50-031	01E01	0.75"	4	#12	XHHW-2	1	#12	XHHW-2	FR: TO: 2 2	 #12 #12	PCM-050-220-01 EXISTING PANEL-7 >> PCM-050-220-01 UPS POWER >> PCM-050-220-01 NON UPS POWER		
L-50-040	01E01 30E01	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: TO: 2	 #12	PCM-050-145-31 EXISTING SUB PANEL A >> PCM-050-145-31 POWER		
L-50-050	10E01	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: TO: 2	 #12	PCM-050-500-01 LP-3A >> PCM-050-500-01 POWER		
L-50-104	10E01	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: TO: 2	 #12	LIT-050-542-01 CONDUIT TEE >> LIT-050-542-01 POWER		L-50-109
L-50-106	10E01	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: TO: 2	 #12	LIT-050-512-11 JUNCTION BOX >> LIT-050-512-11 POWER		L-50-108

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CONDUIT			CONDUCTORS			GROUND				
NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE	DESCRIPTION	CONNECTING SEGMENTS
L-50-107	10E01	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: LIT-050-532-11	L-50-108
									TO: JUNCTION BOX	
									2 #12 >> LIT-050-532-11 POWER	
L-50-108	10E01	0.75"	4	#12	XHHW-2	1	#12	XHHW-2	FR: JUNCTION BOX	L-50-109
									TO: CONDUIT TEE	
									2 #12 >> LIT-050-512-11 POWER	L-50-106
									2 #12 >> LIT-050-532-11 POWER	L-50-107
L-50-109	10E01	1"	6	#12	XHHW-2	1	#12	XHHW-2	FR: CONDUIT TEE	
									TO: PCM-050-500-01	
									2 #12 >> LIT-050-542-01 POWER	L-50-104
									2 #12 >> LIT-050-512-11 POWER	L-50-108
									2 #12 >> LIT-050-532-11 POWER	L-50-108
L-50-111	10E01	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: LCP-050-513-01	L-50-113A
									TO: CONDUIT TEE	
									2 #12 >> LCP-050-513-01 POWER	
L-50-113	10E01	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: LCP-050-543-01	L-50-113A
									TO: CONDUIT TEE	
									2 #12 >> LCP-050-543-01 POWER	
L-50-113A	10E01	0.75"	4	#12	XHHW-2	1	#12	XHHW-2	FR: CONDUIT TEE	L-50-114
									TO: CONDUIT TEE	
									2 #12 >> LCP-050-513-01 POWER	L-50-111
									2 #12 >> LCP-050-543-01 POWER	L-50-113
L-50-113B	10E01	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: LCP-050-533-02	L-50-114
									TO: CONDUIT TEE	
									2 #12 >> LCP-050-533-02 POWER	
L-50-114	10E01	0.75"	6	#12	XHHW-2	1	#12	XHHW-2	FR: CONDUIT TEE	
									TO: LP3A	
									2 #12 >> LCP-050-513-01 POWER	L-50-113A
									2 #12 >> LCP-050-543-01 POWER	L-50-113A
									2 #12 >> LCP-050-533-02 POWER	L-50-113B
L-50-140	10E01	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: LIT-050-512-31	L-50-162
									TO: CONDUIT TEE	
									2 #12 >> LIT-050-512-31 POWER	
L-50-141	10E01	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: PMP-050-512-21	L-50-143
									TO: CONDUIT TEE	
									2 #12 >> PMP-050-512-21 POWER	
L-50-142	10E01	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: PMP-050-512-22	L-50-143
									TO: CONDUIT TEE	
									2 #12 >> PMP-050-512-22 POWER	
L-50-143	10E01	0.75"	4	#12	XHHW-2	1	#12	XHHW-2	FR: CONDUIT TEE	
									TO: LCP-050-500-02	
									2 #12 >> PMP-050-512-21 POWER	L-50-141
									2 #12 >> PMP-050-512-22 POWER	L-50-142
L-50-150	10E01	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: LIT-050-542-31	L-50-161
									TO: CONDUIT TEE	
									2 #12 >> LIT-050-542-31 POWER	
L-50-151	10E01	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: PMP-050-542-21	L-50-153
									TO: CONDUIT TEE	
									2 #12 >> PMP-050-542-21 POWER	
L-50-152	10E01	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: PMP-050-542-22	L-50-153
									TO: CONDUIT TEE	
									2 #12 >> PMP-050-542-22 POWER	
L-50-153	10E01	0.75"	4	#12	XHHW-2	1	#12	XHHW-2	FR: CONDUIT TEE	
									TO: LCP-050-500-02	
									2 #12 >> PMP-050-542-21 POWER	L-50-151
									2 #12 >> PMP-050-542-22 POWER	L-50-152
L-50-160	10E01	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: LCP-050-500-02	L-50-161
									TO: CONDUIT TEE	
									2 #12 >> LCP-050-500-02 IPC POWER	
L-50-161	10E01	0.75"	4	#12	XHHW-2	1	#12	XHHW-2	FR: CONDUIT TEE	L-50-162
									TO: CONDUIT TEE	
									2 #12 >> LIT-050-542-31 POWER	L-50-150
									2 #12 >> LCP-050-500-02 IPC POWER	L-50-160

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ENGINEER	BHT
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CONDUIT			CONDUCTORS			GROUND				
NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE	DESCRIPTION	CONNECTING SEGMENTS
L-50-162	10E01	0.75"	6	#12	XHHW-2	1	#12	XHHW-2	FR: CONDUIT TEE	
									TO: PCM-050-500-01	
									2 #12 >> LIT-050-512-31 POWER	L-50-140
									2 #12 >> LIT-050-542-31 POWER	L-50-161
									2 #12 >> LCP-050-500-02 IPC POWER	L-50-161
L-50-170	10E01	0.75"	2	#10	XHHW-2	1	#10	XHHW-2	FR: LCP-050-500-02	
									TO: LP3A	
									2 #10 >> LCP-050-500-02 TRANSFER PUMPS POV	
N-50-010	01E01	2"	8		CAT6	1	#14	XHHW-2	FR: SP-050-225-01	
									TO: PCM-050-220-01	
									8 CAT6 >> SP-050-225-01 NETWORK	
N-50-020	01E01	2"	1		24/FO	1	#14	XHHW-2	FR: PCM-050-145-11	
									TO: PCM-050-220-01	
									1 24/FO >> PCM-050-145-11 NETWORK	
N-50-030	01E01	3"	2		24/FO	1	#14	XHHW-2	FR: PCM-050-220-01	
									TO: PCM-050-145-31	
									1 24/FO >> PCM-050-145-31 NETWORK	
									1 24/FO >> PCM-050-550-01 NETWORK	N-50-050
N-50-050	01E01	2"	1		24/FO	1	#14	XHHW-2	FR: PCM-050-550-01	N-50-030
	30E01								TO: PCM-050-220-01 VIA PCM-050-145-31	
									1 24/FO >> PCM-050-550-01 NETWORK	
N-50-060	01E01	2"	1		24/FO	1	#14	XHHW-2	FR: PCM-050-500-01	
									TO: PCM-050-550-01	
									1 24/FO >> PCM-050-500-01 NETWORK	
N-50-070	01E01	2"	1		24/FO	1	#14	XHHW-2	FR: PCM-050-500-01	
									TO: SNR-050-901-01	
									1 24/FO >> PCM-050-500-01 NETWORK	
N-50-071	10E01	2"	1		CAT6	1	#14	XHHW-2	FR: LCP-050-500-02	
									TO: PCM-050-500-01	
									1 CAT6 >> LCP-050-500-02 NETWORK	
N-50-080	01E01	2"	1		24/FO	1	#14	XHHW-2	FR: PCM-050-220-01	
									TO: SNR-050-901-01	
									1 24/FO >> PCM-050-220-01 NETWORK	
N-50-090	01E01	2"	1		24/FO	1	#14	XHHW-2	FR: PCM-050-185-01	
									TO: PCM-050-220-01	
									1 24/FO >> PCM-050-185-01 NETWORK	
N-50-100	20E01	2"	2		CAT6	1	#14	XHHW-2	FR: SNR-050-901-01	
									TO: EXISTING SWITCH ELECTRICAL ROOM	
									2 CAT6 >> SNR-050-901-01 NETWORK	
N-50-101	20E01	2"	2	MFR	CABLE	1	#14	XHHW-2	FR: CELLULAR ANTENNAS	
									TO: SNR-050-901-01	
									2 MFR >> CELLULAR ANTENNAS NETWORK	
N-50-102	20E01	2"	1	MFR	CABLE	1	#14	XHHW-2	FR: GPS ANTENNA	
									TO: SNR-050-901-01	
									1 MFR >> GPS ANTENNA NETWORK	
S-50-020	01E01	0.75"	1	2/CS-#16		1	#14	XHHW-2	FR: FIT-050-145-21	S-50-022
									TO: CONDUIT TEE	
									1 2/CS-#16 >> FIT-050-145-21 SIGNAL	
S-50-021	01E01	0.75"	1	2/CS-#16		1	#14	XHHW-2	FR: FIT-050-145-11	S-50-022
									TO: CONDUIT TEE	
									1 2/CS-#16 >> FIT-050-145-11 SIGNAL	
S-50-022	01E01	0.75"	2	2/CS-#16		1	#14	XHHW-2	FR: FIT-050-145-21	
									TO: PCM-050-145-11	
									1 2/CS-#16 >> FIT-050-145-11 SIGNAL	S-50-021
									1 2/CS-#16 >> FIT-050-145-21 SIGNAL	S-50-020
S-50-030	01E01	0.75"	1	2/CS-#16		1	#14	XHHW-2	FR: AIT-050-185-11	
									TO: PCM-050-185-01	
									1 2/CS-#16 >> AIT-050-185-11 SIGNAL	
S-50-031	01E01	0.75"	1	2/CS-#16		1	#14	XHHW-2	FR: AIT-050-185-21	
									TO: PCM-050-185-01	
									1 2/CS-#16 >> AIT-050-185-21 SIGNAL	
S-50-040	01E01	0.75"	1	2/CS-#16		1	#14	XHHW-2	FR: FIT-050-145-31	S-50-042
									TO: CONDUIT TEE	
									1 2/CS-#16 >> FIT-050-145-31 SIGNAL	

CONDUIT SCHEDULE AREA

CLEARWELL AND CHEMICAL SYSTEM UPGRADES

ENGINEER	BHT
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CONDUIT			CONDUCTORS			GROUND				
NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE	DESCRIPTION	CONNECTING SEGMENTS
S-50-041	01E01	0.75"	1	2/CS-#16		1	#14	XHHW-2	FR: FIT-050-145-41 TO: CONDUIT TEE 1 2/CS-#16 >> FIT-050-145-41 SIGNAL	S-50-042
S-50-042	01E01	0.75"	2	2/CS-#16		1	#14	XHHW-2	FR: FIT-050-145-21 TO: PCM-050-145-31 1 2/CS-#16 >> FIT-050-145-31 SIGNAL 1 2/CS-#16 >> FIT-050-145-41 SIGNAL	S-50-040 S-50-041
S-50-101	10E01	0.75"	1	2/CS-#16		1	#14	XHHW-2	FR: LE-050-512-11 TO: LIT-050-512-11 1 2/CS-#16 >> LE-050-512-11 SIGNAL	
S-50-102	10E01	0.75"	1	2/CS-#16		1	#14	XHHW-2	FR: LE-050-532-11 TO: LIT-050-532-11 1 2/CS-#16 >> LE-050-532-11 SIGNAL	
S-50-103	10E01	0.75"	1	2/CS-#16		1	#14	XHHW-2	FR: LE-050-542-01 TO: LIT-050-542-01 1 2/CS-#16 >> LE-050-542-01 SIGNAL	
S-50-104	10E01	0.75"	1	2/CS-#16		1	#14	XHHW-2	FR: LIT-050-542-01 TO: CONDUIT TEE 1 2/CS-#16 >> LIT-050-542-01 SIGNAL	S-50-108A
S-50-106	10E01	0.75"	1	2/CS-#16		1	#14	XHHW-2	FR: LIT-050-512-11 TO: JUNCTION BOX 1 2/CS-#16 >> LIT-050-512-11 SIGNAL	S-50-108
S-50-107	10E01	0.75"	1	2/CS-#16		1	#14	XHHW-2	FR: LIT-050-532-11 TO: JUNCTION BOX 1 2/CS-#16 >> LIT-050-532-11 SIGNAL	S-50-108
S-50-108	10E01	0.75"	2	2/CS-#16		1	#14	XHHW-2	FR: JUNCTION BOX TO: CONDUIT TEE 1 2/CS-#16 >> LIT-050-512-11 SIGNAL 1 2/CS-#16 >> LIT-050-532-11 SIGNAL	S-50-108A S-50-106 S-50-107
S-50-108A	10E01	1"	3	2/CS-#16		1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 1 2/CS-#16 >> LIT-050-542-01 SIGNAL 1 2/CS-#16 >> LIT-050-512-11 SIGNAL 1 2/CS-#16 >> LIT-050-532-11 SIGNAL	S-50-109 S-50-104 S-50-108 S-50-108
S-50-108B	10E01	1.5"	6	2/CS-#16		1	#14	XHHW-2	FR: LCP-050-533-02 TO: CONDUIT TEE 6 2/CS-#16 >> LCP-050-533-02 SIGNAL	S-50-109
S-50-109	10E01	1.5"	9	2/CS-#16		1	#14	XHHW-2	FR: CONDUIT TEE TO: PCM-050-500-01 1 2/CS-#16 >> LIT-050-542-01 SIGNAL 1 2/CS-#16 >> LIT-050-512-11 SIGNAL 1 2/CS-#16 >> LIT-050-532-11 SIGNAL 6 2/CS-#16 >> LCP-050-533-02 SIGNAL	S-50-108A S-50-108A S-50-108A S-50-108B
S-50-111	10E01	1.5"	6	2/CS-#16		1	#14	XHHW-2	FR: LCP-050-543-01 TO: CONDUIT TEE 6 2/CS-#16 >> LCP-050-543-01 SIGNAL	S-50-114
S-50-112	10E01	1.5"	6	2/CS-#16		1	#14	XHHW-2	FR: LCP-050-513-01 TO: CONDUIT TEE 6 2/CS-#16 >> LCP-050-513-01 SIGNAL	S-50-114
S-50-114	10E01	2"	12	2/CS-#16		1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 6 2/CS-#16 >> LCP-050-543-01 SIGNAL 6 2/CS-#16 >> LCP-050-513-01 SIGNAL	S-50-116 S-50-111 S-50-112
S-50-115	10E01	1.5"	6	2/CS-#16		1	#14	XHHW-2	FR: LCP-050-533-01 TO: CONDUIT TEE 6 2/CS-#16 >> LCP-050-533-01 SIGNAL	S-50-116
S-50-116	10E01	2.5"	18	2/CS-#16		1	#14	XHHW-2	FR: CONDUIT TEE TO: PCM-050-500-01 6 2/CS-#16 >> LCP-050-543-01 SIGNAL 6 2/CS-#16 >> LCP-050-513-01 SIGNAL 6 2/CS-#16 >> LCP-050-533-01 SIGNAL	S-50-114 S-50-114 S-50-115
S-50-117	10E01	1.5"	6	2/CS-#16		1	#14	XHHW-2	FR: LCP-050-522-11 TO: JUNCTION BOX 6 2/CS-#16 >> LCP-050-522-11 SIGNAL	S-50-120

CONDUIT SCHEDULE AREA

CLEARWELL AND CHEMICAL SYSTEM UPGRADES

ENGINEER	BHT
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CONDUIT			CONDUCTORS			GROUND				
NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE	DESCRIPTION	CONNECTING SEGMENTS
S-50-118	10E01	1.5"	6	2/CS-#16		1	#14	XHHW-2	FR: LCP-050-522-21 TO: JUNCTION BOX 6 2/CS-#16 >> LCP-050-522-21 SIGNAL	S-50-120
S-50-119	10E01	1.5"	6	2/CS-#16		1	#14	XHHW-2	FR: LCP-050-522-31 TO: JUNCTION BOX 6 2/CS-#16 >> LCP-050-522-31 SIGNAL	S-50-120
S-50-120	10E01	2.5"	18	2/CS-#16		1	#14	XHHW-2	FR: JUNCTION BOX TO: CONDUIT TEE 6 2/CS-#16 >> LCP-050-522-11 SIGNAL 6 2/CS-#16 >> LCP-050-522-21 SIGNAL 6 2/CS-#16 >> LCP-050-522-31 SIGNAL	S-50-122 S-50-117 S-50-118 S-50-119
S-50-121	10E01	1.5"	6	2/CS-#16		1	#14	XHHW-2	FR: LCP-050-522-41 TO: JUNCTION BOX 6 2/CS-#16 >> LCP-050-522-41 SIGNAL	S-50-122
S-50-122	10E01	3"	24	2/CS-#16		1	#14	XHHW-2	FR: JUNCTION BOX TO: PCM-050-500-01 6 2/CS-#16 >> LCP-050-522-11 SIGNAL 6 2/CS-#16 >> LCP-050-522-21 SIGNAL 6 2/CS-#16 >> LCP-050-522-31 SIGNAL 6 2/CS-#16 >> LCP-050-522-41 SIGNAL	S-50-120 S-50-120 S-50-120 S-50-121
S-50-130	10E01	0.75"	2	2/CS-#16		1	#14	XHHW-2	FR: MFC-050-563-21 TO: CONDUIT TEE 2 2/CS-#16 >> MFC-050-563-21 SIGNAL	S-50-132
S-50-131	10E01	0.75"	2	2/CS-#16		1	#14	XHHW-2	FR: MFC-050-563-11 TO: CONDUIT TEE 2 2/CS-#16 >> MFC-050-563-11 SIGNAL	S-50-132
S-50-132	10E01	1"	4	2/CS-#16		1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 2 2/CS-#16 >> MFC-050-563-11 SIGNAL 2 2/CS-#16 >> MFC-050-563-21 SIGNAL	S-50-134 S-50-131 S-50-130
S-50-133	10E01	0.75"	1	2/CS-#16		1	#14	XHHW-2	FR: AIT-050-563-01 TO: CONDUIT TEE 1 2/CS-#16 >> AIT-050-563-01 SIGNAL	S-50-134
S-50-134	10E01	1.5"	5	2/CS-#16		1	#14	XHHW-2	FR: MFC-050-563-21 TO: CONDUIT TEE 2 2/CS-#16 >> MFC-050-563-11 SIGNAL 2 2/CS-#16 >> MFC-050-563-21 SIGNAL 1 2/CS-#16 >> AIT-050-563-01 SIGNAL	S-50-132 S-50-132 S-50-133
S-50-140	10E01	0.75"	1	MFR	CABLE	1	#14	XHHW-2	FR: LE-050-512-31 TO: LIT-050-512-31 1 MFR >> LE-050-512-31 SIGNAL	
S-50-141	10E01	0.75"	1	2/CS-#16		1	#14	XHHW-2	FR: LIT-050-512-31 TO: CONDUIT TEE 1 2/CS-#16 >> LIT-050-512-31 SIGNAL	S-50-152
S-50-150	10E01	0.75"	1	MFR	CABLE	1	#14	XHHW-2	FR: LE-050-542-31 TO: LIT-050-542-31 1 MFR >> LE-050-542-31 SIGNAL	
S-50-151	10E01	0.75"	1	2/CS-#16		1	#14	XHHW-2	FR: LIT-050-542-31 TO: CONDUIT TEE 1 2/CS-#16 >> LIT-050-542-31 SIGNAL	S-50-152
S-50-152	10E01	1"	2	2/CS-#16		1	#14	XHHW-2	FR: CONDUIT TEE TO: PCM-050-500-01 1 2/CS-#16 >> LIT-050-512-31 SIGNAL 1 2/CS-#16 >> LIT-050-542-31 SIGNAL	S-50-141 S-50-151
S-50-200	30E01	0.75"	1	2/CS-#16		1	#14	XHHW-2	FR: CARB-050-553-11 TO: CONDUIT TEE 1 2/CS-#16 >> CARB-050-553-11 SIGNAL	S-50-204
S-50-201	30E01	0.75"	1	2/CS-#16		1	#14	XHHW-2	FR: CARB-050-553-21 TO: CONDUIT TEE 1 2/CS-#16 >> CARB-050-553-21 SIGNAL	S-50-203
S-50-202	30E01	0.75"	1	2/CS-#16		1	#14	XHHW-2	FR: CARB-050-553-31 TO: CONDUIT TEE 1 2/CS-#16 >> CARB-050-553-31 SIGNAL	S-50-203

CONDUIT SCHEDULE AREA

CLEARWELL AND CHEMICAL SYSTEM UPGRADES

ENGINEER	**BHT**
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CONDUIT			CONDUCTORS			GROUND				
NUMBER	**DWG**	**SIZE**	**#**	**SIZE**	**TYPE**	**#**	**SIZE**	**TYPE**	**DESCRIPTION**	**CONNECTING SEGMENTS**
S-50-203	30E01	0.75"	2	2/CS-#16		1	#14	XHHW-2	FR: CONDUIT TEE	S-50-204
									TO: CONDUIT TEE	
									1 2/CS-#16 >> CARB-050-553-21 SIGNAL	S-50-201
									1 2/CS-#16 >> CARB-050-553-31 SIGNAL	S-50-202
S-50-204	30E01	1"	3	2/CS-#16		1	#14	XHHW-2	FR: CONDUIT TEE	
									TO: PCM-050-550-01	
									1 2/CS-#16 >> CARB-050-553-11 SIGNAL	S-50-200
									1 2/CS-#16 >> CARB-050-553-21 SIGNAL	S-50-203
									1 2/CS-#16 >> CARB-050-553-31 SIGNAL	S-50-203

END OF CONDUIT SCHEDULE

END OF SECTION

SECTION 17050

COMMON WORK RESULTS FOR PROCESS CONTROL AND INSTRUMENTATION SYSTEMS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. General requirements applicable to all Process Control and Instrumentation Work.
   2. General requirements for process control and instrumentation submittals.

B. Interfaces to equipment, instruments, and other components:
   1. Drawings, Specifications, and overall design are based on preliminary information furnished by various equipment manufacturers, which identify a minimum scope of supply from the manufacturers. This information pertains to, but is not limited to, instruments, control devices, electrical equipment, packaged mechanical systems, and control equipment provided with mechanical systems.
   2. Provide all material and labor needed to install the actual equipment furnished, include all costs to add any additional instruments, wiring, control system inputs/outputs, controls, interlocks, electrical hardware etc., which may be necessary to make a complete, functional installation based on the actual equipment furnished:
      a. Make all changes necessary to meet the manufacturer's wiring requirements.
   3. Submit all such changes and additions to the Owner and Engineer for acceptance as specified in the Contract Documents.
   4. Review the complete set of Drawings and Specifications in order to ensure that all items related to the instrumentation and control systems are completely accounted for. Include any items indicated on the Drawings or in Specifications from another discipline in the scope of Work:
      a. If a conflict between Drawings and Specifications is discovered, refer conflict to the Owner and Engineer as soon as possible for resolution.
   5. Loop drawings:
      a. Provide complete loop drawings for all systems, including packaged equipment furnished as part of a vendor furnished package, and for all pre-purchased equipment.
      b. The form, minimum level of detail, and format for the loop drawings must match that of sample loop drawing 00GN06.

c. For all signal and control wiring installed or modified under this Contract, all wire labels and terminal block numbers at each end of signal and control wiring shall be clearly indicated on the loop drawings submitted by the Contractor. The Contractor shall facilitate coordination between the ICSC, Electrical subcontractor, and equipment vendors as required to provide loop drawings that accurately reflect the final installed conditions of each loop. All loop drawing linework and text shall be created using the latest version of AutoCAD or a similar CAD program that can convert the drawing files to .dwg. All Loop drawings shall be submitted in 11x17 .PDF file format for review by Engineer and the final Engineer approved loop drawings shall be provided to Owner in .PDF and AutoCAD .dwg format. Handwritten or electronic loop drawing markups are not acceptable.

d. The Owner and Engineer are not responsible for providing detailed loop diagrams for Contractor furnished equipment.

6. Requirements of the Instrumentation and Control Specifications apply to all Instrumentation and Control Work specified in Technical Sections, including packaged mechanical systems, LCPs, VCPs, etc.
7. As specified in this Section, PLC programming and SCADA/HMI software configuration will be provided by the ICSC hereinafter referred to as the Programmer.

C. All instrumentation, and control equipment and systems for the entire project to comply with the requirements specified in the Instrumentation and Control Specifications, whether referenced in the individual Equipment Specifications or not:
1. The requirements of the Instrumentation and Control Specifications apply to all Instrumentation and Control Work specified in other Specifications, including HVAC controls, packaged mechanical systems, Local Control Panels (LCPs), Vendor Control Panels (VCPs), etc.
2. Inform all vendors supplying instrumentation, control systems, panels, and/or equipment of the requirements of the Instrumentation and Control Specifications.
3. Contractor shall be responsible for informing all subcontractor's and/or suppliers of all applicable requirements as specified in the Contract Documents, including but not limited to programming, configuration, interface, and other requirements described in this Section.
   a. Owner shall not be responsible for any additional costs due to the failure of Contractor to notify all subcontractors and/or suppliers of the General Condition requirements.

D. Contract Documents:
1. General:
   a. The drawings and specifications are complementary and are to be used together in order to fully describe the Work.
2. Specifications:
   a. The Contract Documents govern the Work.
   b. These requirements are in addition to all General Requirements specified in the Contract Documents.
3. Contract drawings:

a. The Instrumentation and Control Drawings show in a diagrammatic manner, the desired locations, and arrangements of the components of the Instrumentation Work. Follow the drawings as closely as possible, use professional judgment and coordinate with the other trades to secure the best possible installation, use the entire drawing set for construction purposes.
b. Locations of equipment, control devices, instruments, boxes, panels, etc. are approximate only, exercise professional judgment in executing the Work to ensure the best possible installation:
    1) The equipment locations and dimensions indicated on the Drawings and elevations are approximate. Use the shop drawings to determine the proper layout, foundation, and pad requirements, etc. for final installation. Coordinate with all subcontractors to ensure that all instrumentation and control equipment is compatible with other equipment and space requirements. Make changes required to accommodate differences in equipment dimensions.
c. Installation details:
    1) The Contract Drawings include installation details showing means and methods for installing instrumentation and control equipment. For cases where typical details are not provided or compatible with an installed location, develop installation details that are necessary for completing the Work, and submit these details for review by the Engineer.
    2) All Local Operator Interfaces (LOIs) shall be mounted facing North (preferred) or East.
d. Schematic diagrams:
    1) All controls are shown de-energized.
    2) Schematic diagrams show control function only. Incorporate other necessary functions for proper operation and protection of the system.
    3) Add relays, where required, to provide all necessary contacts for the control system or where needed to function as interposing relays for control voltage coordination, equipment coordination, or control system voltage drop considerations.
    4) Mount all devices shown on motor controller schematic diagrams in the controller compartment enclosure, unless otherwise noted or indicated.
    5) Control schematics are to be used as a guide in conjunction with the descriptive operating sequences indicated on the Drawings or in the Specifications. Combine all information and furnish a coordinated and fully functional control system.

E. Alternates/Alternatives:
    1. Substitute item provisions as specified in the Contract Documents.

F. Changes and change orders:
    1. As specified in the Contract Documents.

1.02 REFERENCES

A. Code compliance:

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

B. Compliance with Laws and Regulations:
    1. As specified in the Contract Documents.

1.03 DEFINITIONS

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

B. Specific definitions:
    1. Control circuit: Any circuit operating at 120 volts alternating current (VAC) or direct current (VDC) or less, whose principal purpose is the conveyance of information (including performing logic) and not the conveyance of energy for the operation of an electrically powered device.

2. Panel: An instrument support system that may be a flat surface, a partial enclosure, or a complete enclosure for instruments and other devices used in process control systems.
3. Power circuit: Any circuit operating at 90 volts (AC or DC) or more, whose principal purpose is the conveyance of energy for the operation of an electrically powered device.
4. Signal circuit: Any circuit operating at less than 50 VAC or VDC, which conveys analog information or digital communications information.
5. Digital bus: A communication network, such as PROFIBUS, Foundation Fieldbus, or DeviceNet, allowing instruments and devices to transmit data, control functions, and diagnostic information.
6. 2-Wire transmitter (loop powered): A transmitter that derives its operating power supply from the signal transmission circuit and requires no separate power supply connections. As used in this Section, 2-wire transmitter refers to a transmitter that provides a signal such as 4 to 20 mA 24VDC regulation of a signal in a series circuit with an external 24 VDC driving potential:
   a. Fieldbus communications signal or both.
7. Powered transmitters: A transmitter that requires a separate power source (120 VAC, 240 VAC, etc.) in order for the transmitter to develop its signal. As used in this Section, the produced signal may be a 4 to 20 mA 24VDC signal, a digital bus communications signal, or both.
8. Modifications: Changing, extending, interfacing to, removing, or altering an existing circuit.
9. System supplier - As specified in ICSC Qualifications in the Quality Assurance article of this Section.
10. Programmer: Responsible for PLC programming, SCADA/HMI software configuration and SCADA network device configuration.

C. NEMA:
1. Type 1 enclosure in accordance with NEMA 250.
2. Type 2 enclosure in accordance with NEMA 250.
3. Type 3 enclosure in accordance with NEMA 250.
4. Type 3R enclosure in accordance with NEMA 250.
5. Type 3S enclosure in accordance with NEMA 250.
6. Type 3X enclosure in accordance with NEMA 250.
7. Type 3RX enclosure in accordance with NEMA 250.
8. Type 3SX enclosure in accordance with NEMA 250.
9. Type 4 enclosure in accordance with NEMA 250.
10. Type 4X enclosure in accordance with NEMA 250.
11. Type 5 enclosure in accordance with NEMA 250.
12. Type 6 enclosure in accordance with NEMA 250.
13. Type 6P enclosure in accordance with NEMA 250.
14. Type 12 enclosure in accordance with NEMA 250.
15. Type 12K enclosure in accordance with NEMA 250.
16. Type 13 enclosure in accordance with NEMA 250.

D. Acronym definitions:
1. ACB: Automatic current balance.
2. ATS: Automatic Transfer Switch.

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

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

1.04 SUBMITTALS

A. Furnish submittals as specified below and in the Contract Documents.

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

C. Submittal organization:

1. First page:
    a. Specification section reference.
    b. Name and telephone number of individual who reviewed submittal before delivery to Engineer.
    c. Name and telephone number of individual who is primarily responsible for the development of the submittal.
    d. Comments.
    e. Contractor's review certification statement and signature.
2. Next pages:
    a. Provide confirmation of specification compliance:
        1) Specification section: Include with each submittal a copy of the relevant specification section.
            a) Indicate in the left margin, next to each pertinent paragraph, either compliance with a check (√) or deviation with a consecutive number (1, 2, 3).
            b) Provide a list of all numbered deviations with a clear explanation and reason for the deviation.
    b. Include a response in writing to each of the Engineer's comments or questions for submittal packages which are re-submitted:
        1) In the order that the comments or questions were presented throughout the submittal.
        2) Referenced by index section and page number on which the comment appeared.
        3) Acceptable responses to Engineer's comments are either:
            a) Engineer's comment or change is accepted and appropriate changes are made.
            b) Explain why comment is not accepted or requested change is not made.
            c) Explain how requirement will be satisfied in lieu of comment or change requested by Engineer.
        4) Any re-submittal, which does not contain responses to the Engineer's previous comments shall be returned for Revision and Re-submittal.
        5) No further review by the Engineer will be performed until a response for previous comments has been received.
3. Remaining pages:
    a. Actual submittal data:
        1) Organize submittals in exactly the same order as the items are referenced, listed, and/or organized in the specification section.
        2) 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 intended to be used.

D. Submittal requirements:
1. Furnish submittals that are fully indexed with a tabbed divider for every component.
2. Sequentially number pages within the tabbed sections. Submittals and operation and maintenance manuals that are not fully indexed and tabbed with sequentially numbered pages, or are otherwise unacceptable, will be returned without review.
3. Furnish submittals in the following general order, each in a separate bound set:

a. Schedule of Values.
b. Product Data.
c. After Engineer acceptance of the Product Data, submit the Project Shop Drawing submittals.
d. Loop Description Submittal.
e. The Process Control Hardware and Software Submittal including, control system software, programming, and screens.
f. Testing, Calibration and Process Start-Up procedures.
g. Operation and Maintenance Data.
h. Training Submittals.
i. Record Documents.

4. Edit all submittals and operation and maintenance manuals so that the submittal specifically applies to only the equipment furnished.
   a. Neatly cross out all extraneous text, options, models, etc. that do not apply to the equipment being furnished, so that the information remaining is only applicable to the equipment being furnished.
5. Submit copies of shop drawings, and product data:
   a. Show dimensions, construction details, wiring diagrams, controls, manufacturers, catalog numbers, and all other pertinent details.
6. Where submittals are required, provide a separate submittal for each specification section. In order to expedite construction, the Contractor may make more than 1 submittal per specification section, but a single submittal may not cover more than 1 specification section:
   a. The only exception to this requirement is when 1 specification section covers the requirements for a component of equipment specified in another section. (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.).
7. Exceptions to Specifications and Drawings:
   a. Include a list of proposed exceptions to the Specifications and Drawings along with a detailed explanation of each.
   b. If there is insufficient explanation for the exception or deviation, the submittal will be returned requiring revision and re-submittal.
   c. Acceptance of any exception is at the sole discretion of the Engineer.
      1) Provide all items (materials, features, functions, performance, etc.) required by the Contract Documents that are not accepted as exceptions.
   d. Replace all items that do not meet the requirements of the Contract Documents, which were not previously accepted as exceptions, even if the submittals contained information indicating the failure to meet the requirements.

E. Submittal preparation:

1. During the period of preparation of submittals, the Contractor shall authorize direct, informal liaison between the ICSC and the Engineer for exchange of technical information. As a result of this liaison, certain minor refinements and revisions may be authorized informally by the Engineer, which do not alter the scope of Work or cause increase or decrease in the Contract price or times. During this informal exchange, no oral statement by the Engineer shall be construed to give formal approval of any component or method, nor shall any statement be construed to grant exception to, or variation from, these Contract Documents.
2. In these Contract Documents, some items of Work are represented schematically, and are designated for the most part by numbers, as derived from criteria in ISA-5.1:
    a. Employ the nomenclature and numbers designated in this Section and indicated on the Drawings exclusively throughout shop drawings, data sheets, and similar submittals.
    b. Replace any other symbols, designations, and nomenclature unique to a manufacturer's, suppliers, or subcontractor's standard methods with those identified in this Section and indicated on the Drawings.

F. Specific submittal requirements:
    1. Shop drawings:
        a. Required for materials and equipment listed in this and other sections.
        b. Furnish sufficient information to evaluate the suitability of the proposed material or equipment for the intended use, and for compliance with these Specifications.
        c. Shop drawings requirements:
            1) Front, side, and, rear elevations, and top and bottom views, showing all dimensions.
            2) Locations of conduit entrances and access plates.
            3) Component layout and identification.
            4) Schematic and wiring diagrams with wire numbers and terminal identification.
            5) Connection diagrams, terminal diagrams, internal wiring diagrams, conductor size, etc.
            6) Anchoring method and leveling criteria, including manufacturer's recommendations for the Project site seismic criteria.
            7) Weight.
            8) Finish.
            9) Nameplates:
                a) As specified in Section 16075 - Identification for Electrical Systems or as indicated on the Drawings.
            10) Temperature limitations, as applicable.
        d. Use equipment and instrument tags as depicted on the P&IDs for all submittals.
        e. Adhere to wiring numbering scheme outlined in Section 16075 - Identification for Electrical Systems throughout the Project:
            1) Uniquely number each wire per the Specifications.
        f. Wire numbers must appear on all equipment drawings.
        g. Organize the shop drawing submittals for inclusion in the Operation and Maintenance Manuals:

1) Furnish the initial shop drawing submittal bound in one or more standard size, 3-ring, D-ring, loose-leaf, vinyl plastic, hard-cover binders suitable for bookshelf storage.
2) Binder ring size: 2 inches.

h. Include the letterhead and/or title block of the firm responsible for the preparation of all shop drawings. Include the following information in the title block, as a minimum:
1) The firm's registered business name.
2) Firm's physical address, email address, and phone number.
3) Owner’s name.
4) Project name and location.
5) Drawing name.
6) Revision level.
7) Personnel responsible for the content of the drawing.
8) Date.

i. The work includes modifications to existing circuits:
1) Clearly show all modifications to existing circuits.
2) In addition, show all existing unmodified wiring to clearly depict the functionality and electrical characteristics of the complete modified circuits.

2. Product data:
a. Submitted for non-custom manufactured material listed in this and other sections and shown on shop drawings.
b. Include:
1) Catalog cuts.
2) Bulletins.
3) Brochures.
4) Quality photocopies of applicable pages from these documents.
5) Identify on the data sheets the Project name, applicable specification section, and paragraph.
6) Identify model number and options for the actual equipment being furnished.
7) Neatly cross out options that do not apply or equipment not intended to be supplied.

c. Use equipment and instrument tags as depicted on the P&IDs for all submittals.
d. Adhere to wiring numbering scheme outlined in Section 16075 - Identification for Electrical Systems throughout the Project:
1) Uniquely number each wire per the Specifications.

e. Wire numbers must appear on all equipment drawings.

3. Detailed sequence of operation for all equipment or systems.
4. Operation and maintenance manuals:
a. Submit preliminary sets of these manuals to the Engineer for review of format and content:
1) Engineer will return 1 set with comments.
2) Revise and/or amend as required and submit the requisite number of copies to the Engineer 15 days before Functional Testing of the systems.

b. Incorporate changes that occur during process start-up and submit as part of the final manuals.

c. Provide comprehensive information on all systems and components to enable operation, service, maintenance, and repair.
d. Include Record Documents and the accepted shop drawing submittals, modified for conditions encountered in the field during the work.
e. Include signed results from Functional Testing and Process Operational Period.
f. Provide installation, connection, operating, calibration, setpoints (e.g., pressure, pump control, time delays, etc.), adjustment, test, troubleshooting, maintenance, and overhaul instructions in complete detail.
g. Provide exploded or other detailed views of all instruments, assemblies, and accessory components together with complete parts lists and ordering instructions.
h. Spare parts list:
    1) Include a priced list of recommended spare parts for all the equipment furnished under this Contract:
        a) Include recommended quantities sufficient to maintain the furnished system for a period of 5 years.
    2) Annotate the list to indicate which items, if any and quantity are furnished as part of this Contract.
i. Provide the name, address, and phone number of manufacturer and manufacturer's local service representative of these parts.
j. Additional operation and maintenance manual requirements:
    1) Completely index manuals with a tab for each section:
        a) Each section containing applicable data for each piece of equipment, system, or topic covered.
        b) Assemble manuals using the accepted shop drawings, and include, the following types of data:
            (1) Complete set of 11-inch by 17-inch drawings of equipment.
            (2) Complete set of 11-inch by 17-inch drawings of the control system.
            (3) Complete set of control schematics.
            (4) Complete parts list for all equipment being provided.
            (5) Catalog data for all products or equipment furnished.
k. Operational Manual:
    1) Prepare and provide a simplified version of the standard manufacturer’s HMI software and system operations manual that includes basic instructions in the application of the system as required for operators in day-to-day operations.
l. Control System Software Record Documents:
    1) Include complete documentation of all the software programs provided for the entire control and PCS system, including:
        a) Listings of all application software on both hard copy and USB flash drive.
        b) Database, both hard copy and USB flash drive.
        c) Communication protocols.
        d) All documentation necessary to maintain, troubleshoot, modify, or update the software system.
m. Organize the operation and maintenance manuals for each process in the following manner:
    1) Section A - Process and Instrumentation Diagrams.

2) Section B - Control Descriptions.
3) Section C - Loop Drawings.
4) Section D - Instrument Summary.
5) Section E - Instrument Data Sheets and Brochures.
6) Section F - Sizing Calculations.
7) Section G - Instrumentation Installation Details.
8) Section H - Test Results.
9) Section I - Operational Manual.
10) Section J - Spare Parts List.
11) Section K - Control System Software.

5. Material and equipment schedules:
   a. Furnish a complete schedule and/or matrix of all materials, equipment, apparatus, and luminaries that are proposed for use:
      1) Include sizes, names of manufacturers, catalog numbers, and such other information required to identify the items.
6. Itemized instrument summary:
   a. Submit a hard copy of the instrument summary.
   b. List all of the key attributes of each instrument including:
      1) Tag number.
      2) Manufacturer.
      3) Model number.
      4) Service.
      5) Area location.
      6) Calibrated range.
      7) Loop drawing number.
   c. Associated LCP, VCP, PCM, or PLC.
7. Instrument data sheets and cut sheets:
   a. Furnish fully completed data sheets, both electronically in Microsoft Word or Excel and in hard copy, for each instrument and component according to ISA-20 Specification Forms for Process Measurement and Control Instruments, Primary Elements and Control Valves. The data sheets provided with the instrument specifications are preliminary and are not complete. They are provided to assist with the completion of final instrument data sheets. Additional data sheets may be required. Include the following information on the data sheet:
      1) Component functional description specified in this Section and indicated on the Drawings.
      2) Manufacturers model number or other product designation.
      3) Tag number specified in this Section and indicated on the Drawings.
      4) System or loop of which the component is a part.
      5) Location or assembly at which the component is to be installed.
      6) Input and output characteristics, including digital bus communication.
      7) Scale range with units and multiplier.
      8) Requirements for electric supply.
      9) Requirements for air supply.
      10) Power consumption.
      11) Response timing.
      12) Materials of construction and of component parts that are in contact with, or otherwise exposed to, process media, and or corrosive ambient air.

13) Special requirements or features, such as specifications for ambient operating conditions.
14) Features and options that are furnished.

b. Provide a technical brochure or bulletin (“cut sheet”) for each instrument on the project. Submit with the corresponding data sheets:
1) Where the same make and model of instrument is used in 2 or more applications on the project, and the process applications are nearly identical, and the materials, features and options are identical submit one brochure or bulletin for the set of identical instruments.
2) Include a list of tag numbers for which it applies with each brochure or bulletin.
3) Furnish technical product brochures that are complete enough to verify conformance with all Contract Document requirements, and to reflect only those features supplied with the device.
4) Cross out models, features, options, or accessories that are not being provided.
5) Clearly mark and identify special options and features.

c. Organization: Index the data sheets and brochures in the submittal by systems or loops.

8. Control panel hardware submittal:
a. Submit the following in 1 submittal package.
b. Complete and detailed bills of materials:
1) Including quantity, description, manufacturer, and part number for each assembly or component for each control panel.
2) Include all items within an enclosure.

c. Complete grounding requirements for each system component including any requirements for PLCs, process LANs, and Control System equipment.
d. Requirements for physical separation between control system components and 120 VAC, 480 VAC, and medium voltage power cables.
e. UPS and battery load calculations to show that the backup capacity and time meet the specified requirements.
f. Provide a data sheet for each control system component together with a technical product brochure or bulletin, which include:
1) The manufacturer's model number or other identifying product designation.
2) Tag and loop number.
3) System to which it belongs.
4) Site to which it applies.
5) Input and output characteristics.
6) Requirements for electric power.
7) Device ambient operating requirements.
8) Materials of construction.

9. Installation recommendations:
a. Submit the manufacturer’s printed recommendations for installation of instrumentation equipment.

10. Training submittals:

a. Develop and submit for review a general training plan for approval by Owner within 14 calendar days from Notice to Proceed. Include complete descriptions of all planned training classes, a preliminary training schedule, a list of all proposed instructors along with resumes, examples of proposed training manuals, and a description of any special training tools to be used (simulators, self-paced modules, personal computer-based training, etc.).
b. The Engineer or Owner will review the general training plan. Special emphasis will be placed on review of the qualifications of the proposed instructors and the timing of the individual courses to maximize their effectiveness. If, in the opinion of the Engineer or Owner, the proposed instructors are not sufficiently qualified to conduct the specified training courses, or lack experience, where required, on the specific configuration of the system, provide more qualified instructors.
c. The general training plan and schedule shall be updated by the Contractor at the beginning of each Phase and approved by the Owner a minimum of 30 days prior to commencement of training.
d. Training course plan submittals:
    1) For each training course or other training activity, submit a detailed, complete outline and agenda for each lesson as specified the Contract Documents.
    2) Describe any student pre-requisites for the course or training activity.
    3) Provide an updated schedule for all sessions of the course, including dates, times, durations, and locations.
    4) Submit training materials.
e. Incorporate all submittal review comments into the course.
f. Do not conduct training courses before review and acceptance of the Course Plan submittal for the course.
g. Record all training in digital format compatible for uploading into the Owner's management software system.

11. Project Record documents:
    a. Furnish as specified in the Contract Documents.
    b. Record Drawing requirements:
        1) Provide Project Record Drawing of all Instrumentation Drawings.
        2) Update Record Drawings weekly.
        3) Record Drawings must be fully updated as a condition of the monthly progress payments.
        4) Clearly and neatly show all changes including the following:
            a) All existing pipe, conduit, wire, instruments or other structures encountered or uncovered during construction.
    c. Shop drawings:
        1) General:
            a) Coordinate all aspects of the Work so that a complete, instrumentation, computer, and control system for the facility is supported by accurate shop and record drawings:
                (1) Clearly show every wire, circuit, and terminal provided under this contract on one or more submitted wiring diagrams.

b) Show all interfaces between any of the following: instruments, vendor control panels, motor control centers, motor starters, variable speed drives, control valves, flow meters, chemical feeders, digital bus network equipment, and other equipment related to the PCS.
c) Generate all drawings developed for this project utilizing commercial CAD software:
    (1) Furnish on USB flash drives containing the following for each drawing:
        (a) Original CAD files in native and DWG format as applicable.
        (b) PDF version.
    (2) Provide hard copies on 11-inch by 17-inch plain bond paper.
d) Upon completion of the Work, update all shop drawings to indicate the final as-built configuration of the systems:
    (1) Should an error be found in a shop drawing during installation or process start-up of equipment, note the correction, including any field changes found necessary, on the drawing and submit the corrections in the Record Documents.
    (2) Update, check, and revise all wiring drawings and other submitted drawings and documents to show final installed conditions.
    (3) Provide as-built shop drawings for all instrumentation equipment on 11-inch by 17-inch using plain bond paper.
    (4) Provide electronic copies of these documents on USB flash drive in native and DWG format and PDF format. Size all drawings to be readable and legible on 11-inch by 17-inch media.
e) Submittal Documents:
    (1) Provide an interim submittal of Record Documents after the PCS system Functional Testing.
    (2) Submit final Record Documents before Substantial Completion or earlier if so specified in the Contract Documents.
f) Review and Corrections:
    (1) Correct any Record Documents or other documents found to be incomplete, not accurate, of poor quality, or containing errors.
    (2) Promptly correct and re-submit Record Documents returned for correction.

2) Furnish written information prepared specifically for this Project using Microsoft Word and.PDF formats and printed on 8.5-inch by 11-inch plain bond paper:
    a) Provide electronic copies of these documents on USB flash drives.

d. Review and corrections:
    1) Correct any record documents or other documents found to be incomplete, not accurate, of poor quality, or containing errors.
    2) Promptly correct and re-submit record documents returned for correction.

12. Loop Drawings:
    a. Submit loop drawings for every analog, discrete, and fieldbus signal and control circuit:
        1) Provide a loop drawing submittal that completely defines and documents the contents of each monitoring, alarming, interlock, and control loop on this Project.
        2) This requirement applies to all signal and control circuits associated with equipment on this Project including vendor supplied equipment packages and control panels.
        3) Provide loop drawings in the format indicated in the contract drawings. Provide all tagging in accordance with the Owner's standard.
    b. Show every instrument and I/O point on at least one loop diagram.
    c. Provide a complete index in the front of each bound volume:
        1) Index the loop drawings by systems or process areas.
    d. Provide drawings showing definitive diagrams for every instrumentation loop system:
        1) Show and identify each component of each loop or system using requirements and symbols from ISA-5.4.
        2) Furnish a separate drawing sheet for each system or loop diagram.
    e. In addition to the ISA-5.4 requirements, show the following details:
        1) Functional name of each loop.
        2) Reference name, drawing, and loop diagram numbers for any signal continuing off the loop diagram sheet.
        3) Show all terminal numbers, regardless of the entity providing the equipment.
        4) MCC panel, circuit, and breaker numbers for all power feeds to the loops and instrumentation.
        5) Designation of and, if appropriate, terminal assignments associated with, every manhole, pull-box, junction box, conduit, and panel through which the loop circuits pass.
        6) Show vendor control panel, instrument panel, conduit, junction box, equipment and PCS terminations, termination identification, wire numbers and colors, power circuits, and ground identifications.
        7) If a circuit is continued on another drawing, show the name and number of the continuation drawing on the loop drawing. Provide complete references to all continuation drawings whether vendor control panels, other loop drawings, existing drawings provided by the Owner, or other drawings.
    f. In addition to the above requirements, provide loop diagrams in accordance with the example loop diagram as indicated on the Drawings.

13. Instrument Installation Drawings:
    a. Submit, instrument installation, mounting, and anchoring details for all components and assemblies, including access requirements and conduit connection or entry details.

b. Furnish for each instrument a dedicated 8 1/2-inch by 11-inch installation detail that pertains to the specific instrument by tag number.
c. For each detail, provide certification and the hard copies, by the instrument manufacturer, that the proposed installation is in accordance with the instrument manufacturer's recommendations and is fully warrantable.
d. For each detail, provide, as a minimum, the following contents:
    1) Necessary sections and elevation views required to define instrument location by referencing tank, building or equipment names and numbers, and geographical qualities such as north, south, east, west, basement, first floor, etc.
    2) Ambient temperature and humidity where the instrument is to be installed.
    3) Corrosive qualities of the environment where the instrument is to be installed.
    4) Hazardous rating of the environment where the instrument is to be installed.
    5) Process line pipe or tank size, service and material.
    6) Process tap elevation and location.
    7) Upstream and downstream straight pipe lengths between instrument installation and pipe fittings and valves.
    8) Routing of tubing and identification of supports.
    9) Mounting brackets, stands, anchoring devices, and sun shades.
    10) Conduit entry size, number, location, and delineation between power and signal.
    11) NEMA ratings of enclosures and all components.
    12) Clearances required for instrument servicing.
    13) List itemizing all manufacturer makes, model numbers, quantities, lengths required, and materials of each item required to support the implementation of the detail.

14. Control Panel Drawings:
    a. Layout Drawings:
        1) Submit panel, enclosure, console, furniture, and cabinet layout drawings for all items provided.
        2) As a minimum, include the following information:
            a) To scale front, side, and plan views.
            b) Dimensions.
            c) Interior and exterior arrangements.
            d) Mounting information, including conduit entrance location.
            e) Finish data.
            f) Tag number and functional name of items mounted in and on each panel, console, and cabinet.
            g) Nameplate legend including text, letter size, materials, and colors.
    b. Wiring and piping diagrams:
        1) Submit panel wiring and piping diagrams for every panel that contains wiring and/or piping.
        2) Include the following information:
            a) Name of panel.
            b) Wiring and piping sizes and types.
            c) Terminal strip numbers.

d) Wire tags and labels.
e) Functional name and manufacturer's designation for items to which wiring and piping are connected.
f) Electrical control schematics in accordance with ANSI standards.

c. Installation drawings:
1) Provide site-specific installation drawings for all control equipment panels, including dimensions.
2) Provide scaled drawings and show the position of the equipment at its intended installation location.
3) Show the placement of all equipment being provided under this Contract and its spatial relationship to all other equipment located in the abutting and adjoining areas.
4) Show all required access and clearances associated with the equipment with a statement of compliance to manufacturer's recommendations, NEC, and other applicable codes.

15. Schematic Diagrams:
a. Submit schematic diagrams for all electrical equipment in ladder diagram format.
b. Include device and field connection terminal numbers on all schematic diagrams.
c. Incorporate equipment manufacturer’s shop drawing information into the schematic diagrams in order to document the entire control system.

16. Control System Diagram:
a. Submit a complete set of control system diagrams including the following information:
1) All PLCs, workstations, printers, communication devices, and communication links:
a) Show all PLCs with their current I/O allocation, and future I/O allocation, current plus spares provided, and maximum potential I/O based on available slots.
2) All cables required for communication requirements.
3) Show each component fully annotated with conduit size and number associated with the power source.

17. Process Control Software Submittal:
a. In accordance with Product Data and Shop Drawing general requirements.
b. Submit a complete description of the standard application software programs, operating system and utility programs, including modifications and explanation of how the specific functional requirements are met:
1) Provide a cross-reference between the Specification requirements and the software submittal, in order to provide the Engineer the ability to identify how each specified requirement or function is met.
c. A complete listing of the PCS system point I/O database:
1) Include for each data point, relevant parameters such as range, contact orientation, limits, incremental limits, I/O card byte, I/O hardware address, and PLC assignment.
2) Organize on a site-by-site basis, separate by point type.
3) In addition to the active I/O points, list the implemented spare I/O points and the available I/O points remaining on each card, as well as other defined future points specified or shown.

4) Upon completion of the Work, update all I/O lists to indicate the final as-built configuration of the systems:
a) Organize as-built I/O list on a site-by-site basis, separated by equipment and point type.

d. Detailed descriptions of procedures used to implement and modify control strategies and database construction.
e. Preliminary overview, screens, station graphic displays, and preliminary reports.
f. Refer to Section 17762 - Control Systems: PCS Software for additional requirements.

18. Instrumentation and Control System Contractor Statement of Qualifications:
a. Submit statement of qualifications of the proposed ICSC in accordance with subsequent requirements of this Section.
19. Control Descriptions:
a. For each control loop, provide a detailed functional description of the operation of the equipment, signals, and controls as shown on the P&IDs:
1) Include all functions depicted or described in the Contract Documents.
2) Include within the Control Description content:
a) All specific requirements.
b) All common requirements that pertain in general to all loops.
c) Listing all ranges, setpoints, timers, values, counter values, etc.
20. Test Procedure Submittals:
a. Submit the proposed procedures to be followed during tests of the PCS and its components in 2 parts:
1) Preliminary Submittal: Outline of the specific proposed tests and examples of proposed forms and checklists.
2) Detailed Submittal: After successful review of the Preliminary Submittal, submit the proposed detailed test procedures, forms, and checklists. Include a statement of test objectives with the test procedures.
21. Test reports:
a. Include the following:
1) A description of the test.
2) List of equipment used.
3) Name of the person conducting the test.
4) Date and time the test was conducted.
5) All raw data collected.
6) Calculated results.
7) Each report signed by the person responsible for the test.
22. Calculations:
a. Where required by specific Instrumentation Specifications:
1) Because these calculations are being provided by a registered professional engineer, they will be reviewed for form, format, and content but will not be reviewed for accuracy and calculation means.

1.05 QUALITY ASSURANCE

A. Manufacture instruments at facilities certified to the quality standards of ISO 9001.

B. ICSC qualifications:
   1. General information on the proposing company:
      a. Document that the ICSC Company has been actively involved in the instrumentation, PLC-based control systems business for a minimum of five years and has adequate facilities, organization structure, manpower, and technical and managerial expertise to properly perform the Work as specified in these Specifications.
      b. For construction estimates in excess of $2 Million of work, submit a financial prospectus indicative of the corporation's financial state. This prospectus shall also include:
         1) A letter from a financial institution indicating a current line of credit and bonding limit which can be applied to this Project.
         2) Latest annual report or reviewed financial statement.
         3) ICSC shall submit documentation showing that they are able to bond all work.
      c. ICSC performing the programming shall have the following qualifications:
         1) Well-versed in Trihedral VTScada HMI software and ISA 101 HMI standards.
         2) Silver-certified Rockwell Automation Partner.
         3) CSIA certified.
   2. Document that the ICSC has a qualified permanent service facility:
      a. Said facility shall be staffed with permanent employees and equipped with the tools and test equipment necessary to calibrate, test, and process start-up all of the instrumentation, control, telemetry, SCADA and control systems hardware and software furnished under this Contract, including remote diagnostic capability.
      b. Document in-house resource of permanent personnel experienced in the design and programming of equipment and systems as specified in these Specifications.
         1) Submit a list of individuals assigned to the project.
      c. Document the existence of a training program staffed by qualified instructors, to provide proper training in the operation and maintenance of equipment as specified in these Specifications.
      d. Document that the firm is a recognized or certified “system integrator partner” or similar designation for the control software and PLC system being supplied for this Project, e.g. Wonderware Certified Developer / System Integrator Partner.
   3. Similar project experience of the company:

a. Provide a list of at least 3 successfully completed projects for a water and/or wastewater system of similar scope and complexity in which the proposing firm used components the same as those intended for use on this Project. The proposing firm must have performed, for each listed project, system engineering, system fabrication and installation, documentation (including schematic, wiring and panel assembly drawings), software configuration and documentation, field testing, calibration and process start-up, operator instruction, and maintenance training. In addition, provide the following information for each project:
    1) Name of plant or system owner, contact name, and current telephone number. Design engineer's name, address, and telephone number. Failure to provide current contact information may result in the listed project being disqualified for use in meeting the minimum requirements for qualification.
    2) Manufacturer and model number(s) of the PLC based control system and the computer-based SCADA system used for both hardware and software.
    3) Brief description of the system.
    4) Approximate number of input and output signals: analog, digital, and fieldbus.
    5) Brief application software description.
    6) Contracted cost of the system, separate by base amount and any change orders for the completed projects.
    7) Duration of the project and date of completion.

4. Information on the proposed Project team members:
    a. Provide the name and resume of the individual persons who will be responsible for each of the following:
        1) Office engineering and management of this Project.
        2) Lead for software configuration/programming.
        3) Individual who will be responsible for the hardware and hardware interface design.
        4) Individual who will be responsible for field testing, calibration, and process start-up.
        5) Individual who will be responsible for operator training.
    b. All of these individuals must be permanent employees of the proposing firm.
5. Information on the PCS system to be supplied:
    a. A proposed system block diagram detailing the system configuration.
    b. Description and specifications of the major equipment components to be furnished for the PCS system. Include the following as a minimum:
        1) PCs.
        2) PLCs.
        3) CPUs.
        4) RTUs.
        5) Printers.
        6) CRTs.
        7) Servers.
        8) Network equipment.
        9) Modems.
        10) Radios.

11) Any other electrical or electronic equipment costing more than $5,000.

c. A brief description of the proposed PCS software's features.

d. Supporting descriptive information, calculations, etc., to facilitate a complete evaluation.

e. A clear statement on a separate page that the proposed system is as specified in the Specifications in terms of performance, reliability, and manufacturer's support.

6. Certification of scope of supply:
   a. Provide a clear description of the proposed (minimum) scope of supply for the proposing ICSC firm. This scope description shall be binding and shall be considered the minimum scope of work for the proposing firm. The intent is to verify that proposing firms can and will perform the complete, minimum scope of the ICSC described above. Additions to this minimum scope of supply are allowed if they do not violate other requirements of the Contract Documents.
   b. Execute and submit a written certification of intent to assume full responsibility for the complete requirements of the Instrumentation and Control Specifications and related Instrumentation Drawings.
   c. The certification shall be typed on the firm's letterhead and signed by an authorized representative of the firm.
7. It is the responsibility of the firm to furnish sufficient information of each item to document compliance with the minimum requirements.
8. Determination of the proposed ICSC qualifications is at the sole discretion of the Engineer and Owner.

C. Qualification minimum requirements:
   1. To be Qualified as an ICSC, a proposing company must meet the minimum requirements set forth in the following list based on the information submitted. For joint ventures, both firms must separately meet the requirements.
   2. Firm has been in business at least 10 years.
   3. Firm has been performing PCS system integration services for at least 5 years.
   4. Firm has been supplying PCS systems to the water and wastewater industries for at least 5 years.
   5. Firm must have an I&C business volume of at least $2.0 million, annually.
   6. Firm and officers do not have adverse criminal or legal records, such as criminal convictions, defaults, loss of licenses, etc.
   7. Firm does not have a poor project performance record, such as repeated claims, litigation, defaults, etc.
   8. Firm demonstrates completion of at least 3 similar (water or wastewater) projects in the past 5 years. Each similar project must include:
      a. Project PCS system cost of at least 1/2 of this Project estimated cost.
      b. Number of new physical IO points at least 75 percent of the new physical IO count of this Project.
      c. Same PLC hardware or PCS software as this Project.
      d. Water or wastewater facility.
      e. At least roughly 2/3 the number of PLCs as the current project PLCs (with CPUs), or greater.
      f. At least 1 operator stations, or greater.

g. Date completed. “Completion” means the similar project has been installed and is substantially complete.

9. Firm must have their own operating UL listed panel fabrication and testing facility.
10. Proposed personnel have adequate experience and credentials, including:
    a. PM and PE have served in similar roles on at least 1 comparable project(s) in the past 5 years.
    b. Lead programmer has a minimum of 5 years of experience on similar projects.
    c. Firm has an in-state registered electrical or control system engineer located in the local office who will be an active and significant member of the project team and who will stamp all drawings produced by the firm for this Project.
11. Firm cannot be in bankruptcy.
12. The financial condition of the firm cannot be such that its financial ability to complete the Project is, in the opinion of the Owner, in doubt.
13. Firm must have a minimum of 20 permanent, full-time technical employees, all of whom must be regularly engaged in I&C/PCS design and implementation work.
14. Firm must have a permanent local office within 250 miles of the Project Site that is staffed with at least 5 technical employees (administrative staff does not count), and has been so staffed for the past 12 months.
15. The proposed equipment, software, and systems must comply with the requirements of the Drawings and Specifications.

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

E. The ICSC must have their own operating UL listed panel fabrication facility. All panels must be fabricated at this facility and meet all UL 508/508A requirements.

F. ICSC:
1. Contractor, through the use of a qualified ICSC, is responsible for the implementation of the PCIS and the integration of the system with other required instrumentation, control devices, and software.
2. The ICSC assumes full responsibility, through the Contractor, to perform all work to select, furnish, install, program, test, calibrate, and place into operation all instrumentation, controls, telemetry equipment, control panels, and control system including application software, for a complete, integrated and functional PCIS system.
3. Due to the complexities associated with the interfacing of numerous control system devices, it is the intent of these Specifications that the ICSC be responsible for the integration of the PCIS with existing devices and devices provided under the Contract Documents with the objective of providing a completely integrated control system.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Store all equipment and materials delivered to the job site in a location that will not interfere with the construction or the Owner’s operations.

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

C. Tagging:
   1. Tag each component and/or instrument to identify its location, instrument tag number, and function in the system.
   2. Firmly attach a permanent tag indelibly machine marked with the instrument tag number, as given in the tabulation, on each piece of equipment constituting the PCS.
   3. Tag instruments immediately upon receipt in the field.
   4. Prominently display identification on the outside of the package.
   5. Utilize the Tag and Loop Number identifications shown on the P&IDs.

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

1.07 PROJECT OR SITE CONDITIONS

A. Site conditions:
   1. Provide a PCS, including all equipment, raceways, and any other components required for a complete installation that meets the environmental conditions for the Site as specified in the General Requirements and below.
   2. Wind:
      a. Provide all equipment and construction techniques suitable for the site wind loading criteria, as specified in the Contract Documents.
   3. Altitude, temperature and humidity:
      a. As specified in the Contract Documents.
      b. Provide all equipment and instrumentation fully rated for continuous operation at this altitude, temperature and humidity conditions with no additional derating factors applied.
      c. Provide additional temperature conditioning equipment to maintain all equipment and instrumentation in non-conditioned spaces or outdoors subject to these ambient temperatures 10 degrees Fahrenheit above the minimum operating temperature and 10 degrees Fahrenheit below maximum operating temperature as determined by the equipment manufacturer's guidelines:
         1) Provide all power wiring for these devices (e.g., heaters, fans, etc.), whether or not indicated on the Drawings.
   4. Area classifications:
      a. Furnish enclosures that match the area classifications as specified in Section 16050 - Common Work Results for Electrical.

5. Site security:
    a. Abide by all security and safety rules concerning the Work on the Site as directed by the Owner and as specified in the Contract Documents.

1.08 SEQUENCING

A. General:
1. As specified in the Contract Documents.
2. Testing requirements are specified in the Contract Documents and17950-Commissioning for Instrumentation and Controls.
3. General scheduling requirements are specified in the Contract Documents.
4. Work restrictions and other scheduling requirements are specified in the Contract Documents**.** Refer to Section 01140 for Engineer's proposed sequence of construction.
5. Commissioning requirements as specified in the Contract Documents.

B. Submit proposed ICSC statement of qualifications:
1. The ICSC must be accepted by the Engineer before any other Work commences.

C. Source testing:
1. Before the delivery and installation of the PCS system to the job site, but after the procurement, assembly, and configuration of all components, perform the Source Test.
2. Before the delivery and installation of control panels, PLCs, control system equipment, and other PCS components at the job site, but after the procurement and assembly of components, perform Source Test.
3. Schedule the Source Test after receiving approval of the Source Test procedures submittal.
4. Submit a copy of the test procedures including all forms at least 21 days before any scheduled test date.
5. Notify the Engineer of scheduled tests a minimum of 15 days before the date of the test.

D. General Field Start-Up and testing procedures:
1. As specified in the Contract Documents.

E. Installation testing:
1. As specified in the Contract Documents.
2. Commence after acceptance of all training, wire test, calibration tests, and loop validation tests, and all inspections have demonstrated that the PCIS complies with all Contract requirements.
3. Acceptance of the PCIS Installation testing must be provided in writing by the Owner before the performance testing may begin.

F. Training:
1. As specified in the Contract Documents.

G. Functional testing:

1. Commence after acceptance of all training, wire test, calibration tests, and loop validation tests, and all inspections have demonstrated that the PCIS complies with all Contract requirements.
2. Loop validation test.
3. As specified in Section 17950 - Commissioning for Instrumentation and Controls.
    a. Notify the Owner of scheduled tests a minimum of 21 days before the estimated completion date of installation and wiring of the PCIS.
    b. Complete loop validation testing a minimum of 5 days before the pre-commissioning phase of the project.
    c. Loop validation certifications:
        1) After the field device loop tests have been successfully completed as specified in Section 17950 - Commissioning for Instrumentation and Controls for all individual instruments, all separate analog control networks, all valves, all VCPs, all motors, all local operator interface panels, all motor control centers, etc., submit a certified copy of all test forms signed by the Contractor, Vendor, and the Owner's representative with test data entered, together with a clear and unequivocal statement that all instrumentation, including all control and signal wiring, has been successfully calibrated, inspected, and tested.
            a) Acceptance of the PCIS Installation Testing must be provided in writing by the Engineer before the Process Operational Period may begin.

H. Provide all special tools and spare parts, as specified in the Maintenance paragraph of this Section, before Process Operational Period commences, suitably wrapped, and identified.

I. Process Operational Period:
    1. Upon completion of the Process Operational Period, conduct an Instrumentation and Controls Process Performance Test as a condition for Project final completion.

1.09 ADMINISTRATIVE REQUIREMENTS

A. Project PCIS overview conference:
    1. Contractor leads the meeting.
    2. Timing:
        a. Prior to start of ICSC and Programmer Work.
    3. Attendees:
        a. Engineer, Owner, ICSC, and Programmer.
        b. Contractor.
        c. Electrical subcontractor.
        d. Manufacturers furnishing major pieces of equipment must attend, including, but not limited to:
            1) Vendor control panels.
            2) Chemical feed systems.
            3) Motor control centers.
            4) Switchgear.
            5) Variable frequency drives.

6) Lighting.
7) Engine generators.

4. Agenda:
   a. Meeting purpose:
      1) Review the entire project, equipment, control philosophy, schedules, and Submittal requirements.
   b. Review entire project.
   c. Review equipment lists.
   d. Review control philosophy.
   e. Review schedules.
   f. Review Submittal requirements.
   g. Safety and security.
   h. Action items.
   i. Next meeting.

B. System configuration meetings: Meet on at least the following occasions:
   1. Preliminary meeting:
      a. Contractor leads the meeting.
      b. Timing:
         1) Before configuration work is begun.
      c. Attendees:
         1) Engineer, Owner, ICSC, and Programmer.
      d. Agenda:
         1) Meeting purpose:
            a) Review the system configuration, the HMI system database, control schemes, displays, report formats, etc.
         2) Review the ICSC provided examples of displays, display symbols, reports, etc., to show the capabilities of the system software.
         3) Safety and security.
         4) Action items.
         5) Next meeting.
   2. Development review meeting:
      a. Contractor leads the meeting.
      b. Timing:
         1) After the initial database is entered and typical screens and reports have been entered.
      c. Attendees:
         1) Engineer, Owner, ICSC, and Programmer.
      d. Agenda:
         1) Meeting purpose:
            a) Review the system configuration, the HMI system database, control schemes, displays, report formats, etc.
         2) Review the system configuration.
         3) Review the HMI system database.
         4) Review the control schemes.
         5) Review the displays.
         6) Review the report formats.
         7) Safety and security.
         8) Action items.
         9) Next meeting.
   3. Pre-submittal review meeting:

a. Contractor leads the meeting.
b. Timing:
    1) Before producing any Submittals.
c. Attendees:
    1) Engineer, Owner, Programmer, and ICSC.
d. Agenda:
    1) Meeting purpose:
        a) Review the system configuration, the HMI system database, control schemes, displays, report formats, etc.
        b) Review an informal hardcopy of developed HMI screens for review by the Engineer.
    2) Review the system configuration.
    3) Review the HMI system database.
    4) Review the control schemes.
    5) Review the displays.
    6) Review the report formats.
    7) Review an informal hardcopy of developed HMI screens.
    8) Review the Submittal schedule.
    9) Safety and security.
    10) Action items.
    11) Next meeting.

4. Final review meeting:
    a. Contractor leads the meeting.
    b. Timing:
        1) After initial completion of configuration work.
        2) Prior to the Source Test.
    c. Attendees:
        1) Engineer, Owner, Programmer, and ICSC.
    d. Agenda:
        1) Meeting purpose:
            a) Review the system configuration, the HMI system database, control schemes, displays, report formats, etc.
        2) Review the system configuration.
        3) Review the HMI system database.
        4) Review the control schemes.
        5) Review the displays.
        6) Review the report formats.
        7) Safety and security.
        8) Action items.
        9) Next meeting.
    e. Make final format revisions after this review.
5. Additional requirements as specified in the following:
    a. Section 17100 - Control Strategies.
    b. Section 17101 - Specific Control Strategies.
    c. Section 17720 - Control Systems: Programmable Logic Controllers.
    d. Section 17762 - Control Systems: PCS Software.

C. Control logic meetings: Meet on at least the following occasions:
1. Preliminary meeting:
    a. Contractor leads the meeting.
    b. Timing:

1) Before configuration work is begun on any PLCs programmed by the Contractor (including those provided through Subcontractors and Suppliers).

c. Attendees:
1) Owner, Engineer, Programmer, and ICSC.
2) Individuals responsible for programming PLCs and other programmable devices supplied by the Contractor may attend by telephone conference call.

d. Agenda:
1) Meeting purpose:
a) Discuss overall control logic.
2) Review list of each PLC and other programmable devices that will interface to the rest of the control system, including make, model, and a description of the interface.
3) Review contact information for each individual responsible for programming each said PLC and other programmable device.
4) Review schedule of Submittals that will contain HMI/LOI interface information.
5) Safety and security.
6) Action items.
7) Next meeting.

2. Development review meeting:
a. Contractor leads the meeting.
b. Timing:
1) After approximately one-half of the HMI/LOI interface Submittals have been submitted.

c. Attendees:
1) Owner, Engineer, Programmer, and ICSC.
2) Individuals responsible for programming PLCs and other programmable devices supplied by the Contractor may attend by telephone conference call.

d. Agenda:
1) Meeting purpose:
a) Discuss progress on control logic.
2) Discuss HMI/LOI interface Submittals to date.
3) Discuss HMI/LOI interface future Submittals and their requirements.
4) Discuss half of the screens “drafted” but not submitted.
5) Review list of each PLC and other programmable devices that will interface to the rest of the control system, including make, model, and a description of the interface.
6) Review contact information for each individual responsible for programming each said PLC and other programmable device.
7) Review schedule of Submittals that will contain HMI/LOI interface information.
8) Safety and security.
9) Action items:
a) Document Vendor Control Panel programming requirements.
10) Next meeting.

3. Pre-submittal review meeting:
a. Contractor leads the meeting.
b. Timing:

1) Before producing any Submittals.
c. Attendees:
1) Engineer, Owner, Programmer, and ICSC.
d. Agenda:
1) Meeting purpose:
a) Coordinate Submittals.
2) Review the system configuration, the HMI system database, control schemes, displays, report formats, etc.
3) Review an informal hardcopy of developed HMI screens for review by the Engineer to determine that requirements are being sufficiently met.
4) Review the Submittal schedule.
5) Safety and security.
6) Action items.
7) Next meeting.
4. Final review meeting:
a. Contractor leads the meeting.
b. Timing:
1) After HMI/LOI interface Submittals have been submitted.
c. Attendees:
1) Owner, Engineer, Programmer, and ICSC.
2) Individuals responsible for programming PLCs and other programmable devices supplied by the Contractor may attend by telephone conference call.
d. Agenda:
1) Meeting purpose:
a) Discuss HMI/LOI interface Submittals and requirements.
2) Review minimum programming requirements:
a) PLC to PLC global data mapping.
b) PLCs to HMI tags mapping.
c) Communication methods.
3) Review advanced requirements, as applicable:
a) Tag naming conventions.
b) LOI screen colors and navigation.
c) Interlock and permissive definitions.
d) Alarms: Clearing, formats, colors, and status.
e) Standard code blocks for common control functionality.
4) Safety and security.
5) Action items.
6) Next meeting.
5. Additional requirements as specified in the following:
a. Section 17100 - Control Strategies.
b. Section 17101 - Specific Control Strategies.
c. Section 17720 - Control Systems: Programmable Logic Controllers.
d. Section 17762 - Control Systems: PCS Software.

1.10 WARRANTY

A. Provide additional warranty as specified in the individual Instrumentation and Control Specifications that extends beyond the Correction Period, as specified in the Contract Documents.

1.11 SYSTEM PROCESS START-UP

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

1.12 OWNER'S INSTRUCTIONS (NOT USED)

1.13 MAINTENANCE

A. Before Substantial Completion, perform all maintenance activities required by the Contract Documents including any calibrations, final adjustments, component replacements or other routine service required before placing equipment or systems in service.

B. Furnish all spare parts as required by the Contract Documents.

C. Spare parts:
   1. Furnish the spare parts selected by the Owner or Engineer from the priced list of spare parts in the hardware submittal.
   2. Furnish a price list of all special tools required to calibrate and maintain all of the instrumentation provided under the Contract Documents. Furnish the special tools selected by the Engineer from the priced list.

D. Provide additional spare parts specified in other sections of the Instrumentation and Control Specifications.

E. Submit all special tools and spare parts, suitably wrapped and identified, before Process Operational Period commences.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Provide similar items from a single manufacturer throughout the PCIS portion of the Project for system standardization.

B. Allowable manufacturers are specified in individual instrument and equipment specifications.

2.02 SYSTEM DESCRIPTION

A. General requirements:
   1. The Work includes everything necessary for and incidental to executing and completing the instrumentation and control system work indicated on the Drawings and specified in the Specifications and reasonably inferable there from including but not limited to:

a. Preparing hardware submittals for field instrumentation.
b. Design, develop, and draft loop drawings, control panel designs, and all other drawing submittals specified in the Instrumentation and Control Specifications.
c. Prepare the test plan, the training plan, and the spare parts submittals.
d. Procure all hardware.
e. Provide all PCS system hardware.
f. Provide all PCS system software.
g. Fabricate panels.
h. Perform factory tests on panels.
i. Perform bench calibration and verify calibration after installation.
j. Oversee and certify installation of the PCS system.
k. Oversee, document, and certify loop testing.
l. Oversee, document, and certify system.
m. Installation Testing.
n. Oversee and document Functional Testing.
o. Conduct the Process Operational Period and the Instrumentation and Controls Process Performance Testing.
p. Prepare operation and maintenance manuals.
q. Conduct training classes.
r. Integrate the PCS with instrumentation and control devices provided under other sections.
s. Provide Record Drawings and Loop Drawings associated with Instruments and equipment:
    1) As specified in the Contract Documents.
    2) For Owner furnished items.
    3) For interfaces with existing equipment.
t. Resolve signal, power, or functional incompatibilities between the PCS and interfacing devices.
u. Perform all required corrective and preventative maintenance.

2. It is the intent of these Specifications that the entire electrical power, instrumentation, and control system be complete and operable. Provide all necessary material and labor for the complete system from source of power to final utilization equipment, including all connections, testing, calibration of all equipment furnished by others, as well as equipment furnished by the Contractor, whether or not specifically mentioned but which are necessary for successful operation.
3. Provide the complete operating PCS to perform the specified monitoring, communications, alarm, control, display, and reporting functions in accordance with the PCS requirements.
4. Coordinate all aspects of the Work between Contractor and all subcontractors before bidding to ensure that all costs associated with a complete installation are included. The Owner is not responsible for any change orders due to lack of coordination of the Work between the Contractor, the ICSC, the other subcontractors, or suppliers.
5. Furnish detailed, complete, and thorough operations and maintenance documentation, including but not limited to operations manuals, maintenance manuals, as-built wiring drawings, training manuals, as-built software documentation, and all other documentation required to operate, modify, and maintain all parts of the PCS.

6. Where demolition is indicated on the Drawings, the electrical subcontractor is responsible for disconnecting equipment electrical connections and rendering the equipment safe. The ICSC is responsible for physically removing all instrumentation to be demolished and return it either to the Owner or dispose of it as directed by the Owner's representative. The ICSC shall be responsible for any program modifications needed based on the demolition of the equipment, both for the loops directly and indirectly affected.
7. Portions of this Project involve installation in existing facilities and interfaces to existing circuits, power systems, controls, and equipment.
    a. Perform and document comprehensive and detailed field investigations of existing conditions (circuits, power systems, controls, equipment, etc.) before performing any Work.
    b. Provide and document interface with, modifications to, upgrade, or replacement of existing circuits, power systems, controls, and equipment.
8. Revise in a manner as directed by the Engineer all I/O and addressing that the Engineer determines to be unacceptable as a result of a lack of Contractor coordination between Contract Documents and all suppliers.

B. The detailed scope of work is summarized below and includes all specifications and drawings to describe the work.

C. SCADA Architecture:
1. The Owner has a fully integrated Trihedral VTScada environment consisting of integrated IO Server, Historian, Thin Client Server and Trend Server. All new systems shall be integrated into the Owner's existing infrastructure.
2. Remote sites communicate through radio to the main SCADA system server. Integrate all system components into the Owner's central management systems for authentication, device management, network monitoring, system security, and backup and recovery. All graphics of these systems shall be integrated into the Owner's master system to allow for viewing from any other node in the system based on user authentication credentials.

D. Network Communications:
1. The Owner has an existing radio system which communicates to remote sites. In-plant fiber and radio systems also exist for local communications. All new systems shall be integrated into the Owner's existing network systems.
2. Water and Wastewater plants shall consist of fiber Ethernet based local area networks. All major switches shall be managed and networks for control, security, and IT shall be physically separated using separate hardware devices. The local fiber network shall have a ring topology for fault tolerance with a gigabit backbone. All networks shall be connected back to a central plant firewall to secure communications between the local facility and the Owner's central datacenter.
3. Remote sites shall utilize radio communications to communicate back to central SCADA server.

E. System Security
1. All networks shall implement industry best practices for network security including NIST SP 800-82 and IEC 62443.
2. All default passwords on all network connected components shall be changed to an Owner provided set of credentials.

3. Configure authentication of all network connected equipment supporting active directory services to be integrated into the Owner's existing SCADA domain.
4. Install and configure Owner's anti-virus software on each computer and server.
5. Coordinate with Owner's IT department for configuration of network management using SNMP and logfile management using syslog. Configure systems for software updating in accordance with the Owner's standard policies and procedures.

F. Operating facility:
1. Existing facilities must remain fully functional throughout the entire construction period. In consideration of this requirement, comply with the following guidelines where work is done on existing facilities:
   a. All outages must be of minimal duration and fully coordinated and agreed to by the Owner. Adjust the construction to meet the requirements of the Owner.
   b. As weather and facility demand conditions dictate, re-adjust the construction schedule to meet the demands placed upon Owner by its users.
   c. Where portions of the Work are in existing facilities and require interface to existing circuits, power systems, controls and equipment, perform comprehensive and detailed field investigations of existing conditions. Determine all information necessary to document, interface with, modify, upgrade, or replace existing circuits, power systems, controls, and equipment.
2. According to individual circumstances and in compliance with the Drawings, extend or replace conduit and cable connections from existing locations.
3. Where shown or specified, replace existing field instruments with new.
4. Contractor is responsible for the integrity and measurement accuracy of all loops.
5. Any defect found in existing equipment is the responsibility of the Owner. Contractor is not responsible for defects on existing Owner components.
6. The standards of documentation, instrument tagging, cable and conductor termination, terminal identification and labeling that apply to the new installation apply equally to the existing installation.

2.03 EXISTING PRODUCTS (NOT USED)

2.04 MATERIALS

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

B. Provide materials complying with the applicable industrial standard as specified in the Contract Documents.

2.05 MANUFACTURED UNITS (NOT USED)

2.06 EQUIPMENT (NOT USED)

2.07 COMPONENTS

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

B. Unless otherwise specified, furnish individual instruments that have a minimum accuracy of within 0.5 percent of full scale and a minimum repeatability of within 0.25 percent of full scale.

C. Signal transmission:
   1. Analog signals:
      a. Furnish analog measurements and control signals that vary in direct linear proportion to the measured variable, unless otherwise indicated.
      b. Furnish electrical analog signals outside control panels that are 4-to-20 milliamperes 24 VDC, except as indicated.
      c. Electrically or optically isolate all analog signals from other signals.
      d. Furnish regulated analog signals that are not affected by changes in supply voltage or load resistance within the unit's rating.
      e. Maintain the total 4-to-20 milliamperes loop impedance to 10 percent below the published value at the loop operating voltage.
      f. Where necessary, reduce loop impedance by providing current-to-current (I/I) isolation amplifiers for signal re-transmission.
   2. Pneumatic signals:
      a. All pneumatic signals: 3-to-15 pounds per square inch gauge.
   3. Discrete input signals:
      a. As indicated in the controller hardware specification.
   4. Discrete output signals:
      a. Dry contacts or TRIAC outputs (with express written approval by the Engineer) as needed to coordinate with the field device.
      b. Provide external terminal block mounted fuse with blown fuse indication for all discrete outputs.
      c. Provide interposing relays for all discrete outputs for voltage and/or current compatibilities.
      d. Provide interposing relays as required for functionality of the control circuit.
   5. Signal performance and design criteria:
      a. Stability:
         1) After Controls have taken corrective action, oscillation of the final control element shall not exceed 2 cycles per minute or a magnitude of motion of 0.5 percent of full travel.
      b. Response:
         1) Any change in setpoint or controlled variable shall produce a corrective change in position of the final control element and stabilized within 30 seconds.
      c. Agreement:
         1) Setpoint indication of controlled variable and measured indication of controlled variable shall agree within 3 percent of full scale over a 6:1 operating range.

d. Repeatability:
    1) For any repeated magnitude of control signal, from either an increasing or decreasing direction, the final control element shall take a repeated position within 0.5 percent of full travel regardless of force required to position the final element.
e. Sensitivity:
    1) Controls shall respond to a setpoint deviations and measured variable deviations within 1.0 percent of full scale.
f. Performance:
    1) All instruments and control devices shall perform in accordance with the manufacturers' specifications.

D. Discrete circuit configuration:
    1. Configure discrete control circuits to fail safe, on loss of continuity or loss of power.
    2. Alarm contacts: Fail to the alarm condition.
    3. Control contacts fail to the inoperative condition unless otherwise indicated on the Drawings.

E. Grounding:
    1. Analog signal cables shields shall only be grounded at a single point in the loop. Unless otherwise noted, ground signal cable shields at control panel.
    2. For communication and data line signal cable shields and drain wires should be grounded at both ends of the cable.
    3. Insulate the shielding and exposed drain wire for each signal cable with heat-shrink tubing.
    4. Terminate the signal cable shield on a dedicated grounding terminal block.
    5. Provide isolating amplifiers within control panels for field equipment possessing a grounded input or output, except when the panel circuit is galvanically isolated.

F. Instrument air:
    1. Where indicated on the Drawings, provide dry, filtered control air at 30 pounds per square inch gauge nominal pressure piped to all field instruments and instrument panels requiring air:
        a. Provide each field instrument with an integral, non-adjustable filter/regulator assembly to provide regulated air.
        b. Provide each instrument panel requiring air with an adjustable filter/regulator assembly with gauge and an air manifold to provide air to pneumatic instruments.
        c. Filter all air to 5-micron maximum particle size.
        d. Provide low pressure switch to alarm on insufficient air supply.

2.08 ACCESSORIES

A. Provide flow conditioning devices or other required accessories if necessary to meet the accuracy requirements in the Contract Documents.

B. Nameplates:

1. Provide a nameplate for each controller, instrument transducer, instrument power supply, solenoid, or any other control device located either in the field or within panels.
2. All nameplates shall be of identical style, color, and material throughout the facility.
3. Device nameplates shall include:
    a. Designations as indicated on the Drawings and identified on the Process and Instrumentation Drawings.
        1) Device tag and loop number ID (e.g., FIT-60.011).
        2) PLC ID (e.g., PLC-11).
        3) Power information (e.g., PCM-11, 120VAC).
    b. White lettering on a black background, laminated plastic.
4. All instruments shall be equipped with Type 316 stainless steel nameplate with the instrument tag stamped in 3/8-inch letters and connected to the instrument using Type 316 stainless steel wire.

2.09 MIXES (NOT USED)

2.10 FABRICATION (NOT USED)

2.11 FINISHES (NOT USED)

2.12 SOURCE QUALITY CONTROL

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

B. Arrange with all manufacturers of the equipment and fabricators of panels and cabinets, to allow the Owner and Engineer to inspect and witness the testing of the equipment at the site of fabrication:
    1. Equipment includes the cabinets, special control systems, flow measuring devices, and other pertinent systems and devices.

C. Source Test is specified in Section 17950 - Commissioning for Instrumentation and Controls.

PART 3 EXECUTION

3.01 EXAMINATION

A. The ICSC is encouraged to attend a pre-bid conference and examine the premises completely before bidding. It is the ICSC's responsibility to be fully familiar with the existing conditions and local requirements and regulations.

B. Review the existing Site conditions and examine all shop drawings for the various items of equipment in order to determine exact routing and final terminations for all wiring and cables.

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

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. Equipment locations indicated on the Drawings may change due to variations in equipment size or minor changes made by others during construction:
    1. Verify all dimensions as indicated on the Drawings:
        a. Actual field conditions govern all final installed locations, distances, and levels.
    2. Review all information indicated on the Drawings, including architectural, structural, mechanical, instrumentation, and the accepted electrical, instrumentation, and mechanical shop drawings, and coordinate Work as necessary to adjust to all conditions that arise due to such changes.
    3. Make minor changes in location of equipment before rough in, as directed by the Owner or Engineer.

B. Perform all related Electrical Work in accordance with the applicable sections of the Electrical Specifications.

C. The PCIS configurations are diagrammatic:
    1. The locations of equipment are approximate unless dimensioned.
    2. Where Project conditions require, make reasonable changes in locations and arrangements.

D. Field instruments installation:
    1. Install field instruments as specified in the Contract Documents, API RP 550 and RP 551, and the manufacturer’s instructions.
    2. Mount field instruments so that they can be easily read, readily approached, and easily serviced, and so they do not restrict access to mechanical equipment:
        a. Mount field instruments on a pipe stand or local panel, if they are not directly mounted, unless otherwise indicated on the Drawings.
        b. Provide sun shields for all field electronic instruments located outdoors.
    3. Make connections from rigid conduit systems to field instruments with PVC coated flexible conduit:
        a. Type of flexible conduit required for the area classification:
            1) Area classification as specified in Section 16050 - Common Work Results for Electrical.
        b. Maximum length of 18 inches.
    4. Connect field instruments with cable as specified in the Electrical Specifications, except when the manufacturer requires the use of special cable, or otherwise specified in this Section:
        a. Special cable applications shall be in accordance with the NEC.
    5. Verify the correctness of each installation:
        a. Polarity of electric power and signal connections.
    6. Ensure all process connections are free of leaks.

7. Provide a power disconnect switch for each 120 VAC powered instrument which does not have a built-in power disconnect:
    a. Disconnect enclosure suitable for the area classification:
        1) As specified in Section 16050 - Common Work Results for Electrical.

E. Process sensing lines and air tubing:
1. Install individual tubes parallel and/or perpendicular to and near the surfaces from which they are supported.
2. Provide supports for rigid tubing at intervals of not more than 3 feet.
3. Slope horizontal runs of instrument tubing at a minimum of 1/16-inch per foot to allow for draining of any condensate.
4. Bends:
    a. Make bends for parallel lines symmetrical.
    b. Make bends without deforming or thinning the walls of the tubing.
5. Square-cut and clean all ends of tubing before being inserted in the fittings.
6. Provide bulkhead fittings at all panels requiring pipe and/or tubing entries.
7. Use stainless steel tubing for all piping hard piped from the air header, unless otherwise indicated on the Drawings or not compatible with the fluids or atmosphere in the area:
    a. Use flexible connections only on moving equipment and under the constraint that the length shall be less than 1.5 times maximum travel of the equipment.

F. Equipment tie-downs:
1. Anchor all instruments, control panels, and equipment by methods that comply with seismic and wind bracing requirements, which apply to the Site.
2. All control panels, VCPs, LCPs, RTUs, PCMs, etc., shall be permanently mounted and tied down to structures.

G. Existing instrumentation:
1. Clean, recondition and re-calibrate each existing instrument to be reused, removed, or reinstalled using an authorized service facility of the instrument manufacturer.
2. Provide certification of this Work before reinstallation of each instrument.

H. Instrument tagging:
1. As specified in Section 16075 - Identification for Electrical Systems.
2. Provide all field-mounted instruments with nameplates:
    a. Nameplates engraved with the instrument’s full tag number as indicated on the Drawings:
        1) Affix tags with stainless steel wire fasteners.
3. Provide all back of panel instruments with nameplates:
    a. Engraved with the instrument’s full tag number as indicated on the Drawings:
4. Provide all front of panel instruments with a nameplate:
    a. Engraving to include the following:
        1) Instrument’s full tag number.
        2) Service description.
    b. Nameplates:
        1) Secure nameplates to the panel with stainless steel screws.

2) Use an accepted adhesive if screws would violate the NEMA or other ratings of the enclosure.

I. Cable and conductor termination:
   1. Terminate all cables and conductors on terminal blocks.
   2. Terminal block enclosures:
      a. Suitable for the area classification as specified in Section 16050 - Common Work Results for Electrical.

J. Surge protection:
   1. Provide outdoor field instrument loops with voltage surge protection units installed on the instruments and in the control panel.
   2. Individually fuse each 4 to 20 milliamperes direct current loop with a 1/2-ampere fuse between power supplies and receiver surge protectors.
   3. Provide voltage surge protection for 4 wire transmitters and analyzers:
      a. Protect both power source and signal loop.

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

3.05 RE-INSTALLATION (NOT USED)

3.06 COMMISSIONING

A. As specified in the Contract Documents.

B. Owner Training:
   1. Demonstration requirements are specified in Section17950 - Commissioning for Instrumentation and Controls.
   2. General:
      a. Provide system maintenance and operator training courses for all the instrumentation and control systems furnished.
      b. Provide system maintenance and operator training courses for all the instrumentation and control equipment and systems furnished, as described below.
         1) All training described below shall be provided by the Contractor.
      c. Conduct all training at the Project Site unless another location is accepted by the Engineer and Owner:
         1) Include instruction on the use of all maintenance equipment and special tools provided under the Contract.

         Tailor training classes to the specific needs of the class participants:
         2) Develop separate courses for operators, maintenance staff, and supervisors:
            a) The specific categories and number of personnel in each category are identified below.
         3) Furnish training courses that are a combination of classroom and hands-on training:
            a) To the greatest extent possible, utilize components from the Owner’s PCS system.
            b) Limit classes that include extensive hands-on activities to a maximum of 5 students per class.

4) Present the minimum number of sessions, specified in Section 17950 - Commissioning for Instrumentation and Controls, for each course in order to satisfy class size restrictions and limitations scheduling Owner staff.
5) Furnish additional sessions if required to accommodate the total number of personnel identified for each course.

d. Schedule individual training classes:
1) Coordinate with the Owner at least 3 weeks before the start of the class.
2) Schedule training classes Monday - Friday between 7:30 a.m. and 3:30 p.m.
3) Each individual daily training session, travel time excluded:
a) Minimum duration of 4 hours.
b) Maximum duration of 7 hours.
c) Breaks scheduled at least every 90 minutes and 1 hour for lunch.
4) Complete training for maintenance personnel 90 days before Process Operational Period.
5) Complete operator training classes before process start-up of the control system software, or any part of it:
a) As specified in the Sequencing article of this Section.
6) Schedule follow-up training classes after the PCS start-up on a schedule determined by the Owner.

e. Instructor qualifications:
1) Highly qualified training instructors for technical training with demonstrated expertise in not only control system functionality but also professional training techniques:
a) Instructor qualifications are subject to the approval of the Engineer.
2) Furnish training instructors thoroughly familiar with the PCIS system, who are members of the implementation team.
3) One of the individuals conducting the PCIS training course must be the same individual responsible for the majority of the programming that was performed for the instrumentation and control system.

3. Training manuals and materials:
a. Furnish training manuals and other materials for training courses.
b. Manuals are to be professionally written to present the course material in a format that is easy to comprehend.
c. The manuals are to serve as teaching aids during presentation of the training classes.
d. Manuals are to serve as reference material after the training has been completed.
e. Record all training and provide digital copies to the Owner in format compatible with the Owner’s management software system.

3.07 FIELD QUALITY CONTROL

A. Inspection:
1. Allow for inspection of PCIS installation as specified in the Contract Documents**.**

2. Provide any assistance necessary to support inspection activities.
3. Engineer inspections may include, but are not limited to, the following:
    a. Inspect equipment and materials for physical damage.
    b. Inspect installation for compliance with Drawings and Specifications.
    c. Inspect installation for obstructions and adequate clearances around equipment.
    d. Inspect equipment installation for proper leveling, alignment, anchorage, and assembly.
    e. Inspect equipment nameplate data to verify compliance with design requirements.
    f. Inspect cable terminations.
    g. Inspect/witness instrument calibrations/verifications.
4. Inspection activities conducted during construction do not satisfy inspection requirements specified in Section 17950 - Commissioning for Instrumentation and Controls.

B. Instrument Installation Inspection:
1. Provide any assistance necessary to support inspection activities.
2. Inspections may include, but are not limited to, the following:
    a. Inspect equipment and materials for physical damage.
    b. Inspect the installed arrangement, lay lengths, orientation, piping obstructions, etc., that could affect the instruments accuracy or repeatability.
    c. Inspect installation for compliance with Drawings and Specifications.
    d. Inspect installation for obstructions and adequate clearances around equipment.
    e. Inspect equipment installation for proper leveling, alignment, anchorage, and assembly.
    f. Inspect equipment nameplate data to verify compliance with design requirements.
    g. Inspect cable terminations.
    h. Inspect/witness instrument calibrations/verifications.
3. Inspection activities conducted during construction do not satisfy inspection requirements specified in Section 17950 - Commissioning for Instrumentation and Controls.
4. Field acceptance testing: (Functional Testing) is specified in Section 17950 - Commissioning for Instrumentation and Controls. Additional general requirements are specified in the Contract Documents.

C. Installation supervision:
1. Ensure that the entire PCIS is installed in a proper and satisfactory manner. At a minimum, the ICSC shall provide the following services:
    a. Installation resources:
        1) Coordinate with the Contractor regarding installation requirements of the Contract Documents.
    b. Provide technical assistance to installation personnel by telephone:
        1) Furnish installation personnel with at least 1 copy of the accepted submittals, including all installation details.
    c. Periodic inspections during the construction period.

d. A complete check of the completed installation to ensure that it is in conformance with the requirements of the equipment manufacturer and the Contract Documents.
e. Field verify accuracy and calibration of all instruments.

3.08 ADJUSTING

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

B. Make all revisions necessary to the control system software, as directed by the Engineer.
1. It is understood that the Contractor knows and agrees that changes will be required in the control system software during the Source Testing, Functional Testing, Process Operational Period, Process Start-Up, and during the Project Correction Period.

3.09 CLEANING

A. As specified in the Contract Documents.

B. Vacuum clean all control panels and enclosures before process start-up and again after final completion of the project.

C. Clean all panel surfaces.

D. Return to new condition any scratches and/or defects.

E. Wipe all instrument faces and enclosures clean.

F. Leave wiring in panels, manholes, boxes, and other locations in a neat, clean, and organized manner:
1. Neatly coil and label all spare wiring lengths.
2. Shorten, re-terminate, and re-label excessive spare wire and cable lengths, as determined by the Engineer.

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

3.10 PROTECTION

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

3.11 SCHEDULES (NOT USED)

END OF SECTION

SECTION 17100

CONTROL STRATEGIES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Contractor-developed loop description submittal requirements.
   2. General programming requirements.
   3. Common control functions:
      a. General control and monitoring functions to be provided throughout the PCS system.
         1) These requirements apply to all systems and supplement the specific loop descriptions and information indicated on the Drawings.
   4. PLC Design Standards.
   5. SCADA Design Standards.

1.02 REFERENCES

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

1.03 DEFINITIONS

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

B. Hardwired control: Control circuitry that does not utilize software to initiate functionality.

C. Hardwired interlocks: A safety or protective feature that will interrupt operation of the equipment in all operating modes with no required operator intervention.

D. Software interlocks: A safety or protective feature that will interrupt operation of the equipment when the PLC has control.

E. Slew rate: Rate of change in respect to time.

F. Clamp: Imposed upper and lower limits on setpoints to eliminate entries outside the allowable control parameters.

G. Watchdog timer: Timers imposed to test components such as discrete I/O to verify the health of the card.

1.04 SYSTEM DESCRIPTION

A. This section outlines control and programming standards for use on all projects. This section is supplemented by project specific control strategies to be implemented on this project. Existing control logic, function blocks, graphical objects, templates, and program organization shall be re-used to the greatest extent possible for overall system standardization. Obtain existing code libraries and objects from the Owner prior to starting any work.

B. Project specific control strategies are to be implemented using existing logic to the greatest degree possible and reuse control strategies for similar systems at other Owner facilities. Obtain examples of similar systems during software workshops.

C. PLC design standards are provided which document existing PLC programming, standards, and implementation guidelines. Where sections are not completed but needed during a specific project, they shall be coordinated, and standards developed as part of the software workshops and project implementation and testing. The final agreed upon methods and standards shall be documented in this manual as part of the project.

D. SCADA design standards are provided which document existing SCADA software requirements, graphical screens, graphical standards, and implementation guidelines. Where sections are not completed but needed during a specific project, they shall be coordinated and standards developed as part of the software workshops and project implementation and testing. The final agreed upon methods and standards shall be documented in this manual as part of the project.

1.05 SUBMITTALS

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

B. All PLC logic and HMI graphic screens must be submitted for review prior to implementation on any system. Any PLC logic or HMI conventions developed that do not meet existing standards will be rejected and require redevelopment.

1.06 QUALITY ASSURANCE (NOT USED)

1.07 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.08 PROJECT OR SITE CONDITIONS (NOT USED)

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

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

1.12 SYSTEM START-UP (NOT USED)

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS (NOT USED)

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION (NOT USED)

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION

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

B. After the bid has been awarded, the ICSC shall submit an RFI for the Owner standard graphics and PLC objects library.

C. General programming requirements:
   1. Use variable names or aliases derived from tag and loop identification on the P&IDs for all process values.
      a. Submit names for Owner approval.
      b. Unless otherwise noted, utilize floating-point format for all PLC algorithms and calculations.
      c. Provide PLC logic to convert raw input values into engineering units in a floating-point format.
   2. Store all adjustable parameters in the PLC, and configure so that an operator with sufficient security access can change the parameters from the LOI or HMI. Update and display the current value at all locations, regardless of where the last change was made.
   3. Reusable PLC code blocks:
      a. Owner will provide standard user defined function blocks (UDFBs) and user-defined types (UDTs) for PLC programming. Utilize these standards wherever possible in PLC programming.
      b. Develop and use new standard user defined function blocks (UDFBs) and user defined types (UDTs) where appropriate and obtain approval from Owner before use. One instance of each standard code block shall reside in each PLC and shall be referenced in main routines and subroutines.
      c. New code blocks that the Contractor would like to use as a standard shall be submitted to Owner for review and approval.
      d. Provide complete library of standard code blocks to Owner as part of O&M documentation.
      e. Each new code block must be documented as shown in the example in the PLC Design Standards document and added to this document.
   4. Documentation:
      a. All control logic shall be completely annotated including all rungs, instructions, and tags.
      b. Each routine shall have a title and a detailed description of the control strategy represented by the control logic. Where parameters are passed to the routine, all parameters shall be defined in the routine description.
      c. Analog tag descriptions representing process variables shall include the engineering unit range of the analog variable.
      d. Digital tag descriptions shall include the On and Off state labels.
      e. Complete, grammatically correct sentences and terminology, consistent with water treatment processes, shall be utilized in the development of rung and routine descriptions.
      f. All equations developed in the process logic shall be fully documented in the rung or routine description. A description of each constant and variable utilized in the equation shall be defined including engineering units.
   5. Program slew rates for 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 the HMI.
   6. Saved setpoints:
      a. Provide an operator selection to save all setpoint values.

b. Furnish 1 or more screens at the HMI 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. Where possible use a DFB or AOI to 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.

7. Nuisance alarm suppression:
   a. Provide nuisance alarm suppression to prevent alarm floods caused by failure conditions such as power fail or communication loss or major equipment item failures.
   b. Adjust alarm delays and resets as required to prevent alarm floods.
   c. Implement nuisance alarm suppression in all standard blocks.
8. Store a copy of all adjustable parameters and accumulated and integrated totals in PCS:
   a. Upon re-loading of the PLC program, re-load these values to the PLC from PCS or processor memory card.
   b. PLCs provide a minimum 2 week data storage to provide for data accumulation and later communication to the Historian in the event of a network interruption.
9. Calculated values:
   a. Program calculations such that division by zero errors cannot occur.
   b. Prevent calculations from generating values that exceed the limits of the equipment or data type structures (integers) internal to the PLC.
   c. Configure counting functions (start counts and operation counts) to allow a minimum of 10,000 counts, and to roll-over to zero at an even decimal interval (1 followed by 4 or more zeros).
   d. Configure integrating functions to accurately accumulate the maximum rate from the instrument/equipment (totalizers, run time meters) for a minimum of 30 years. Utilize manufacturer AOI/DFBs etc. where possible.
10. Timers:
    a. Provide programmable settling and proving timers in control sequences as required for starting and stopping of equipment to allow the process to settle down before proceeding with any additional control functions.
       1) The settling timers may be overridden by setting the timer to 0 seconds.
11. Control Panel status:
    a. Design the PLC system to function as a stand-alone unit that performs all of the control functions described in this Section completely independent from the functions of the PCS system PC-based operator interfaces:
       1) Failure of the PCS system shall not impact data acquisition, control, scaling, alarm checking, or communication functions of the PLC.
    b. Furnish a minimum of 1 screen that depicts the status of all enclosures containing PLCs, communication equipment, UPS or I/O in the control system, including but not limited to the following:
       1) PLC cabinet over-temperatures from high temperature switch.
       2) Intrusion status on all enclosures equipped with intrusion switches.
       3) AC power failure:
          a) Monitor ahead of UPS.

4) DC power supply failure:
a) For redundant power supplies, alarm when either power supply or the diode bridge fails.
5) UPS failure signal.
6) UPS Low Battery signal.
7) Digital bus network Coupler and or Gateway failure signal.
8) Ethernet Switch failure signal.

12. PLC system communication status:
a. Furnish a minimum of 1 screen to display all communication errors and status within the PCS:
1) Communication between PCS and PLCs, PLC to PLC, PLC to RIO and PLC and or PCS to VCP.
2) 4-20 mA HART interface cards.
3) Digital bus network status:
a) DeviceNet and ControlNet scanners.
4) Modbus Gateway modules.
5) Display status of each node, and summary of failures over the past 60 minutes.
b. Generate a communications alarm if any communication fault is detected or there is no response from a node for more than a user specified time.
c. In the event of communications loss:
1) Continue normal operation at each PLC.
2) Where control parameters are received over a communications link:
a) If a link fails where process elements use the remote value for closed-loop control, hold operating status, speed and position, of the process elements at their last state before the communication alarm, unless other I/O local to that PLC indicates shutdown or over-ride conditions:
(1) Ensure that the operator can control the process using PCI MANUAL mode at the local LOI.
b) If a link fails where process elements use the remote value to determine setpoints, continue to operate using the last value received:
(1) Provide a manual override entry at the local LOI to allow an operator to enter a different value for any such remote signal.
(2) Generate an alarm whenever an over-ride value is in use.

13. 4-20 mA Hart interface cards:
a. Provide the following HART protocol information for each populated channel on the card:
1) Process variable values:
a) Primary process variable (analog): 4-20 mA current signal.
b) Primary process variable (digital): Digital value in engineering units.
c) Percent range: Primary process variable expressed as percent of calibrated range.
d) Loop current: Loop current value in milliamps.
e) Secondary process Variable 1: Digital value in engineering units available from multivariable devices (if applicable).

2) Host commands:
    a) Set primary variable units.
    b) Set upper range.
    c) Set lower range.
    d) Set damping value.
    e) Set message.
    f) Set tag.
    g) Set date.
    h) Set descriptor.
    i) Perform loop test: Force loop current to specific value.
    j) Initiate self-test: Start device self-test.
    k) Get more status available information.
3) Status and diagnostic alerts:
    a) Device malfunction: Indicated device self-diagnostic has detected a problem in device operation.
    b) Configuration changed: Indicates device configuration has been changed.
    c) Cold start: Indicates device has gone through power cycle.
    d) More status available: Indicates additional devices status data available.
    e) Primary variable analog output fixed: Indicates device in fixed current mode.
    f) Primary variable analog output saturated: Indicates 4-20 mA signal is saturated.
    g) Secondary variable out of limits: Indicates secondary variable value outside the sensor limits.
    h) Primary variable out of limits: Indicates primary variable value outside the sensor limits.
4) Device identification:
    a) Instrument tag: User defined, up to 8 characters.
    b) Descriptor: User defined, up to 16 characters.
    c) Manufacturer name (code): Code established by HCF and set by manufacturer.
    d) Device type and revision: Set by manufacturer.
    e) Device serial number: Set by manufacturer.
    f) Sensor serial number: Set by manufacturer.
5) Calibration information:
    a) Date: Date of last calibration, set by user.
    b) Upper range value: Primary variable value in engineering units for 20 mA point, set by user.
    c) Lower range value: Primary variable value in engineering units for 4 mA point, set by user.
    d) Upper sensor limit: Set by manufacturer.
    e) Lower sensor limit: Set by manufacturer.
    f) Sensor minimum span: Set by manufacturer.
    g) PV damping: Primary process variable damping factor, set by user.
    h) Message: Scratch pad message area (32 characters), set by user.
    i) Loop current transfer function: Relationship between primary variable digital value and 4-20 mA current signal.

j) Loop current alarm action: Loop current action on device failure (upscale/downscale).
k) Write protect status: Device write-protect indicator.

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 the LOI and HMI. Enable acknowledgement from either the HMI or the LOI.
c. Generate high, high-high, low, and low-low level alarms where indicated:
1) Provide an alarm reset deadband for each analog value to prevent excessive repeated alarms.
2) Provide logic and timers to inhibit analog alarms based on process events. For example, inhibit low flow alarms when a pump is stopped, or has not been running long enough to establish flow.
d. Flash all alarm and fail conditions and their respective indicators on the PCS graphic screens and local indicating lights until the condition is acknowledged by the operator, even if the alarm condition is no longer present.
e. 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.
f. Once the alarm has been cleared and the operator has acknowledged the alarm or fail condition, turn the graphic alarm indicator off.
g. 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.
h. Use interlocks and proving timers to prevent alarms from operating due to power loss, except for loss of power alarms.
i. Furnish an alarm silence pushbutton at each PCM, LOI, or LCP with an audible alarm to signal the PLC to turn off the audible alarm until the next alarm occurs.
j. Call Out alarms that are not acknowledged after a setpoint period of time shall activate the auto dialer.
k. Lamp test: Furnish lamp test pushbuttons at each control panel with more than 10 pilot lights, that illuminates all pilot lights on the panel:
1) The lamp test may sequence through blocks of lights.
2) Minimum on time for each lamp during lamp test 15 seconds.
l. Horns and Beacons:
1) Activate PCM horn and beacon on all critical alarms and on other alarms as defined by the Facility Alarm Philosophy.

2) Deactivate PCM horn and beacon when PCM reset pushbutton is activated.
3) Silence PCM horn when PCM silence pushbutton is activated.

m. Dual analog instruments:
1) For applications where 2 or more analog instruments are measuring the same process variable:
a) Generate an operator adjustable percent deviation alarm.
b) Use selector switch where shown on the drawings to switch between instruments, allowing operator to take instrument out of service which needs calibration or repair without affecting process.

3. Where a reset is shown for counts, totals and times maintained in the PLC:
a. Provide a reset selection on the HMI screen that displays the value.
b. Provide a preset function on the HMI 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 the PCS archive.
e. Log the value before preset, preset value, operator, time, and date of preset in the PCS 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 PCS 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 PCS displays.
2) Do not reset daily start count when overall count is reset.
3) Archive starts for each day through PCS.

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 PCS screens.
b. Where indicated, calculate total run time for each day:
1) Display current day and previous day run time on the HMI 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 PCS.

6. For all monitored analog values:
a. Convert all values to engineering units in floating-point format within the PLC.
b. Maintain trends in PCS.
1) Display minima and maxima on the HMI, and archive through PCS.
c. Flows and Weights:
1) Totalize flows in the PLC logic:
2) Where totalized flows are input to a discrete input, count input pulses and multiply by the volume per pulse.
3) Where no totalizer input is shown, integrate the analog input over time.
4) Display totals on the HMI and LOI.
5) Archive totals to the historical database through PCS.

d. Generate an alarm whenever an over-ride value is in use.
e. Calculate hourly, daily, and monthly averages:
    1) Calculations shall be performed by the PLC.
    2) Display averages on the HMI, and archive through PCS.
    3) Display minima and maxima on the HMI, and archive through PCS.
f. Calculate minimum and maximum values each day, and month:
    1) Calculations may be performed by the PLC or PCS.
    2) Display minima and maxima on the HMI, and archive through PCS.
g. Generate an alarm whenever an over-ride 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 specific to critical analog values, 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.
            c) Where applicable, include logic which qualifies the value and does not allow storage of non-real values. For example, if a pump is Off then a Flow measurement should not read a non-zero value.

8. 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 and display rate of change of volume on all tanks and vessels:
        1) Establish the maximum withdraw rate at which the volume should decrease (all pumps or feeders operating at maximum output). Generate an alarm whenever the volume decreases faster than this rate.
        2) Establish the maximum fill rate at which the volume should increase when filling. Generate an alarm whenever the volume increases faster than this rate. Verify tank and vessel level is fluctuating to verify the validity of the IO register. If it is determined the register is not active or failed in a manner that leaves a stagnant value generate an alarm.
        3) Display 24-hr usage that takes into account filling times unless a day tank is being used.

9. 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 affect.
        2) Monitor analog input signal quality:
            a) Over range: The input value is above the normal range (typically over 21 mA).
            b) Under range: The input value is below the normal range (typically under 3 mA, indicating a probable broken connection).
            c) Generate alarms for over or under range inputs.
            d) Do not use over or under range values for control or calculation purposes:
                (1) Where a second instrument is provided to monitor the same condition (a redundant instrument, or additional instruments furnished for averaging or different operating modes), and has a valid signal, use that input for control.
                (2) Otherwise, hold all outputs affected by the signal at their last values before the signal went out of range.
        3) Digital input filtering (proving timer):
            a) Provide an adjustable time delay function (0-10 seconds) on discrete input for the purpose of de-bouncing.
            b) By default, discrete inputs shall be configured with de-bounce timers set to zero seconds.
10. Instrument scaling (HMI/LOI):
    a. Provide 1 or more maintenance 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.
11. PCS MANUAL-DISABLED-AUTO:
    a. Where indicated, provide MANUAL-DISABLED-AUTO and START-STOP selections in the PCS, accessed from an LOI or HMI for operators with sufficient security, to provide the following operating modes:
        1) PCS AUTO: The normal, automatic control mode of the strategy which allows full PLC control in response to process conditions and programmed sequences, or by override value by SCADA system or Operator through LOI / HMI.
        2) PCS MANUAL: Enables PCS Manual control where control decisions are made by an operator through the PCS START-STOP, OPEN/CLOSE, or other selections as indicated.
        3) PCS DISABLED: Automated PCS 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 MANUAL (either direction) occurs with a smooth transition. Keep running or position status unchanged when control is switched to LOCAL 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.

12. Display the current status of all operator selections (PCS MANUAL/AUTO, PCS START/STOP, etc.) on LOI and HMI.
13. Interlocks:
    a. Implement software interlocks where indicated to place equipment in a safe condition in response to impending hazardous process conditions. Apply software interlocks when equipment is operating in PCS AUTO or PCS MANUAL:
14. Permissives:
    a. Implement software permissives where indicated to prevent equipment from starting in an unsafe condition.
    b. Apply software permissives when equipment is operating in PCS AUTO or PCS MANUAL.
15. Process control algorithms:
    a. Jog and hold: Unless otherwise indicated, use jog and hold control algorithms where possible:
        1) When the error between process variable and setpoint is beyond a setpoint deadband:
            a) Jog valve or ramp speed in the required direction for a preset “Jog Time” or until the process variable reaches or passes the setpoint.
            b) Then hold speed or position through a setpoint “Hold Time.”
            c) Continue alternating jog and hold until the error is less than the deadband.
        2) Provide operator access to Jog Time and Hold Time setpoints from the HMI.
    b. 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 PCS), or when the equipment has reached a physical limit.
            h) When controlled equipment is being operated in remote PCS MANUAL, configure the PID function to track the process variable to provide a smooth transfer between Manual and Automatic modes.
            i) Provide selectable slew rates with adjustable setpoints to allow the PID algorithm to slowly ramp to its final value to minimize system disturbance.
16. Equipment alternating and sequencing:
    a. Distribute number of starts and run time equally between identical equipment.

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 PCS 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 PCS 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 PCS AUTO or PCS MANUAL control modes based upon operator selection using the PCS 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) Re-establish PLC control of a device in a “Failed” state only after 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).

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. Motor equipped with current detection shall shut down and report a “failed” status on detection of high current.

h. 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.

i. 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).

j. Speed control:
    1) Modulate speed on VFD-driven motors using jog and hold, or 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 higher of:
            (1) Minimum motor speed to maintain adequate cooling for the type of load driven (constant or variable torque).
            (2) Minimum equipment speed, such as minimum speed to deliver flow or to deliver minimum flow for equipment cooling or lubrication.
        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 and ramp down the previously running equipment to the mid operating speed (adjustable in the PLC). Determine preset values for each condition based on equipment and system characteristics to provide approximately the same total flow or process condition with the new load running at the mid speed (for example if one pump is running and the second pump will be added, then the total flow of both pumps running at mid operating speed should be approximately the same as flow of one pump at Start Next speed).
(3) Once both equipment reach the mid operating speed, resume the speed control algorithm for those equipment.
(4) 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 initial "Stop Next" speed 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 speed of running equipment except for the equipment to be stopped up to a preset value based on the number of items running. Determine preset values for each condition based on equipment and system characteristics to provide approximately the same total flow or process condition with one fewer load running (typically slightly below the preset "Start Next" speed) while ramping speed of equipment to be stopped down to the preset minimum speed.
(b) Operate all remaining equipment at the same speed following the output of the speed control algorithm. Stop the load once it reaches minimum speed.

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 PCS screens.
b. Start an "Open Activation" timer whenever the device is expected to be open (PLC has issued an OPEN command in PCS AUTO, or OPEN was selected in PCS LOCAL.
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 PCS AUTO, or CLOSE was selected in PCS MANUAL):
   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. Limit the number of open/close /commands so that it does not exceed the manufacturer requirements.
e. 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) Place the device in a “Failed” state.
      b) Generate a “Position Fail” alarm.
f. Provide separate time delay settings for each function and for each device.
g. If the valve position inputs indicate an invalid state (i.e., valve open and closed at the same time), place the device in a “Failed” state and generate an “Invalid State” alarm.
h. Re-establish PLC control of a device in a “Failed” state only after 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 PCS.
i. For all alarm conditions, control other devices (as stopping pumps, etc.) as stated in the individual loop descriptions to make the system safe.
j. 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) per hour in the PLC:
   1) Display count on the HMI.

19. Chemical systems (LOI/HMI):
    a. Provide the following chemical system screens:
        1) Where 1 LOI manages more than 1 chemical system, a main menu screen will allow the operator to access the individual chemical system screens using software keys.
        2) One or more 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.
    b. Chemical system calculations: Perform calculations as indicated in the individual loop descriptions. Use the following assumptions, unless otherwise noted:
        1) Where chemical flow feedback is not used, assume feeder output is linear in response to control signal.
        2) Zero signal (typically 4 mA) produces zero flow.
        3) Perform flow-pacing calculations using as described in the individual loop descriptions.
    c. Provide the setpoints and in the individual loop descriptions. Typical setpoints include:
        1) Q_C: Chemical pump flow rate measured from calibration column at maximum feeder output (typically in gallons of solution per hour).
        2) D: Desired chemical concentration in the process stream in engineering units (typically milligrams of chemical per liter of process fluid).
        3) Q_f: Process flow measurement upstream of dosage point (typically in million gallons per day of process fluid).
        4) ρ: Density of the chemical solution to be fed (typically in pounds per gallon). Used to calculate the concentration of the chemical in the solution.
        5) C: Concentration of the chemical in the solution to be fed (typically in decimal format. For example, 0.25 for 25 percent chemical solution).
    d. Provide the selections indicated in the individual loop descriptions. Typical selections include:
        1) 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 (Q_C) 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.

2) TRIM FACTOR: Refer to the equations below.

e. Chemical control algorithms:

1) FLOW PACE algorithm:

a) 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.

b) Calculation is as follows (units may vary from those shown in the calculation below):

Use the following equation to calculate the chemical pump flow rate:

$$Q_C = \frac{D \cdot Q_f \cdot 8.34}{C \cdot p \cdot 24}$$

Where:
Q_C = Chemical Pump Flow Rate (gal/hr)
D = Dose setpoint (mg/L)
Q_f = Process Flow Measurement (MGD)
8.34 = Conversion Factor [(lbs • L)/(MG • day • mg)]
C = Chemical Concentration (ratio in decimal format. For example, use 0.25 for 25 percent chemical solution)
p = Chemical Density (lbs/gal)
24 = Conversion Factor (days to hours)

Use the following equation to calculate the chemical pump speed control setpoint:

$$S = \frac{Q_C}{Q_{max}}$$

Where:
S = Chemical Pump Speed Control Setpoint (0 to 100 percent)
Q_C = Flow Setpoint From Equation Above (gal/hr)
Q_{max} = Maximum Pump Flow Setpoint Based on Calibration Column Test (gal/hr).

2) FLOW PACE (open loop) with TRIM FACTOR (analyzer trim) algorithm:

a) 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.

b) Calculation is as follows (units may vary from those shown in the calculation below):

Use the following equation to calculate the chemical pump flow rate pre-trim:

$$Q_{CPT} = \frac{D \cdot Q_f \cdot 8.34}{C \cdot p \cdot 24}$$

Where,
Q_{CPT} = Chemical Pump Flow Rate Pre-Trim (gal/hr)
D = Dose setpoint (mg/L)
Q_f = Process Flow Measurement (MGD)

8.34 = Conversion Factor [(lbs • L)/(MG • day • mg)]
C = Chemical Concentration (ratio in decimal format. For example, use 0.25 for 25 percent chemical solution)
p = Chemical Density (lbs/gal)
24 = Conversion Factor (days to hours)

Use the following equation to calculate the trim factor:

$$TF = Q_{CPT} \cdot 0.1 \cdot \left(\frac{AI - \frac{1}{2}(QAH + QAL)}{-\frac{1}{2}(QAH - QAL)} \right)$$

Where:
TF = Trim Factor (gal/hr)
Q_{CPT} = Chemical Pump Flow Rate Pre-Trim (gal/hr)
AI = Analyzer Output to be Used For Trim Calculation
QAH = Analyzer Band High Value
QAL = Analyzer Band Low Value

Use the following equation to calculate the chemical pump flow rate with trim:

$$Q_{CWT} = Q_{CPT} + TF$$

Where:
Q_{CWT} = Chemical Pump Flow Rate with Trim (gal/hr)
Q_{CPT} = Chemical Pump Flow Rate Pre-Trim (gal/hr)
TF = Trim Factor (gal/hr)

Use the following equation to calculate the chemical pump speed control setpoint:

$$S = \frac{Q_{CWT}}{Q_{max}}$$

Where:
S = Chemical Pump Speed Control Setpoint (0 to 100 percent)
Q_{CWT} = Flow Setpoint from Equation Above (gal/hr)
Q_{max} = Maximum Pump Flow Setpoint Based on Calibration Column Test (gal/hr).

3) FLOW PACE with closed loop algorithm:
   a) 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.
   b) This flow rate setpoint shall be derived from the process flow and operator setpoints for dosage and concentration.
   c) Calculation is as follows (units may vary from those shown in the calculation below):

Use the following equation to calculate the chemical pump flow rate:

$$Q_C = \frac{D \cdot Q_f \cdot 8.34}{C \cdot p \cdot 24}$$

Where:
Q_C = Chemical Pump Flow Rate (gal/hr)
D = Dose setpoint (mg/L)
Q_f = Process Flow Measurement (MGD)
8.34 = Conversion Factor [(lbs • L)/(MG • day • mg)]

C = Chemical Concentration *(ratio in decimal format. For example, use 0.25 for 25 percent chemical solution)*
p = Chemical Density (lbs/gal)
24 = Conversion Factor (days to hours)

4) The speed (control variable) of the chemical feed pump shall be determined by the output of a PID controller.
   a) Setpoint of the PID controller shall be the result of the equation in the paragraph above.
   b) FLOW PACE (open and closed loop) and FLOW PACE (open and closed loop) with TRIM FACTOR for sodium hypochlorite, ammonia and all other chemicals with a long transport lag (time it takes process to react to changes in chemical injection flow) PID control algorithms shall use an oversaturated integral time and zero crossing deadband function to compensate for the transport lag.

f. Virtual day tanks:
   1) Chemical systems without actual day tanks will have their own “virtual” day tank, which will use either a pre-set volume (operator adjustable) or a calculated daily use rate based on the totalized flow (volume) of the chemical magnetic flowmeters over the virtual day tank cycle.
      a) The “virtual” day tank will start at the pre-set volume or the calculated volume (operator-selectable) and based on the storage tank level, the volume in the “virtual” day tank will decrease until the total “volume” in the virtual day tank is used.
      b) Virtual day tank will automatically compensate for any changes in the system due to the use of the dilution system (revised solution concentration).
      c) Once this occurs, the operator will be provided with a “pop-up” screen stating that the “virtual” day tank volume is used.
      d) Once this occurs, the operator will be provided with a “pop-up” screen stating that the virtual day tank needs to be refilled. Pop-up screen will contain the following information:
         (1) Time {hours and minutes} since the last day tank filling.
         (2) Volume utilized in the “virtual” day tank (based on the level transmitter measuring the chemical storage tank).
         (3) Dose {mg/L} based on the average flow rate over the “virtual” day tank cycle.
         (4) Target dose {mg/L} based on operator input.
   2) Provide a double check using the actual flowmeter values to compare with the calculated dose.
      a) Compare the magnetic flowmeter value with the calculated dose.
      b) Magnetic flowmeter value will be based on an hourly average of chemical flow rate over the day tank cycle.
   3) As an added level of control any chemical system that has an analyzer used for feedback will be tracked and alarmed if outside the operating parameters.
   4) Alarm if any condition falls outside of the flow, or level parameters.

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.
        5) Settings.
        6) Racked out.
21. Power Data:
    a. Retrieve data from:
        1) Power Quality Meters (PQMs) at 480V.
        2) Main Breaker Protective Relays on 12.47 kV Switchgear.
        3) Generator Master Control Panel.
        4) Digital bus networks, as indicated.
        5) Where available, use EtherNet IP communications.
    b. Display the following data (to the extent it is available) from the specified device.
        1) Current XXXX.X A:
            a) A-Phase.
            b) B-Phase.
            c) C-Phase.
        2) Volts: XXXX.X V:
            a) A-Phase.
            b) B-Phase.
            c) C-Phase.
        3) Reactive power: XXXX.X kVAR.
        4) Real power: XXXX.X kW.
        5) Apparent power: XXXX.X kVA.
        6) Power factor: 0.XX.
        7) Energy: XXXXXXX kW*hr.
        8) Demand peak: XXXX Amp.
        9) Demand peak: XXXX kW.
    c. For engine/generator system monitoring, also display percent of rated output.
22. Power Supply and Distribution displays Power Quality Meters display:
    a. In addition to the Power Data listed above, display the following (where available) from PQMs, Protective Relays, and Generator Master Control Panel:
        1) Frequency: Hertz.
        2) THD (current and voltage): up to 31st harmonic.
    b. Calculate, indicate, historize, and trend data in a 12.47 kV Meter Table that lists measurements from the following Protection Relays:
        1) Protection Relay on 52-G1.
        2) Protection Relay on 52-G2.
        3) Protection Relay on 52-M1.
        4) Protection Relay on 52-M2.
        5) Protection Relay on 52-M3.
        6) Display calculated values for "Load At 12.47 kV", which sums the current, kW, and kW-hr values for all five Protection Relays.

7) Display calculated values for "Load At 480V", which sums the current, kW, and kW-hr values for all PQM meters.
8) Display calculated values for "Transformer and Line Losses", which subtracts "Load at 480V" from "Load At 12.47 kV" for current, kW, and kW-hr values for all PQM meters.

c. Display the data in a 480V Meter Table that lists measurements from all power quality meters on the plant.

23. Digital bus Starters, RVSS and VFDs equipped with EtherNet IP communications:
    a. Communicate and display all values listed in the equipment specifications, indicated on the Drawings, or listed below.
    b. Communicate start and stop commands, and receive running feedback over the fieldbus network.
    c. Provide data entry screen for the cost of electricity in dollars per (kw*hr), which will be used in calculations for display.
    d. Monitor the following additional values, and display on the HMI:
        1) Motor current, phase A, B, and C.
        2) Over current alarm.
        3) Under current alarm.
        4) Running status.
        5) Phase loss.
        6) Stall.
        7) Number of starts.
        8) History of past 5 trips.
    e. Calculate, indicate, historize, and trend, the following additional values:
        1) Full Load Amps (static value, Engineer will provide).
        2) Average Motor Operating Current.
        3) Run Time (Hours).
        4) Operating Hours (Hours/Year).
        5) Average Load Factor (equals Average Motor Current Operating Current/Full Load Amps) - *display as a percentage.*
        6) Annual Energy Use (kW*hr).
        7) Annual Operating Cost (dollars).
        8) Percent of Site Electric Use (equals Annual Energy Use/Sum of Annual Energy (kW*hr) values for all PQM meters).
    f. For Variable Frequency Drives:
        1) Speed command.
        2) Speed feedback.
    g. For RVSS, Variable Frequency Drives, and where otherwise shown or available, monitor the following over the digital bus network:
        1) Line voltage.
        2) Power.
        3) Power factor.
        4) Over voltage alarm.
        5) Under voltage alarm.
        6) Over current alarm.
        7) Under current alarm.
        8) Indicate, historize, trend, and alarm data as indicated in the ACS I/O Tables on the Drawings.

24. Calculate, indicate, historize, and trend plant-wide calculated values for kW by the following Groups.
    a. Calculated values (summed from starter data for all equipment within the Groups identified below):
        1) Demand peak: XXXX Amp.
        2) Demand peak: XXXX kW.
        3) Electric Power Consumption, by Process Group (kW): XXXX kW.
        4) Electric Power Consumption, by Process Group (percent): XX.XX percent (equals Electric Power Consumption, by Process Group (kW)/Sum of Electric Power Consumption on all 480V Meters).
        5) Electric Energy Consumption, by Process Group (kW*hr): XXXX kW*hr.
        6) Electric Energy Consumption, by Process Group (percent): XX.XX percent (equals Electric Energy Consumption, by Process Group (kW)/Sum of Electric Energy Consumption on all 480V Meters).
    b. Groups - Engineer to provide lists of starters (FVNR, RVSS, VFD, and monitored feeder breaker) associated with each of the following treatment processes.
    c. Display a Process Energy Consumption Table that lists the calculated values for each of the identified Groups.
    d. Display a Process Energy Pie Graph that portions wedges according to the values calculated in Electric Energy Consumption, by Process Group (5). Label wedges, (with numeric percentage), for Groups to cover at least 90 percent of the Pie Graph. The remainder wedge of Pie Graph area can be labelled as "Other" (with numeric percentage).
25. Instruments equipped with digital bus communications:
    a. Communicate and display all values listed in the equipment specifications, indicated on the Drawings, or listed below:
        1) Instrument diagnostics.
        2) Communications health.
        3) Process variable.
        4) Alarm summary.
        5) All totalizers (if applicable).
        6) Indicate, historize, trend, and alarm data as indicated in the ACS I/O Tables on the Drawings.
26. Calculate, indicate, historize, and trend calculated values for additional, process-specific measurements. Algorithms will be provided by the Engineer.
    a. Influent:
        1) Influent flows (diurnally) vs. time (mgd vs. hours for 2 weeks, running).
        2) Influent flows (daily vs. time (mgd vs. *day of the week* for 1 week, running).
        3) Influent flows (diurnally) vs. time (mgd vs. *month of the year* for the last 3 years, running).
    b. Aeration basins:
        1) BOD loading rate vs. time.
        2) MLSS in Aeration Basins vs. time.
        3) Solids retention time (total and aerobic) vs. time.
        4) Aerobic solids retention time and WW temperature vs. time.
        5) Aerobic solids retention time and WAS load vs. time.
        6) Aerobic solids retention time and MLSS vs. time.

7) Sludge volume index vs. time.
8) Effluent ammonia and nitrate, phosphorus vs. time.

c. Secondary clarifiers:
1) Surface overflow rate vs. time.
2) Solids loading rate vs. time.
3) Effluent TSS vs. time.
4) Solids blanket depth vs. time.
5) RAS flows and percent of influent vs. time.

d. Effluent.

e. Solids treatment.

f. Plant-wide process measurements:
1) Surface overflow rate vs. time.
2) Solids loading rate vs. time.
3) Effluent TSS vs. time.
4) Solids blanket depths vs. time.
5) RAS flows and percent of influent vs. time.

27. Valves and gate operators equipped with digital bus communications:
a. Communicate and display all controls and data listed in the equipment specification, as indicated on the Drawings, or listed below:
1) Open, close or direct position commands.
2) Fully open and closed status.
3) Position.
4) High torque, overload and other applicable alarms.
5) Indicate, historize, trend, and alarm data as indicated in the ACS I/O Tables on the Drawings.

b. Establish initial torque curves using manufacturer's software for performance tracking and wear.

28. Power failure:
a. Retain all operating setpoints during power failure.

b. Restore plant operation to the state it was before the power loss:
1) Store the operating state of all major equipment and systems in the PLC, and retain the last state during a power loss.

c. Provide an operator selection to permit the plant to re-start. Once re-start is selected:
1) Allow plant loads to re-start, and allow loads to sequence on and ramp up following normal control logic. Where loads were operating in PCS MANUAL, restore their operation to the state before the power loss.
2) Use the logic described above for preventing concurrent starts to provide necessary delays between each start.

d. Operating on generator power:
1) Include running and starting kW and kVA requirements for each major equipment and system in registers in the PLC:
a) Where running load can vary due to speed, valve position, etc., use the normal starting value plus 25 percent of the difference between the maximum and minimum values.
2) Inhibit starting of loads from process control logic and from operator selection (in PCS MANUAL) that will exceed generator capability.
3) Generate the following alarms:
a) Generator near capacity: When measured kW or kVA reaches 90 percent of the rating of the generator.

b) Generator at capacity: When measured kW or kVA reaches 95 percent of the rating of the generator.
c) Unable to start: When an operator selects a load that would exceed generator starting or running capacity.
d) Insufficient capacity: When the control system needs to start a load, but is inhibited due to generator capacity.

4) Whenever the Generator at Capacity alarm is active, inhibit starting of any loads, and inhibit increase in speed of all control loops, and other changes that would increase electrical load.
5) Display the following power system data on the HMI and LOI in numerical and graphical formats:
a) Available power.
b) Current power demand.
c) Capacity of the generator.
d) Current power demand load as a percentage of capacity.
e) Generator frequency.
f) Fuel tank level.
g) Rate of fuel use.
h) Estimated run time remaining.

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL (NOT USED)

3.08 ADJUSTING (NOT USED)

3.09 CLEANING (NOT USED)

3.10 DEMONSTRATION AND TRAINING

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

3.11 PROTECTION (NOT USED)

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 17101A

SPECIFIC CONTROL STRATEGIES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Loop descriptions for:
      a. Clarifier Rakes and Turbines.
      b. Clarifier Sludge Blowdown Pumps.
      c. 4-Log Sample Panel.
      d. Ferric Chloride Storage and Feed System.
      e. Polymer Feed System.
      f. Sodium Hypochlorite Feed System.
      g. Phosphate Storage and Feed System.
      h. Carbon Dioxide (CO^2) Feed System.
      i. Ammonia Feed System.
      j. Fluoride Feed System.
      k. Chemical Transfer System.

1.02 REFERENCES

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

B. Section 17100 - Control Strategies: describes additional chemical storage and feed system monitoring and control requirements.

C. Abbreviations:
   1. IPC - Industrial Panel Computer (SCADA HMI touch screen PC).

D. 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 and Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

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 CLARIFIER RAKES AND TURBINES

A. General:
   1. References:
      a. P&ID Drawings:
         1) 14N01.
         2) 14N02.
         3) 14N03.
         4) 14N04.
   2. Key equipment:
      a. PCM-050-500-01.
      b. PCM-050-145-11.
      c. PCM-050-145-31.
      d. CLA-050-141-11.
      e. CLA-050-142-11.
      f. CLA-050-141-21.
      g. CLA-050-142-21
      h. CLA-050-141-31.
      i. CLA-050-142-31
      j. CLA-050-141-41.
      k. CLA-050-142-41.
   3. Abstract:
      a. Clarifier rakes and turbines are manually started and stopped from the VCP in the field. Existing clarifier rake and turbine status monitoring signals will be migrated from DFS to the new SCADA system.
   4. PCS monitoring:
      a. New VTScada SCADA HMI screens will be developed, installed and tested for the clarifiers by the Programmer and will display all active PLC-050-500-01 clarifier status I/O points.
      b. PCM-050-145-11 and PCM-050-145-31 clarifier rake and turbine status I/O points shown on the clarifier P&IDs are future I/O points provided by the Owner.

3.02 CLARIFIER SLUDGE BLOWDOWN PUMPS

A. General:
   1. References:
      a. P&ID Drawings:
         1) 14N01.
         2) 14N02.

3) 14N03.
4) 14N04.

2. Key equipment:
   a. PCM-050-220-01.
   b. PMP-050-143-11.
   c. PMP-050-143-12.
   d. PMP-050-143-21.
   e. PMP-050-143-22.
   f. PMP-050-143-31.
   g. PMP-050-143-32.
   h. PMP-050-143-41.
   i. PMP-050-143-42.
3. Abstract:
   a. Clarifier Nos. 1-4 are each equipped with a pair of sludge blowdown pumps that operate in a duty/standby configuration to convey sludge to the sludge holding tanks. The pumps are controlled by a single existing PLC control panel that will be replaced with a new PCM panel, PCM-050-220-01, provided under this Contract. PCM-050-220-01 will utilize the existing power, control and signal wiring. The duty pump runs based on a pre-set interval time with a pre-set duration time. Duty/standby assignment is alternated between pumps with each sludge blowdown cycle. Some of the pumps may not be in working order.

B. Temporary Controls:
   1. Prior to replacing the existing sludge blowdown PLC control panel with the new PCM, Contractor will provide temporary PLC or relay logic control hardware that provides automatic alternation between the duty and standby sludge blowdown pump between cycles and starts and stops the duty sludge blowdown pumps based on a pre-set time interval for a pre-set duration. Remote monitoring and control of the temporary controls from a SCADA HMI screen is not required. Once the new PCM panel is installed the controls for each sludge blowdown pump are to be migrated to the new PCM and the temporary controls removed. Migration of the sludge blow down pump controls to the new PCM panel will be performed in accordance with Section 01140 Work Restrictions with no downtime of the automatic sludge blowdown cycle.

C. General Requirements:
   1. New Sludge Blowdown Pump VTScada SCADA HMI screens and PLC-050-220-01 logic will be provided by the Programmer.
   2. PLC-050-220-01 logic will mimic the automatic operation of the existing PLC control logic that resides in the four (4) existing Allen-Bradley MicroLogix PLCs. Programmer will request a digital copy of existing PLC logic from the Owner.

D. PCS monitoring and control:
   1. Manual mode:
      a. Refer to Section 17100 – Control Strategies.

2. Auto mode:
    a. The logic will automatically alternate each pair sludge blowdown pumps automatically based on running time or manual input from the operator. The pumps will run for a set-point adjustable duration at set-point adjustable time-of-day intervals.
3. Set-points, indicators and alarms:
    a. Refer to Drawings and Section 17100 - Control Strategies for indicators and alarms.
    b. Programmer will coordinate with Owner for run duration and interval set-point ranges.
    c. All status and alarm signals shown on the P&ID will be monitored from new sludge blowdown PLC logic in PLC-050-220-01 and new SCADA HMI graphic screens.

3.03 4-LOG SAMPLE PANEL

A. General:
1. References:
    a. P&ID Drawings:
        1) 22N01.
2. Key equipment:
    a. PCM-050-220-01.
    b. SP-050-225-01.
    c. AIT-050-225-21.
    d. AIT-050-225-22.
    e. AIT-050-225-23.
    f. AIT-050-225-24.
    g. AIT-050-225-25.
    h. AIT-050-225-26.
    i. FSL-050-225-21.
    j. PMP-050-225-01.
3. Abstract:
    a. The 4-Log Sample Panel, SP-050-225-01, sample pump will pull sample water from the West Clear Well Sample Point for analysis by redundant pH/Temp, Chlorine and Turbidity Analyzers. The analyzer readings will be displayed and stored by the new SCADA HMI system and utilized for automatic Chlorine and Ammonia control by PLC-050-500-01. The panel will be connected to the PLC network through PCM-050-220-01 via an EtherNet/IP connection.

B. General Requirements:
1. VTScada SCADA HMI graphic screens and PLC-050-220-01 logic for the 4-log Sample Panel, SP-050-225-01, will be provided by the Programmer.
2. Operators will have the ability to select the duty instrument or analyzer from the SCADA screen or to allow PLC logic to automatically select the duty instrument or analyzer based on measured signal quality or signal out of range.
3. Analyzer Ethernet/IP connection status will be indicated on the dedicated SCADA HMI screen.
4. The sample pump will run continuously.

C. Set-points, indicators and alarms:
    a. Refer to Drawings and Section 17100 - Control Strategies for indicators and alarms.
    b. All 4-Log Sample Panel status and alarm signals shown on the P&ID will be monitored from new PLC logic in PLC-050-220-01 and new SCADA HMI graphic screens.
    c. A low sample flow alarm will be indicated on the dedicated HMI screen when the sample flow switch detects a flow rate that is less than the minimum set-point configured in FSL-50-225-01, for an operator adjustable alarm delay, initially set to 1 minute.
    d. 4-Log chlorine residual is below low residual set-point, initially set at 0.88 free chlorine, for an operator adjustable alarm delay, initially set to 1 minute.
    e. 4-Log chlorine residual is above high residual set-point, initially set a 3.0 ppm, for an operator adjustable alarm delay, initially set to 1 minute.
    f. 4-Log turbidity greater than high turbidity set-point, initially set at 1.0 turbidity, for an operator adjustable alarm delay, initially set to 1 minute.
    g. 4-Log pH less than or equal to the low pH set-point, initially set at 9.0, for an operator adjustable alarm delay, initially set to 1 minute.
    h. 4-Log pH greater than high pH set-point, initially set at 10.0, for an operator adjustable alarm delay, initially set to 1 minute.

3.04 FERRIC CHLORIDE STORAGE AND FEED SYSTEM

A. General:
    1. References:
        a. P&ID Drawings:
            1) 51N01.
            2) 51N02.
    2. Key equipment:
        a. PCM-050-500-01.
        b. TNK-050-512-31.
        c. PMP-050-513-11.
        d. PMP-050-513-21.
        e. PMP-050-513-31.
        f. PMP-050-513-41.
        g. PMP-050-513-51.
        h. LSH-514-01.
        i. LIT-512-11.
        j. FE/FIT-050-145-11 - Clarifier 1 Influent Insertion Magmeter.
        k. FE/FIT-050-145-21 - Clarifier 2 Influent Insertion Magmeter.
        l. FE/FIT-050-145-31 - Clarifier 3 Influent Insertion Magmeter.
        m. FE/FIT-050-145-41 - Clarifier 4 Influent Insertion Magmeter.

3. Abstract:
    a. An Owner furnished, Contractor installed ferric chloride metering pump skid equipped with five metering pumps will feed ferric chloride from the Ferric Chloride Day Tank, TNK-050-512-31, to four clarifier influent injection points. Under the default ferric chloride metering pump skid valve configuration PMP-050-513-11 will feed ferric chloride to the Clarifier 1 influent flow stream, PMP-050-513-21 will feed ferric chloride to the Clarifier 2 influent flow stream, PMP-050-513-41 will feed ferric chloride to the Clarifier 3 influent flow stream and PMP-050-513-51 will feed ferric chloride to Clarifier 4 influent flow stream. PMP-050-513-31 will function as a swing pump that will feed ferric chloride to any of the four clarifiers depending on how the metering pump skid valves are manually opened and closed by the operator.

B. General Requirements:
    a. New Ferric Chloride Storage and Feed System VTScada SCADA HMI screens and PLC-050-500-01 logic will be provided by the Programmer.
    b. Each of five existing ferric chloride metering pumps will receive a 4-20mA feed rate signal from PLC-050-500-01, located in control panel PCM-050-500-01, and modulate the flow of ferric chloride that is fed to each of the four clarifiers.
    c. The ferric chloride metering pumps will normally be operated in remote manual at a fixed dosing rate (fixed pump speed, set from the SCADA HMI).
    d. The operator will have the ability to assign the swing pump, PMP-050-513-31, to any of the four clarifiers. When the swing pump is assigned to a clarifier that clarifiers influent flow meter will be utilized by the PLC logic for automatic flow pacing. The SCADA HMI screens will indicate which clarifier the swing pump is assigned to.

C. PCS monitoring and control:
    1. Manual mode:
        a. Refer to Section 17100 - Control Strategies.
    2. Auto mode:
        a. A single mode of automatic operation will be provided for use at the Owner’s discretion: FLOW PACE (open loop). In FLOW PACE mode the ferric chloride metering pump will modulate metering pump speed to maintain a ratio of ferric chloride injection flow to clarifier influent flow.
    3. Set-points, indicators and alarms:
        a. Refer to Drawings and Section 17100 - Control Strategies for indicators and alarms.
        b. All ferric chloride feed system status and alarm signals shown on the P&ID will be monitored from new ferric chloride system PLC logic in PLC-050-500-01 and new SCADA HMI graphic screens.

3.05 POLYMER FEED SYSTEM

A. General:
    1. References:
        a. P&ID Drawings:
            1) 52N01.

2) 52N02.

2. Key equipment:
   a. PCM-050-500-01.
   b. PMP-050-522-11.
   c. PMP-050-522-21.
   d. PMP-050-522-31.
   e. PMP-050-522-41.
   f. FE/FIT-050-145-11 - Clarifier 1 Influent Insertion Magmeter.
   g. FE/FIT-050-145-21 - Clarifier 2 Influent Insertion Magmeter.
   h. FE/FIT-050-145-31 - Clarifier 3 Influent Insertion Magmeter.
   i. FE/FIT-050-145-41 - Clarifier 4 Influent Insertion Magmeter.
3. Abstract:
   a. Four existing polymer metering pump skids, each dedicated to one of the four existing clarifiers, feed liquid polymer to the clarifier influent injection point.

B. PCS Control:
1. General Requirements:
   a. New Polymer Storage and Feed System VTScada SCADA HMI screens and PLC-050-500-01 logic will be provided by the Programmer.
   b. Each of four existing polymer metering pumps will receive a 4-20mA feed rate signal from PLC-050-500-01, located in control panel PCM-050-500-01, and modulate the flow of polymer that is fed to each of the four clarifiers. PMP-050-522-21 will feed polymer to Clarifier 1. PMP-050-522-11 will feed polymer to Clarifier 2.PMP-050-522-31 will feed polymer to Clarifier 3. PMP-050-522-41 will feed polymer to Clarifier 4.
   c. The polymer metering pumps will typically be operated in FLOW PACE mode.
2. Manual mode: Refer to Section 17100 - Control Strategies.
3. Auto mode:
   a. Refer to the “Chemical systems (LOI/HMI)” subsection in Section 17100 for detailed automatic chemical control requirements.
   b. A single mode of automatic operation will be provided for use at the Owner’s discretion: FLOW PACE. In FLOW PACE mode the polymer metering pump will modulate metering pump speed to maintain a ratio of individual polymer injection pump flow output to the corresponding clarifier influent flow rate.
4. Indicators and Alarms:
   a. Refer Section 17100 - Control Strategies for indicators and alarms.
   b. All polymer feed system status and alarm signals shown on the P&ID will be monitored from new polymer system PLC logic in PLC-050-500-01 and new SCADA HMI graphics screens.

3.06 SODIUM HYPOCHLORITE STORAGE AND FEED SYSTEM

A. General:
1. References:
   a. P&ID Drawings:
      1) 53N01.
      2) 53N02.
2. Key equipment:

a. PCM-050-500-01.
b. PMP-050-533-11.
c. PMP-050-533-21.
d. PMP-050-533-31.
e. PMP-050-533-41.
f. PMP-050-533-51.
g. PMP-050-533-61.
h. PMP-050-533-71.
i. PMP-050-533-81.
j. AE/AIT-050-225-21 - Chlorine Residual Analyzer No. 1 (4-Log).
k. AE/AIT-050-225-22 - Chlorine Residual Analyzer No. 2 (4-Log).
l. Finished Water Chlorine Residual Analyzer No. 1.
m. Finished Water Chlorine Residual Analyzer No. 2.
n. FE/FIT-050-145-11 - Clarifier 1 Influent Insertion Magmeter.
o. FE/FIT-050-145-21 - Clarifier 2 Influent Insertion Magmeter.
p. FE/FIT-050-145-31 - Clarifier 3 Influent Insertion Magmeter.
q. FE/FIT-050-145-41 - Clarifier 4 Influent Insertion Magmeter.
r. TNK-050-532-11 - Sodium Hypochlorite Storage Tank 1.
s. TNK-050-532-21 - Sodium Hypochlorite Storage Tank 2.

3. AbstractAn existing sodium hypochlorite metering pump skid equipped with five metering pumps and a new sodium hypochlorite metering pump skid equipped with three metering pumps will feed sodium hypochlorite from Sodium Hypochlorite Storage Tanks TNK-050-532-11 and TNK-050-532-21 to the clarifier effluent, West Clearwell 4-Log disinfection, and East Clearwell influent injection points. Under the default sodium hypochlorite metering pump skid valve configuration, PMP-050-533-11 will feed sodium hypochlorite to the Clarifier 1 effluent injection point, PMP-050-533-21 will feed sodium hypochlorite to the Clarifier 2 effluent injection point, PMP-050-533-41 will feed sodium hypochlorite to the Clarifier 3 effluent injection point, PMP-050-533-51 will feed sodium hypochlorite to the Clarifier 4 effluent injection point, PMP-050-533-61 will feed sodium hypochlorite to the West Clearwell 4-Log disinfection injection point, and PMP-050-533-81 will feed sodium hypochlorite to the East Clearwell influent injection point. PMP-050-533-31 will function as a swing pump for the Clarifier 1 through Clarifier 4 effluent injection points, and PMP-050-533-71 will function as a swing pump for the West Clearwell 4-Log disinfection and East Clearwell influent injection points, depending on how the metering pump skid valves are manually opened and closed by the operator. The Clarifier 1 through Clarifier 4 influent flow meters will be utilized for flow pacing.
4. General Requirements:
    a. New Sodium Hypochlorite Storage and Feed System VTScada SCADA HMI screens and PLC-050-500-01 logic will be provided by the Programmer.
    b. Each sodium hypochlorite metering pump will receive a 4-20mA feed rate signal from PLC-050-500-01, located in control panel PCM-050-500-01, and modulate the flow of sodium hypochlorite that is fed to each injection point.

c. From the SCADA HMI screen, the operator will have the ability to assign metering pumps to an injection point, as well as the ability to assign individual Clarifier 1-4 influent flow meters (or a summation of these flow meters), FE/FIT-050-145-11, FE/FIT-050-145-21, FE/FIT-050-145-31 and FE/FIT-050-145-4, for flow pacing. Assignments will be based on the valve positions manually set by the operator in the field.
d. Metering Pump No. 1 (PMP-050-533-11) will be initially assigned to the Clarifier 1 effluent injection point. PMP-050-533-11 output will be flow paced by the logic in PLC-050-500-01 using FE/FIT-050-145-11 for flow pacing.
e. Metering Pump No. 2 (PMP-050-533-21) will be initially assigned to the Clarifier 2 effluent injection point. PMP-050-533-21 output will be flow paced by the logic in PLC-050-500-01 using FE/FIT-050-145-21 for flow pacing.
f. Metering Pump No. 3 (PMP-050-533-31) will function as a standby “swing” pump that can be assigned to any of the Clarifier 1 through Clarifier 4 effluent injection points, depending on how the metering pump skid valves are manually opened and closed by the operator.
g. Metering Pump No. 4 (PMP-050-533-41) will be initially assigned to the Clarifier 3 effluent injection point. PMP-050-533-41 output will be flow paced by the logic in PLC-050-500-01 using FE/FIT-050-145-31 for flow pacing.
h. Metering Pump No. 5 (PMP-050-533-51) will be initially assigned to the Clarifier 4 effluent injection point. PMP-050-533-51 output will be flow paced by the logic in PLC-050-500-01 using FE/FIT-050-145-41 for flow pacing.
i. Metering Pump No. 6 (PMP-050-533-61) will be initially assigned to the West Clearwell 4-Log disinfection injection point. The sum of all online clarifier flows will be utilized for flow pacing. One of a redundant pair of 4-Log chlorine residual analyzers, AE/AIT-050-225-21 or AE/AIT-050-225-22, will provide feedback for automatic trimming of the flow pacing set-point.
j. Metering Pump No. 7 (PMP-050-533-71) will function as a standby “swing” pump that can be assigned to either the West Clearwell 4-Log disinfection injection point or the East Clearwell influent injection point, depending on how the metering pump skid valves are manually opened and closed by the operator.

k. Metering Pump No. 8 (PMP-050-533-81) will be initially assigned to the East Clearwell influent injection point. The sum of all online clarifier flows will be utilized for flow pacing. One of a redundant pair of finished water chlorine residual analyzers will provide feedback for automatic trimming of the flow pacing set-point. The values of the existing chlorine residual analyzers shall be read by PLC-050-500-01 from the existing PLC over the Ethernet/IP network. Contractor shall coordinate with Owner for the tags and network address information required to read existing chlorine residual analyzer signals.

l. For 4-Log sodium hypo control and finished water trim sodium hypo control, a PID control algorithm with a zero crossing deadband and an oversaturated integral time shall be used for FLOW PACE and FLOW PACE with TRIM FACTOR to compensate for the long transport lag (time delay that occurs between the moment a change is made to the chemical flow rate and process reaction occurs). Consistent, stable performance of the sodium hypochlorite control loops shall be demonstrated by the Contractor through a minimum of 7 days of trend data submitted to Engineer for review and approval.

B. PCS monitoring and control:
   1. Manual mode:
      a. Refer to Section 17100 - Control Strategies.
   2. Auto mode:
      a. Refer to the “Chemical systems (LOI/HMI)” subsection in Section 17100 for detailed automatic chemical control requirements.
      b. PMP-050-533-11 will have one mode of automatic operation: FLOW PACE (open loop). In FLOW PACE mode sodium hypochlorite metering pump PMP-050-533-11 will modulate metering pump speed to maintain a ratio of sodium hypochlorite injection flow to Clarifier 1 influent flow.
      c. PMP-050-533-21 will have one mode of automatic operation: FLOW PACE (open loop).In FLOW PACE mode sodium hypochlorite metering pump PMP-050-533-21 will modulate metering pump speed to maintain a ratio of sodium hypochlorite injection flow to Clarifier 2 influent flow.
      d. PMP-050-533-41 will have one mode of automatic operation: FLOW PACE (open loop).In FLOW PACE mode sodium hypochlorite metering pump PMP-050-533-41 will modulate metering pump speed to maintain a ratio of sodium hypochlorite injection flow to Clarifier 3 influent flow.
      e. PMP-050-533-51 will have one mode of automatic operation: FLOW PACE. In FLOW PACE mode sodium hypochlorite metering pump PMP-050-533-51 will modulate metering pump speed to maintain a ratio of sodium hypochlorite injection flow to Clarifier 4 influent flow.
      f. PMP-050-533-61 will have two modes of automatic operation: FLOW PACE (open loop) and FLOW PACE (open loop) with TRIM FACTOR.
         1) In FLOW PACE mode sodium hypochlorite metering pump PMP-050-533-61 will modulate metering pump speed to maintain a set-point adjustable ratio of sodium hypochlorite injection flow to the sum of Clarifiers 1-4 influent flow.
         2) In FLOW PACE with TRIM FACTOR, the dose set point (ppm) will be trimmed using the 4-Log chlorine residual analyzer, AE-050-225-21 or AE-050-225-22, chlorine residual value and operator entered free chlorine setpoint.

g. PMP-050-533-81 will have two modes of automatic operation: FLOW PACE (open loop) and FLOW PACE (open loop) with TRIM FACTOR.
    a) In FLOW PACE mode sodium hypochlorite metering pump PMP-050-533-81 will modulate metering pump speed to maintain a set-point adjustable ratio of sodium hypochlorite injection flow to the sum of Clarifiers 1-4 influent flow.
    b) In FLOW PACE with TRIM FACTOR, the dose set point (ppm) will be trimmed using one of the redundant finished water chlorine residual analyzer chlorine values and operator entered free chlorine setpoint.

3. Set-points, indicators and alarms:
    a. Refer to Drawings and Section 17100 - Control Strategies for indicators and alarms.
    b. All sodium hypochlorite feed system status and alarm signals shown on the P&ID will be monitored from new sodium hypochlorite system PLC logic in PLC-050-500-01 and new SCADA HMI graphic screens.
    c. Provide alarms on the following conditions:
        1) Filter maintenance chlorine flow pacing cannot be maintained due to metering pump failure; alarm delay initially set at 2 minutes.
        2) Filter maintenance chlorine flow pacing cannot be maintained due to loss of any Clarifier influent flow meter signal; alarm delay initially set at 1 minute.
        3) 4-Log chlorine residual cannot be maintained due to metering pump failure; alarm delay initially set at 1 minutes.
        4) 4-Log chlorine residual cannot be maintained due to loss of any Clarifier influent flow meter signal; alarm delay initially set at 1 minute.
        5) Finished water chlorine residual cannot be maintained due to metering pump failure; alarm delay initially set at 1 minute.
        6) Finished water chlorine residual cannot be maintained due to loss of any Clarifier influent flow meter signal; alarm delay initially set at 1 minute.
        7) Finished water chlorine residual cannot be maintained due to metering pump failure; alarm delay initially set at 1 minute.

3.07 PHOSPHATE STORAGE AND FEED SYSTEM

A. General:
    1. References:
        a. P&ID Drawings:
            1) 54N01.
            2) 54N02.
    2. Key equipment:
        a. PCM-050-500-01.
        b. PMP-050-543-11.
        c. PMP-050-543-21.
        d. PMP-050-543-31.
        e. PMP-050-543-41.
        f. PMP-050-543-51.
        g. TNK-050-542-31.
        h. PMP-050-542-21.

i. PMP-050-542-22.
j. FE/FIT-050-145-11 - Clarifier 1 Influent Insertion Magmeter.
k. FE/FIT-050-145-21 - Clarifier 2 Influent Insertion Magmeter.
l. FE/FIT-050-145-31 - Clarifier 3 Influent Insertion Magmeter.
m. FE/FIT-050-145-41 - Clarifier 4 Influent Insertion Magmeter.

3. Abstract:
   a. An Owner furnished, Contractor installed phosphate metering pump skid equipped with five metering pumps will feed phosphate from the Phosphate Day Tank, TNK-050-542-31, to four clarifier effluent injection points. Under the default phosphate metering pump skid valve configuration PMP-050-513-11 will feed phosphate to the Clarifier 1 effluent flow stream, PMP-050-513-21 will feed phosphate to the Clarifier 2 effluent flow stream, PMP-050-513-41 will feed phosphate to the Clarifier 3 effluent flow stream and PMP-050-513-51 will feed phosphate to Clarifier 4 effluent flow stream. PMP-050-513-31 will function as a swing pump that will feed phosphate to any of the four clarifiers depending on how the metering pump skid valves are manually opened and closed by the operator.

B. General Requirements:
   a. New Phosphate Storage and Feed System VTScada SCADA HMI screens and PLC-050-500-01 logic will be provided by the Programmer.
   b. Each of five existing phosphate metering pumps will receive a 4-20mA feed rate signal from PLC-050-500-01, located in control panel PCM-050-500-01, and modulate the flow of phosphate that is fed to each of the four clarifiers.
   c. The phosphate metering pumps will normally be operated in FLOW PACE mode.
   d. The operator will have the ability to assign the swing pump, PMP-050-543-31, to any of the four clarifiers. When the swing pump is assigned to a clarifier that clarifiers effluent flow meter will be utilized by the PLC logic for automatic flow pacing. The SCADA HMI screens will indicate which clarifier the swing pump is assigned to.

C. PCS monitoring and control:
   1. Manual mode:
      a. Refer to Section 17100 - Control Strategies.
   2. Auto mode:
      a. A single mode of automatic operation will be provided for use at the Owner’s discretion: FLOW PACE (open loop). In FLOW PACE mode the phosphate metering pump will modulate metering pump speed to maintain a ratio of phosphate injection flow to clarifier influent flow.
   3. Set-points, indicators and alarms:
      a. Refer to Drawings and Section 17100 - Control Strategies for indicators and alarms.
      b. All phosphate feed system status and alarm signals shown on the P&ID will be monitored and controlled from new phosphate system PLC logic in PLC-050-500-01.

3.08 CARBON DIOXIDE (CO^2) FEED SYSTEM

A. General:
   1. References:
      a. P&ID Drawings:
         1) 55N01.
         2) 55N02.
         3) 55N03.
   2. Key equipment:
      a. CARB-050-553-11 - Carbonator 1.
      b. CARB-050-553-21 - Carbonator 2.
      c. CARB-050-553-31 - Carbonator 3.
      d. AE/AIT-050-185-11 - Filter Influent pH (North Treatment Basin).
      e. AE/AIT-050-185-21 - Filter Influent pH (South Treatment Basin).
      f. FE/FIT-050-145-11 - Clarifier 1 Influent Insertion Magmeter.
      g. FE/FIT-050-145-21 - Clarifier 2 Influent Insertion Magmeter.
      h. FE/FIT-050-145-31 - Clarifier 3 Influent Insertion Magmeter.
      i. FE/FIT-050-145-41 - Clarifier 4 Influent Insertion Magmeter.
   3. Abstract:
      a. Three existing Carbonator units modulate the flow of gaseous CO2 into a carrier water piping system that feeds CO2 to each of the four clarifiers.

B. Temporary Controls:
      a. Temporary network hardware, monitoring/control hardware and all required software licenses and appurtenances will be provided by the Contractor, through the ICSC, and configured by the Programmer to allow the Owner's existing DFS SCADA system to read the following analyzer and flow meter signals over the Ethernet network for the purpose of maintaining the existing chemical feed system control strategies until the new PLCs and SCADA HMI screens are fully operational:
         1) AE/AIT-050-185-11 - Filter Influent pH (North Treatment Basin).
         2) AE/AIT-050-185-21 - Filter Influent pH (South Treatment Basin).
         3) FE/FIT-050-145-11 - Clarifier 1 Influent Insertion Magmeter.
         4) FE/FIT-050-145-21 - Clarifier 2 Influent Insertion Magmeter.
         5) FE/FIT-050-145-31 - Clarifier 3 Influent Insertion Magmeter.
         6) FE/FIT-050-145-41 - Clarifier 4 Influent Insertion Magmeter.

C. General Requirements:
      a. New Carbon Dioxide Feed System VTScada SCADA HMI screens and PLC logic will be provided by the Programmer.
      b. Each of three existing carbonator units will receive a 4-20mA feed rate signal from PLC-050-550-01. The enabled carbonators will modulate the flow of CO^2 gas/water solution that is fed to the four existing clarifiers. The CO^2 feed system will be monitored and controlled by a new PLC control panel, PCM-050-550-01, furnished by the Contractor.

D. PCS Control:
   1. Manual mode:
      a. Refer to Section 17100 - Control Strategies.

2. Auto mode:
    a. The carbonators will have two modes of automatic operation: FLOW PACE (open loop) and FLOW PACE (open loop) + TRIM FACTOR.
        1) In FLOW PACE mode the enabled carbonator units will modulate metering pump speed to maintain a ratio of CO^2 injection flow to the summation of clarifier influent flows (F-050-145-11, F-050-145-21, F-050-145-31, F-050-145-41).
        2) In FLOW PACE + TRIM FACTOR mode the ratio of CO^2 solution flow to the sum of clarifier influent flow will be incrementally adjust up or down by + or - 1% after an adjustable interval time.
3. Set-points, indicators and alarms:
    a. Refer to Drawings and Section 17100 - Control Strategies for indicators and alarms.
    b. All CO^2 feed system status and alarm signals shown on the P&ID will be monitored and controlled from new CO^2 feed system PLC logic in PLC-050-550-01.

3.09 AMMONIA FEED SYSTEM

A. General:
1. References:
    a. P&ID Drawings:
        1) 56N01.
2. Key equipment:
    a. PCM-050-500-01.
    b. MFC-050-563-11.
    c. MFC-050-563-21.
    d. AE/AIT-050-225-21 - Chlorine Residual Analyzer No. 1 (4-Log).
    e. AE/AIT-050-225-22 - Chlorine Residual Analyzer No. 2 (4-Log).
    f. FE/FIT-050-145-11 - Clarifier 1 Influent Insertion Magmeter.
    g. FE/FIT-050-145-21 - Clarifier 2 Influent Insertion Magmeter.
    h. FE/FIT-050-145-31 - Clarifier 3 Influent Insertion Magmeter.
    i. FE/FIT-050-145-41 - Clarifier 4 Influent Insertion Magmeter.
3. Abstract:
    a. One of two existing, redundant anhydrous ammonia mass flow controllers will modulate the flow of gaseous ammonia into a carrier water piping system that injects ammonia solution into the East Clearwell influent piping (crossover pipe between East Clearwell and West Clearwell). The ammonia will be flow paced with a set-point that is a multiplier of ammonia to the 4-Log chlorine residual analyzer, AE/AIT-050-225-21 or AE/AIT-050-225-22, chlorine residual value.

B. General Requirements:
1. New Ammonia Storage and Feed System VTScada SCADA HMI screens and PLC-050-500-01 logic will be provided by the Programmer.
2. Each of the two existing anhydrous ammonia mass flow controllers will receive a 4-20mA feed rate signal from PLC-050-500-01, located in control panel PCM-050-500-01, and modulate MFC-050-563-11 or MFC-050-563-21 to control the ammonia feed rate. The operators will have the ability to manually assign the duty mass flow controller in SCADA, based on the ammonia feed system valve configuration, manually set by the operator in the field.

C. PCS monitoring and control:
   1. Manual mode:
      a. Refer to Section 17100 - Control Strategies.
   2. Auto mode:
      a. Refer to the “Chemical systems (LOI/HMI)” subsection in Section 17100 for detailed automatic chemical control requirements.
      b. The ammonia metering pumps will have one mode of automatic operation: FLOW PACE (closed loop).
         1) In FLOW PACE mode the operator will enter an ammonia feed set-point that is a multiplier of ammonia to 4-Log chlorine residual, set between 1 and 5 in 0.1 resolution. The assigned ammonia mass flow controller will modulate output to maintain a ratio of ammonia injection flow to a summation of clarifier influent flow based on the ratio dose set point. Residual ammonia must be adjusted to provide an ammonia residual that is always between 0.03 and 0.07 ppm.
   3. Set-points, indicators and alarms:
      a. Refer to Drawings and Section 17100 - Control Strategies for indicators and alarms.
      b. All ammonia feed system status and alarm signals shown on the P&ID will be monitored and controlled from new ammonia system PLC logic in PLC-050-500-01.
      c. Provide alarms on the following conditions:
         1) Ammonia Residual cannot be maintained due to loss of ammonia mass flow controller flow status signal; alarm delay initially set at 2 minutes.
         2) Ammonia Residual cannot be maintained due to loss of any Clarifier influent flow meter signal; alarm delay initially set at 2 minutes.
      d. Ammonia Residual cannot be maintained due to loss of 4-Log chlorine residual analyzer chlorine residual signal; alarm delay initially set at 2 minutes.

3.10 FLOURIDE FEED SYSTEM

A. General:
   1. References:
      a. P&ID Drawings:
         1) 57N01.
         2) 57N02.
   2. Key equipment:
      a. PCM-050-500-01.
      b. PMP-050-573-11.
      c. PMP-050-573-21.
      d. PMP-050-573-31.
      e. LSH-050-572-01.
      f. LIT-050-572-11.
      g. FE/FIT-050-145-11 - Clarifier 1 Influent Insertion Magmeter.
      h. FE/FIT-050-145-21 - Clarifier 2 Influent Insertion Magmeter.
      i. FE/FIT-050-145-31 - Clarifier 3 Influent Insertion Magmeter.
      j. FE/FIT-050-145-41 - Clarifier 4 Influent Insertion Magmeter.

3. Abstract:
    a. An Owner furnished, Contractor installed fluoride metering pump skid equipped with three fluoride metering pumps modulates the flow of fluoride to the clarifiers through two separate injection points. PMP-050-573-11 will feed fluoride to the Clarifiers 1 & 2 effluent flow stream injection point. PMP-050-513-31 will feed fluoride to Clarifiers 3 & 4 effluent flow stream injection point. PMP-050-573-21 will function as a standby “swing” pump that will fluoride to either Clarifiers 1 & 2 or Clarifiers 3 & 4, depending on how the valves on the metering pump skid are manually opened and closed by the operator.

B. General Requirements:
    a. New Fluoride Storage and Feed System VTScada SCADA HMI screens and PLC-050-500-01 logic will be provided by the Programmer.
    b. Each of three existing fluoride metering pumps will receive a 4-20mA feed rate signal from PLC-050-500-01, located in control panel PCM-050-500-01, and modulate the flow of fluoride that is injected into the clarifier effluent flow streams.

C. PCS monitoring and control:
    1. Manual mode:
        a. Refer to Section 17100 - Control Strategies.
    2. Auto mode:
        a. Refer to the “Chemical systems (LOI/HMI)” subsection in Section 17100 for detailed automatic chemical control requirements.
        b. A single mode of automatic operation will be provided:
            1) FLOW PACE (open loop). In FLOW PACE mode the fluoride metering pump will modulate metering pump speed to maintain a ratio of fluoride injection flow to a summation of clarifier influent flow. One metering pump will be assigned to Clarifiers 1&2, with flow ratio logic summing flow readings F-050-145-11 and F-050-145-21 for flow pacing. The second metering pump will be assigned to Clarifiers 3&4, with flow ratio logic summing flow readings F-050-145-31 and F-050-145-41 for flow pacing.
    3. Set-points, indicators and alarms:
        a. Refer to Drawings and Section 17100 - Control Strategies for indicators and alarms.
        b. All fluoride feed system status and alarm signals shown on the P&ID will be monitored and controlled from new fluoride system PLC logic in PLC-050-500-01.

3.11 CHEMICAL TRANSFER SYSTEM

A. General:
    1. References:
        a. P&ID Drawings:
            1) 51N01.
            2) 54N01.
    2. Key equipment:
        a. PCM-050-500-01.
        b. LCP-050-500-02.

c. LIT-050-512-11.
d. TNK-050-512-11.
e. VAL-050-512-15.
f. TNK-050-512-31.
g. PMP-050-512-21.
h. PMP-050-512-22.
i. LSHH-050-512-31.
j. LIT-050-512-31.
k. TNK-050-542-11.
l. VAL-050-542-15.
m. LIT-050-542-11.
n. TNK-050-542-31.
o. VAL-050-542-15.
p. TNK-050-542-31.
q. PMP-050-542-21.
r. PMP-050-542-22.
s. LSHH-050-542-31.
t. LIT-050-542-31.

3. Abstract:
   a. Two ferric chloride transfer pumps will transfer ferric chloride from the existing ferric chloride bulk storage tank, TNK-050-512-11, to the new day tank, TNK-050-512-31.
   b. Two phosphate transfer pumps will transfer phosphate from the existing phosphate bulk storage tank, TNK-050-542-11, to the new day tank, TNK-050-542-31.
   c. A transfer valve between each bulk tank and set of transfer pumps will be opened only during chemical transfers from the bulk tank to day tank for safety purposes.

B. General Requirements:
   1. A chemical transfer system local control panel, LCP-050-500-02, will provide local monitoring and control of the ferric chloride and phosphate transfer pumps. The LCP will be equipped with motor starters, a touch screen IPC, local operators and status indicators for starting and stopping the ferric chloride and phosphate transfers. LCP-050-500-02 will be monitored and controlled by PLC-050-500-01 in PCM-050-500-01.
   2. New Chemical Transfer System VTScada SCADA HMI screens and PLC-050-500-01 logic will be provided by the Programmer. IPC-050-500-02 will display the chemical transfer system SCADA HMI graphic screens.

C. Hardwired control:
   1. Pilot devices:
      a. LCP:
         1) START pushbutton (Ferric Chloride).
         2) STOP pushbutton (Ferric Chloride).
         3) START (Phosphate).
         4) STOP (Phosphate).
         5) SILENCE/RESET pushbutton.
         6) EQUIPMENT STOP pushbutton.

D. PCS monitoring and control:
   1. Both monitoring and control of ferric chloride and phosphate transfers will be available only from IPC-050-500-02, including, but not limited to transfer start/stop, transfer valve open/close, transfer pump start/stop, set-point adjustment, status indication and alarm indication. Transfers and transfer valve and pump control will not be available from any other SCADA HMI screens, for safety purposes. The SCADA HMI will display all ferric chloride and phosphate transfer information and transfer pump status, set-points and alarms, but no adjustments to the set-points or other parameters associated with Fluoride transfer will be available from the SCADA HMI.
   2. Ferric and Phosphate Transfer Valves:
      a. Auto/Manual Selection:
         1) Ferric and Phosphate Transfer Valve Auto/Manual Selection - from IPC-050-500-02 only, operators will have the ability to select “Automatic” or “Manual” mode for transfer valve VAL-050-512-15 and VAL-050-542-15 by means of a graphical Auto/Manual selector switch on the valve HMI screen faceplate.
      b. Manual mode:
         1) Refer to Section 17100 - Control Strategies.
         2) The operator will have the ability to open and close VAL-050-512-15 and VAL-050-542-15 manually from the valve’s HMI faceplate on IPC-050-500-02.
      c. Manual Mode:
         1) VAL-050-512-15 will be opened/closed automatically based on the automatic ferric chloride transfer sequence described herein.
         2) VAL-050-542-15 will be opened/closed automatically based on the automatic phosphate transfer sequence described herein.
   3. Ferric Chloride and Phosphate Transfer Pumps:
      a. Auto/Manual Selection:
         1) Ferric and Phosphate Transfer Pump Auto/Manual Selection - from IPC-050-500-02 only, operators will have the ability to select “Automatic” or “Manual” mode for transfer pumps PMP-050-512-21, PMP-050-512-22, PMP-050-542-21, and PMP-050-542-22 by means of a graphical Auto/Manual selector switch on the valve HMI screen faceplate.
      b. Manual Mode:
         1) Refer to Section 17100 - Control Strategies.
         2) When either of the pair of ferric chloride or phosphate transfer pumps are set to Manual mode, automatic transfer sequences will be disabled for that chemical and the transfer pump that is set to manual will be the only pump in the pair allowed to run. The other pump will be temporarily disabled and mode selection for that pump will also be disabled. The disabled pumps icon will be temporarily greyed out. Either the start button on the pump faceplate on the IPC-050-500-02 HMI graphic screen or momentary “Start” button on LCP-050-500-02, will be used to start the selected pump.
      c. Auto Mode:
         1) For both Ferric Chloride and Phosphate, when both transfer pumps are set to Automatic mode the duty transfer pump will be started and stopped automatically by the selected automatic transfer mode sequence, Operator Maintained Automatic or Automatic.

4. Ferric Chloride and Phosphate Automatic and Operator Maintained Automatic Transfer Modes:
    Automatic Mode (Default) – When operator presses the “Start” button momentarily on LCP-050-500-02 an automatic transfer sequence will be activated. The transfer valve will open. Once PLC-050-500-01 confirms that the transfer valve is in the opened position, the duty transfer pump will start and run. When any one of the following events occurs the running transfer pump will stop and transfer valve will close:
        1) Operator presses the “Stop” button or ESD button.
        2) Day Tank Fill Level Set-point is reached as determined by the day tank radar level signal.
        3) Day Tank Maximum Fill Time Set-Point (determined by Contractor during clean water testing period) is reached.
        4) Day Tank Overflow Alarm signal is activated.
        5) Any of the run permissive interlocks for the running transfer pump are activated.
    b. Operator Maintained Automatic Mode – This mode is functionally the same as Automatic mode only the operator is required to press and hold (maintain) the “Start” button in order maintain the automatic transfer sequence. When the Start button is released the automatic sequence will stop and the running transfer pump will stop, and transfer valve will close.
    c. If the Day Tank Fill Level Set-point is reached an HMI screen pop-up will be displayed that reads “Ferric Chloride Transfer Complete” or “Phosphate Transfer Complete” depending on which chemical was transferred.
5. Transfer Pump Duty/Standby/Out of Service:
    a. Refer to Section 17100 - Control Strategies.
    b. An Automatic/Manual selector on the IPC-050-500-02 HMI graphic screen will allow for toggling between manual and automatic duty and standby pump selection and out of service selection.
    c. Automatic Duty/Standby Transfer Pump Selection – When both transfer pumps are in automatic mode the pumps will alternate duty/standby roles after each start/stop cycle. When an automatic transfer is initiated (or maintained) the duty pump will start. When the transfer stops the duty pump will be assigned as the standby pump and the standby will be assigned as the duty pump.
    d. Manual Duty/Standby Transfer Pump Selection – A check box or bubble type selector on the IPC-050-500-02 HMI graphic screen will allow for manual selection of pump roles, as indicated in the table below. Placing the pump in “Out of Service” will disable the pump.
6. Equipment Stop (ESD):
    a. When the Equipment Stop switch is pressed all chemical transfers will stop.
7. Run Permissive Interlocks (PLC Logic): Transfer pumps will not be allowed to run in either Manual or Automatic mode if any of the following conditions are true:
    a. Transfer Valve Opened status signal is not received by PLC after an adjustable set-point, initially set at 30 seconds, configured during startup.
    b. Day Tank Level is at or above Day Tank Fill Level Set-point.
    c. Day Tank Overflow Alarm is active.
    d. Bulk Storage Tank level is below Minimum Transfer Level Set-point.

e. Selected Duty Transfer Pump Motor Overload is active.
f. The other transfer pump is set to “Manual” mode or status of the other transfer pump is “Running”. Only one transfer pump can run at time.
g. Transfer Pump is placed in “Out of Service”.
h. Equipment Stop (ESD) button is Pressed.
i. Common Alarm is activated.

8. Set-points, indicators and alarms:
   a. Refer to Drawings and Section 17100 - Control Strategies for indicators and alarms.
   b. At a minimum, the following alarms will be indicated on the HMI screen and will activate the LCP common alarm:
      1) Day Tank Fill Time Exceeded (Transfer Fail) – Should the duration between transfer start and the “Day Tank Fill” set-point being reached exceed a duration set-point (seconds) determined during startup, an alarm will be displayed on the HMI “Fluoride Day Tank Fill Time Exceeded. Transfer Failed.”. Any running transfer pumps will be automatically stopped.
      2) Transfer Valve Failed to Open – Should the duration between the Transfer Valve open command and opened status exceed a duration set-point, determined during startup and initially set at 30 seconds, an alarm will be displayed on the HMI “Transfer Valve Open Time Exceeded. Valve Failed to Open”.
      3) Transfer Valve Failed to Close – Should the duration between the Transfer Valve close command and closed status exceed a duration set-point determined during startup and initially set at 30 seconds, an alarm will be displayed on the HMI “Transfer Valve Close Time Exceeded. Valve Failed to Close”.
      4) Transfer Pump Motor Overload.
      5) Equipment Stop (ESD) button is Pressed.
   c. Critical Alarms – The following alarms will be indicated on the HMI screen and illuminate the common alarm indicator lamp and horn and strobe light on the LCP:
      1) Day Tank High-High Level Alarm (PLC Set-point determined during startup).
      2) Day Tank Overflow Alarm – Capacitive Level Switch on Day Tank overflow pipe activates.
      3) Day Tank Drain Rate Alarm – Should the level in the day tank chemical volume decrease at a calculated drain rate (gpm) that exceeds a gallons per minute set-point, when no transfers are running, the alarm will activate. (PLC Set-point determined during startup, initially set at 5 gpm).
   d. Non-critical Alarms and Notifications– The following alarms and notifications will be indicated on the HMI screen. Refer to Section 17100 and the Drawings for additional requirements.
      1) Intrusion detected.
      2) Alarm Horn Silenced.
      3) Transfer Mode changed to Automatic.
      4) Transfer Mode changed to Operator Maintained Automatic.
      5) Transfer Pump Placed in Manual Mode.
      6) Transfer Valve Place in Manual Mode.

7) Bulk Storage Tank Level Below Minimum Transfer Level (PLC Set-point determined during startup).
8) Day Tank Below Minimum Operating Level (PLC Set-point determined during startup).

3.12 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

END OF SECTION

SECTION 17201

LEVEL MEASUREMENT: SWITCHES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Capacitance level switch.

1.02 REFERENCES

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

1.03 SUBMITTALS

A. Furnish Submittals as specified in Section 01330 - Submittal Procedures and Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Provide complete documentation covering the traceability of calibration instruments.

1.04 QUALITY ASSURANCE

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

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

C. Manufacture instrument facilities certified to the quality standards of ISO 9001 - Quality Systems - Model for Quality Assurance in Design/Development, Production, Installation and Servicing.

1.05 DELIVERY, STORAGE, AND HANDLING

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

1.06 PROJECT OR SITE CONDITIONS

A. Project environmental conditions as specified in Section 01850 - Design Criteria.

1.07 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
   1. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or Specifications.

1.08 WARRANTY

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

1.09 MAINTENANCE

A. Furnish parts, materials, fluids, etc., necessary for operation, maintenance, and calibration purposes throughout the warranty period. Deliver these supplies before Project Substantial Completion.

PART 2 PRODUCTS

2.01 GENERAL

A. Provide instruments identified in the Contract Documents.

2.02 DESIGN AND PERFORMANCE CRITERIA

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

2.03 MANUFACTURERS

A. One of the following or equal:
   1. Capacitance level switch:
      a. IFM, KI5038 or Engineer approved equal.

2.04 MANUFACTURED UNITS

A. As specified in this Section, including Attachment A - ISA Datasheet - Level Measurement: Switches.

B. Capacitance level switch:
   1. Shall be made up of mechanically rigid and rugged non-metallic probe and probe housing made of PBT with a capacitive sensor and control relay.
   2. Switch:
      a. Sensing element with a threaded connection.
      b. Control relay senses the liquid level by capacitance measurement between the electrode probe, the process liquid, and the equipment ground:
         1) Power supply:
            a) As indicated in the datasheets.
            b) 24 VDC (3-Wire Device).

2) Outputs:
a) Relay outputs:
(1) As indicated in the datasheets.
(2) 1 Form C contact.
(3) Programmable for adjustable hysteresis.
(4) Configurable for fail-safe operation.

c. Electrical connection: manufacturer supplied cable.
d. Enclosure:
1) As indicated in the datasheets.
2) Non-hazardous area:
a) NEMA Type 4X.
3) For more information, see Attachment A - ISA Datasheet - Level Measurement: Switches.

2.05 ACCESSORIES

A. Provide threaded adapter for connecting capacitance level switch as required to connect to process piping.

2.06 FINISHES (NOT USED)

2.07 SOURCE QUALITY CONTROL

A. FM approval certification or equal when installed in classified areas.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine the installation location for the instrument and verify that the instrument will work properly when installed.

3.02 INSTALLATION

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

3.03 CALIBRATION AND TESTING

A. As specified in Section 17950 - Commissioning for Instrumentation and Controls.

3.04 SCHEDULES

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

END OF SECTION

ATTACHMENT A - ISA DATASHEET - LEVEL MEASUREMENT: SWITCHES

Level Switch

SPECIFICATION 17201

PROJECT INFORMATION

PLANT
PROJECT 200948
CUSTOMER CITY OF DELRAY BEACH
LOCATION

ELEMENT/SWITCH

GENERAL NOTE: FIELDS SHOWN WITH THE [*] SYMBOL ARE NOT SHOWN ON THE DATASHEET BUT MAY BE REQUIRED BY THE CONTRACT DOCUMENTS. THE CONTRACTOR SHALL SUBMIT COMPLETE ISA DATASHEETS FOR EACH INSTRUMENT PER ALL SPECIFIED REQUIREMENTS.

TAG	P&ID	SERVICE	CAPACITANCE PROX				
LSHH-050-512-32	51N01	FLUID	[*]	HAZARDOUS APP	N/A	POWER	[*]
LE-050-512-32		MEASURING PRINCIPLE	CAPACITANCE	ELEM. ENC. CLASS	NEMA 4X	POWER LOCATION	LOOP
		SET POINT	0.5 INCH	ELEM. MATERIAL	MFR. STD.	OUTPUT	RELAY
		MOUNTING	INTEGRAL	SWITCH ENCL. CLASS	NEMA 4X	RELAY FORM	SPST
		TYPICAL DETAILS	[*]	ENCL. MATERIAL	MFR. STD.	PLC	PLC-050-500-01
		SURGE PROTECTION	NO				

TAG	P&ID	SERVICE	CAPACITANCE PROX				
LSHH-050-542-32	54N01	FLUID	[*]	HAZARDOUS APP	N/A	POWER	[*]
LE-050-542-32		MEASURING PRINCIPLE	CAPACITANCE	ELEM. ENC. CLASS	NEMA 4X	POWER LOCATION	LOOP
		SET POINT	0.5 INCH	ELEM. MATERIAL	MFR. STD.	OUTPUT	RELAY
		MOUNTING	INTEGRAL	SWITCH ENCL. CLASS	NEMA 4X	RELAY FORM	SPST
		TYPICAL DETAILS	[*]	ENCL. MATERIAL	MFR. STD.	PLC	PLC-050-500-01
		SURGE PROTECTION	NO				

SECTION 17207

LEVEL MEASUREMENT: RADAR FREQUENCY MODULATED CONTINUOUS WAVE

PART 1 GENERAL

1.01 SUMMARY

A. Section includes requirements for:
   1. Radar (FMCW - frequency modulated continuous wave) level instruments.

1.02 REFERENCES

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

B. Abbreviations.

1.03 SUBMITTALS

A. Furnish Submittals as specified in Section 01330 - Submittal Procedures and Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Furnish commissioning Submittals listed below, and as specified in this Section and Section 01756 - Commissioning:
   1. Manufacturer’s representative qualifications.
   2. Owner training.

1.04 QUALITY ASSURANCE

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

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

C. Furnish commissioning Submittals listed below, and as specified in this Section and Section 01756 - Commissioning:
   1. Manufacturer’s representative qualifications.
   2. Owner training.

1.05 DELIVERY, STORAGE, AND HANDLING

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

1.06 PROJECT OR SITE CONDITIONS

A. As specified in Section 01850 - Design Criteria.

1.07 ADMINISTRATIVE REQUIREMENTS

A. Notify the Engineer if any installation condition does not meet the instrument manufacturer’s recommendations or specifications.

1.08 WARRANTY

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

PART 2 PRODUCTS

2.01 GENERAL

A. Provide instruments identified in Contract Documents.

2.02 DESIGN AND PERFORMANCE CRITERIA

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

2.03 MANUFACTURERS

A. Provide one of the following:
   1. VEGA, VEGAPULS 21 with VEGAMET 841 remote display.
   2. Engineer approved equivalent by Endress & Hauser or Siemens.

2.04 MANUFACTURED UNITS

A. As specified in this Section, including Attachment A - ISA Datasheet - Level Measurement: Radar Frequency Modulated Continuous Wave.

B. Frequency Modulated Continuous Wave (FMCW):
   1. General:
      a. The radar liquid level measurement element (antenna) shall operate on the frequency modulated continuous wave (FMCW) radar signaling technology at approximately 80 GHz frequency sweep.
      b. The radar wave reflects from the surface being measured and received back to the instrument via a sensor.
      c. The instrument measures the travel time between the transmitting surface, and receiver to calculate the level.

2. Performance requirements:
    a. Accuracy: minimum of ±0.2 mm.
    b. Resolution: minimum 0.1 percent of full range.
    c. Beam angle: 8°.
    d. Maximum sensing distance: 15m.
    e. Range: As indicated on the Drawings and/or in the instrument datasheets.
3. Element:
    a. Element process material compatibility: Manufactured of PVDF.
    b. Connections:
        1) Process: The antenna design shall be suitable for mounting in a nozzle or flange, or as indicated on the Drawings or Instrument index or required by the application.
        2) Product condensation on the antenna shall not affect performance.
        3) Electrical Conduit entry: 1/2-inch male NPT.
4. Transmitter:
    a. As indicated in the datasheets.
    b. NEMA 4X weatherproof, plastic housing.
    c. Operating range of -40 to 70 degrees Celsius at 10 to 100 percent relative humidity.
    d. Power supply:
        1) As indicated in the datasheets.
        2) 24 VDC.
    e. Output(s):
        1) As indicated in the datasheets.
        2) Isolated 4 to 20 mA DC with HART communication protocol.
    f. Self-diagnostics and automatic data checking.
    g. Signal Integrity:
        1) Able to ignore momentary level spikes or momentary loss of echo and indicate loss of echo condition on indicating transmitter unit.
    h. Adjustment:
        1) Configuration via Smartphone, Tablet or PC with Bluetooth communications.
    i. Protected terminals and fuses in a separate compartment which isolates field connection from electronics.
5. Remote Display:
    a. NEMA 4X weatherproof, plastic housing.
    b. Operating range of -40 to 70 degrees Celsius at 10 to 100 percent relative humidity.
    c. Power supply: 120Vac.
    d. Output(s): Isolated 4 to 20 mA DC with HART communication protocol.
    e. Display: Large backlit LCD display for level or volume.
    f. Adjustment: Configuration via Smartphone, Tablet or PC with Bluetooth communications.

2.05 ACCESSORIES

A. Software: Provide Windows based PC software for configuration and echo mapping.

B. Mounting hardware:
    1. All mounting angle, bracket materials and fasteners must be suitable for the chemical and environment in which they are being installed.

2. Provide a combination of a custom FRP strut and radar manufacturer supplied swing-type mounting bracket system (VEGA mounting angle with adjustable bracket type A) to suspend the transmitter 6” above each chemical bulk storage and day tank to provide a non-contact installation with the radar signal passing through the top of the plastic tank. The radar mounting bracket system shall be mounted to a wall, ceiling, nearby permanent structure or the chemical tank itself. The radar transmitter manufacturer supplied mounting bracket shall allow for the transmitter to be swung out of the way of tank nozzles and ladders for maintenance purposes.

C. Radar Installation Detail Submittal - Submit a radar mounting system detail for each chemical bulk storage and day tank furnished under this Contract for approval by Engineer.

D. Provide a sunshield for remote displays mounted outdoors.

2.06 FINISHES (NOT USED)

2.07 SOURCE QUALITY CONTROL

A. Factory calibrate each level transmitter at a facility that is traceable to NIST.

B. Provide complete documentation covering the traceability of calibration instruments.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine the installation location for the instrument and verify that the instrument will work properly when installed.

3.02 INSTALLATION

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

B. Coordinate the installation with trades to ensure that the mechanical system has necessary appurtenances for proper installation of instruments.

C. Configure the radar’s mapping software during installation to omit interference caused by tank nozzles, walls, or obstructions inside the vessel. A radar level empty tank calibration shall be performed for each chemical bulk storage and day tank furnished under this Contract using the radar transmitter manufacturer’s configuration software. During empty tank calibration each plastic tank shall be filled with water just above the bottom of the tank to allow the radar sweep to reflect off the water surface and not the floor below the tank.

D. Radar level transmitter shall be mounted in a non-contact location, 6” above the tank and in accordance with radar manufacturer installation recommendations.

E. Radar level remote displays shall be mounted on a wall or stanchion (pipe stand) mounting system and shall be clearly visible to operators. For both stanchion and wall mounted displays located outdoors, provide a custom fabricated 316L stainless steel sunshield.

3.03 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

B. Testing and Demonstration of Radar Level Devices:
   1. Radar level transmitters and remote displays are to be tested and demonstrated to Engineer and Owner by the Contractor to be working properly by filling the chemical bulk storage and day tanks furnished under this Contract with potable water prior to the introduction of chemical into the tanks. Testing shall include filling bulk storage tanks with water at a rate the meets or exceeds a truck filling rate and no less than a rate of 60 gallons per minute. Day tanks shall be filled with water using the chemical transfer pumps. During the tank fill testing the radar measurement shall be linear and stable as the liquid level increases. Failure to demonstrate a linear and stable radar level response shall be considered a failure of the test and demonstration by the Engineer and require the Contractor to troubleshoot and resolve the cause of the error and to repeat the demonstration at the Contractor's expense. Refer to Section 01140 - Work Restrictions for additional requirements.

C. Owner Training:
   1. Perform Owner training as specified in Section 01756 - Commissioning.
   2. Topics:
      a. Operation topics:
         1) Perform a live demonstration of the radar instrument configuration using the manufacturer's Bluetooth smartphone or tablet app, including an empty tank calibration procedure and how to ignore radar signal returns that are not important for level measurement.
   3. Number of sessions:
      a. Operations: 1.
      b. Maintenance: 1.

3.04 ADJUSTING

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

B. Perform radar transmitter 4-20mA output scaling adjustment and all other required adjustments as required to provide an accurate liquid level reading over the full range.

3.05 SCHEDULES

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

END OF SECTION

Engineers...Working Wonders With Water®

Level Transmitter

RESERVOIR

PROJECT INFORMATION

PLANT		**CUSTOMER**	CITY OF DELRAY BEACH
PROJECT	200948	**LOCATION**	

GENERAL NOTE: FIELDS SHOWN WITH THE [*] SYMBOL ARE NOT SHOWN ON THE DATASHEET BUT MAY BE REQUIRED BY THE CONTRACT DOCUMENTS. THE CONTRACTOR SHALL SUBMIT COMPLETE ISA DATASHEETS FOR EACH INSTRUMENT PER ALL SPECIFIED REQUIREMENTS.

GENERAL

TAG	LIT-050-512-31 (LE-050-512-31)		
SPECIFICATION NUMBER	17207	**MEASURING PRINCIPLE**	RADAR FREQUENCY
DRAWING NUMBER	51N01	**PLC**	PLC-050-500-01
SERVICE	RADAR FMCW	**TYPICAL DETAILS**	[*]

CONNECTION

PROCESS CONNECTION	N/A

FLUID

LEVEL RANGE	0-500 GALLONS	**TEMPERATURE**	N/A

ELEMENT

ELEMENT TAG NO.	LE-050-512-31	**ENCLOSURE CLASS**	NEMA 4X
ELEMENT HAZ. MATERIALS	N/A	**ELEMENT MATERIAL**	MFR. STD.
SUBMERGENCE DETECTION	NO	**TEMPERATURE COMP.**	NO
HEATED ELEMENT	NO		

TRANSMITTER

TRANSMITTER TAG NO.	LIT-050-512-31	**HAZARDOUS APPROVALS**	N/A
MOUNTING	REMOTE	**ENCLOSURE CLASS**	NEMA 4X
POWER	120VAC-1P	**OUTPUT**	4-20 MA
AMBIENT TEMPERATURE	[*]	**MEASUREMENT APPL**	LEVEL
SURGE PROTECTION	NO		

NOTES

[*]

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RESERVOIR

PROJECT INFORMATION

PLANT		**CUSTOMER**	CITY OF DELRAY BEACH
PROJECT	200948	**LOCATION**	

GENERAL NOTE: FIELDS SHOWN WITH THE [*] SYMBOL ARE NOT SHOWN ON THE DATASHEET BUT MAY BE REQUIRED BY THE CONTRACT DOCUMENTS. THE CONTRACTOR SHALL SUBMIT COMPLETE ISA DATASHEETS FOR EACH INSTRUMENT PER ALL SPECIFIED REQUIREMENTS.

GENERAL

TAG	LIT-050-532-11 (LE-050-532-11)		
SPECIFICATION NUMBER	17207	**MEASURING PRINCIPLE**	RADAR FREQUENCY
DRAWING NUMBER	53N01	**PLC**	PLC-050-500-01
SERVICE	RADAR FMCW	**TYPICAL DETAILS**	[*]

CONNECTION

PROCESS CONNECTION	N/A

FLUID

LEVEL RANGE	[*]	**TEMPERATURE**	N/A

ELEMENT

ELEMENT TAG NO.	LE-050-532-11	**ENCLOSURE CLASS**	NEMA 4X
ELEMENT HAZ. MATERIALS	N/A	**ELEMENT MATERIAL**	MFR. STD.
SUBMERGENCE DETECTION	NO	**TEMPERATURE COMP.**	NO
HEATED ELEMENT	NO		

TRANSMITTER

TRANSMITTER TAG NO.	LIT-050-532-11	**HAZARDOUS APPROVALS**	N/A
MOUNTING	REMOTE	**ENCLOSURE CLASS**	NEMA 4X
POWER	120VAC-1P	**OUTPUT**	4-20 MA
AMBIENT TEMPERATURE	[*]	**MEASUREMENT APPL**	LEVEL
SURGE PROTECTION	NO		

NOTES

[*]

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PROJECT INFORMATION

PLANT		**CUSTOMER**	CITY OF DELRAY BEACH
PROJECT	200948	**LOCATION**	

GENERAL NOTE: FIELDS SHOWN WITH THE [*] SYMBOL ARE NOT SHOWN ON THE DATASHEET BUT MAY BE REQUIRED BY THE CONTRACT DOCUMENTS. THE CONTRACTOR SHALL SUBMIT COMPLETE ISA DATASHEETS FOR EACH INSTRUMENT PER ALL SPECIFIED REQUIREMENTS.

GENERAL

TAG	LIT-050-542-11 (LE-050-542-11)		
SPECIFICATION NUMBER	17207	**MEASURING PRINCIPLE**	RADAR FREQUENCY
DRAWING NUMBER	54N01	**PLC**	PLC-050-500-01
SERVICE	RADAR FMCW	**TYPICAL DETAILS**	[*]

CONNECTION

PROCESS CONNECTION	N/A

FLUID

LEVEL RANGE	[*]	**TEMPERATURE**	N/A

ELEMENT

ELEMENT TAG NO.	LE-050-542-11	**ENCLOSURE CLASS**	NEMA 4X
ELEMENT HAZ. MATERIALS	N/A	**ELEMENT MATERIAL**	MFR. STD.
SUBMERGENCE DETECTION	NO	**TEMPERATURE COMP.**	NO
HEATED ELEMENT	NO		

TRANSMITTER

TRANSMITTER TAG NO.	LIT-050-542-11	**HAZARDOUS APPROVALS**	N/A
MOUNTING	REMOTE	**ENCLOSURE CLASS**	NEMA 4X
POWER	120VAC-1P	**OUTPUT**	4-20 MA
AMBIENT TEMPERATURE	[*]	**MEASUREMENT APPL**	LEVEL
SURGE PROTECTION	NO		

NOTES

[*]

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Level Transmitter

RESERVOIR

PROJECT INFORMATION

PLANT		**CUSTOMER**	CITY OF DELRAY BEACH
PROJECT	200948	**LOCATION**	

GENERAL NOTE: FIELDS SHOWN WITH THE [*] SYMBOL ARE NOT SHOWN ON THE DATASHEET BUT MAY BE REQUIRED BY THE CONTRACT DOCUMENTS. THE CONTRACTOR SHALL SUBMIT COMPLETE ISA DATASHEETS FOR EACH INSTRUMENT PER ALL SPECIFIED REQUIREMENTS.

GENERAL

TAG	LIT-050-542-31 (LE-050-542-31)		
SPECIFICATION NUMBER	17207	**MEASURING PRINCIPLE**	RADAR FREQUENCY
DRAWING NUMBER	54N01	**PLC**	PLC-050-500-01
SERVICE	RADAR FMCW	**TYPICAL DETAILS**	[*]

CONNECTION

PROCESS CONNECTION	N/A

FLUID

LEVEL RANGE	0-80 GALLONS	**TEMPERATURE**	N/A

ELEMENT

ELEMENT TAG NO.	LE-050-542-31	**ENCLOSURE CLASS**	NEMA 4X
ELEMENT HAZ. MATERIALS	N/A	**ELEMENT MATERIAL**	MFR. STD.
SUBMERGENCE DETECTION	NO	**TEMPERATURE COMP.**	NO
HEATED ELEMENT	NO		

TRANSMITTER

TRANSMITTER TAG NO.	LIT-050-542-31	**HAZARDOUS APPROVALS**	N/A
MOUNTING	REMOTE	**ENCLOSURE CLASS**	NEMA 4X
POWER	120VAC-1P	**OUTPUT**	4-20 MA
AMBIENT TEMPERATURE	[*]	**MEASUREMENT APPL**	LEVEL
SURGE PROTECTION	NO		

NOTES

[*]

SECTION 17301

FLOW MEASUREMENT: SWITCHES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Thermal dispersion flow switches.
   2. Piston type flow switches.
   3. Vane type flow switches.
   4. Shuttle flow switches.
   5. Magnetic flow switches.
   6. Doppler non-contact flow switch.

1.02 REFERENCES

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

1.03 SUBMITTALS

A. Furnish Submittals as specified in Section 01330 - Submittal Procedures and Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Provide complete documentation covering the traceability of calibration instruments.

1.04 QUALITY ASSURANCE

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

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

1.05 DELIVERY, STORAGE, AND HANDLING

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

1.06 PROJECT OR SITE CONDITIONS

A. As specified in Section 01850 - Design Criteria.

1.07 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
   1. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

1.08 WARRANTY

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

1.09 MAINTENANCE

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

PART 2 PRODUCTS

2.01 GENERAL

A. Provide instruments identified in the Contract Drawings.

2.02 DESIGN AND PERFORMANCE CRITERIA

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

2.03 MANUFACTURERS

A. One of the following or equal:
   1. Thermal dispersion type:
      a. Fluid Components International LLC, FLT93.
      b. Kayden.

2.04 MANUFACTURED UNITS

A. As specified in this Section, including Attachment A - ISA Datasheet - Flow Measurement: Switches.

B. Thermal dispersion type:
   1. General:
      a. Instrument uses a heated probe and a reference probe.
         1) Deviation in the amount of heat measured by the reference probe deviates beyond the setpoint an adjustable relay closes.

2) Switch:
a) Micro-processor based with continuous self-diagnostics, “Smart Heater” to prevent sensor failure, no mechanical jumpers or trim pots, and a 3-year warranty.

2. Performance requirements:
a. Accuracy:
1) Liquids: Within 0.5 percent reading or within 0.04 fps.
b. Repeatability: Within 1 percent of setpoint range.
c. Response time: 0.5 to 2.5 seconds.
d. Adjustable bypass delay timer.
e. Adjustable range.

3. Switch characteristics:
a. Exposed parts: Powder coated aluminum housing.
b. Wetted parts:
1) Materials as recommended by the manufacturer and approved by the Engineer.
c. Power supply:
1) 115 VAC.
d. Operating temperature range:
1) -40 degrees Fahrenheit to 140 degrees Fahrenheit.
e. Enclosure:
1) As indicated in the datasheets.
2) Non-hazardous area:
a) NEMA Type 4X.

4. General:
a. Fluid flow causes a piston (with a central circular opening) to move along the axis of a precision-tapered shaft, creating a variable orifice between the hole and the shaft.

5. Performance requirements:
a. Accuracy: Within 10 percent full scale.
b. Adjustable range.

6. Switch characteristics:
a. Material:
1) Body: Brass or stainless steel.
2) Other internals: Stainless steel.
b. Contacts: Single pole, double throw (SPDT).
c. Maximum operating temperature: 200 degrees Fahrenheit.
d. Enclosure
1) Non-hazardous area:
a) NEMA Type 4X.
e. For more information, see Attachment A - ISA Datasheet - Flow Measurement: Switches.

C. Provide sunshades for outdoor installations.

2.05 FINISHES (NOT USED)

2.06 SOURCE QUALITY CONTROL

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

B. Provide FM approval certification or equal when installed in classified areas.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine the installation location for the instrument and verify that the instrument will work properly when installed.

3.02 INSTALLATION

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

3.03 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

3.04 SCHEDULES

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

END OF SECTION

ATTACHMENT A - ISA DATASHEET - FLOW MEASUREMENT: SWITCHES

Flow Switch

SPECIFICATION 17301

PROJECT INFORMATION

PLANT

PROJECT 200948

CUSTOMER CITY OF DELRAY BEACH

LOCATION

ELEMENT/SWITCH

GENERAL NOTE: FIELDS SHOWN WITH THE [*] SYMBOL ARE NOT SHOWN ON THE DATASHEET BUT MAY BE REQUIRED BY THE CONTRACT DOCUMENTS. THE CONTRACTOR SHALL SUBMIT COMPLETE ISA DATASHEETS FOR EACH INSTRUMENT PER ALL SPECIFIED REQUIREMENTS.

TAG	P&ID						
FSL-050-225-21	22N01	**SERVICE**	THERMAL FLOW SWITCH				
FE-050-225-21		**FLUID**	WATER	**HAZARDOUS APP**	N/A	**POWER**	120VAC-1P
		MEASURING PRINCIPLE	THERMAL	**ELEM. ENC. CLASS**	NEMA 4X	**POWER LOCATION**	LOOP
		SET POINT	0-7 GPM	**SWITCH ENCL. CLASS**	NEMA 4X	**OUTPUT**	RELAY
		PROCESS CONNECTION	F-NPT	**PRESSURE**	N/A	**RELAY FORM**	SPDT
		CONNECTION MATERIAL	[*]	**TEMPERATURE**	N/A	**PLC**	PLC-050-220-01
		INSERTION LENGTH	PER MANUFACTURER	**VISCOSITY**	N/A	**SURGE PROTECTION**	NO
		TYPICAL DETAILS	[*]				

SECTION 17401

PRESSURE/VACUUM MEASUREMENT: DIAPHRAGM AND ANNULAR SEALS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Diaphragm seals.
   2. Annular seals.

1.02 REFERENCES

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

B. Standards:
   1. American National Standards Institute (ANSI).

1.03 SUBMITTALS

A. Furnish Submittals as specified in Section 01330 - Submittal Procedures and Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Additional requirements:
   1. Product data:
      a. Manufacturer’s installation instructions.
      b. Seal type.
      c. Body materials.
      d. Diaphragm material.
      e. Fill fluid type.
      f. Seal size.
      g. Options.
      h. Process connection.

1.04 QUALITY ASSURANCE

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

B. Examine the complete set of Contract Documents and verify the compatibility with the installed conditions, including:
   1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
   2. Physical conditions:
      a. Installation and mounting requirements.
      b. Location within the process.

c. Accessories: Verify that required accessories are provided and are compatible with the process conditions and physical installation.

1.05 DELIVERY, STORAGE, AND HANDLING

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

1.06 PROJECT OR SITE CONDITIONS

A. As specified in Section 01850 - Design Criteria.

1.07 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
   1. Notify the Engineer if any installation condition does not meet the manufacturer's recommendations or specifications.

1.08 WARRANTY

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

1.09 MAINTENANCE

A. Furnish a spare annular seal for every size provided in the Project.

PART 2 PRODUCTS

2.01 GENERAL

A. Provide seals identified in the Contract Documents.

2.02 DESIGN AND PERFORMANCE CRITERIA

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

2.03 MANUFACTURERS

A. Diaphragm seals:
   1. For chemical applications, liquids containing solids, and liquids with pulsating flow having pressures less than or equal to 15 pounds per square inch gauge: One of the following or equal:
      a. Ashcroft:
         1) Flushing connection: Type 741.
         2) Without flushing connection: Type 740.
   2. For chemical applications, liquids containing solids, and liquids with pulsating flow having pressures greater than or equal to 15 pounds per square inch gauge: One of the following or equal:
      a. Ashcroft:

1) Flushing connection: Type 201.
2) Without flushing connection: Type 200.

B. Annular seals:
1. One of the following or equal:
a. Ashcroft, Wafer Isolation Ring.

2.04 MANUFACTURED UNITS

A. Diaphragm seals:
1. General:
a. Diaphragm seal and pressure instrument shall be assembled by the pressure instrument manufacturer and shipped as an assembly.
2. Requirements:
a. Seal type:
1) Metallic diaphragm: Welded to upper housing.
2) Elastomer diaphragm: Bonded to upper housing.
b. Process connection:
1) As indicated in the instrument datasheets.
2) 1-inch NPT.
c. Instrument connection: 1/2-inch NPT.
d. Material construction:
1) As indicated in the instrument datasheets.
2) Type 316 stainless steel.
e. Provide 1/4-inch flushing connection in diaphragm lower housing or provide flushing ring.
f. Flush port plug: Same material of construction as diaphragm lower housing.
g. Provide fill/bleed connection.
h. Mounting: As indicated in the Contract Documents.
i. Provide Type 316 stainless steel armored capillary for remote installations.
j. Nuts and bolts: Type 316 stainless steel.
k. Materials of construction:
1) Sewage, sludge, liquids containing solids, and liquids with pulsating flow having pressures less than or equal to 15 pounds per square inch:
a) Diaphragm: Type 316 stainless steel.
b) Lower housing: Type 316 stainless steel.
c) Upper housing: Manufacturer's standard.
d) Fill fluid: Silicone oil.
2) Sewage, sludge, liquids containing solids, and liquids with pulsating flow having pressures greater than 15 pounds per square inch:
a) Diaphragm: Type 316 stainless steel.
b) Lower housing: Type 316 stainless steel.
c) Upper housing: Manufacturer's standard.
d) Fill fluid: Silicone oil.
3) Chlorine:
a) Diaphragm: Tantalum.
b) Lower housing: Hastelloy C.
c) Upper housing: Manufacturer's standard.
d) Fill fluid: Halocarbon.

4) Ferric chloride:
    a) Diaphragm: PTFE or tantalum.
    b) Lower housing: PVC or titanium.
    c) Upper housing: Manufacturer's standard.
    d) Fill fluid: Silicone oil.
5) Fluorosilicic acid:
    a) Diaphragm: Viton™.
    b) Lower housing: PVC.
    c) Upper housing: Manufacturer's standard.
    d) Fill fluid: Silicone oil.
6) Hydrochloric acid:
    a) Diaphragm: PVDF or tantalum.
    b) Lower housing: Hastelloy B2.
    c) Upper housing: Manufacturer's standard.
    d) Fill fluid: Fluorolube.
7) Ozone:
    a) Diaphragm: Type 316 stainless steel.
    b) Lower housing: Type 316 stainless steel.
    c) Upper housing: Manufacturer's standard.
    d) Fill fluid: Halocarbon.
8) Potassium permanganate:
    a) Diaphragm: PTFE or tantalum.
    b) Lower housing: PVDF or titanium.
    c) Upper housing: Manufacturer's standard.
    d) Fill fluid: Halocarbon.
9) Sodium permanganate:
    a) Diaphragm: PTFE.
    b) Lower housing: PVDF.
    c) Upper housing: Manufacturer's standard.
    d) Fill fluid: Halocarbon.
10) Sodium bisulfite:
    a) Diaphragm: Tantalum.
    b) Lower housing: Titanium.
    c) Upper housing: Manufacturer's standard.
    d) Fill fluid: Silicone oil.
11) Sodium hydroxide:
    a) Diaphragm: Monel.
    b) Lower housing: Monel.
    c) Upper housing: Manufacturer's standard.
    d) Fill fluid: Silicone oil.
12) Sodium hypochlorite:
    a) Diaphragm: Tantalum.
    b) Lower housing: Titanium.
    c) Upper housing: Manufacturer's standard.
    d) Fill fluid: Halocarbon.
13) Sulfur dioxide:
    a) Diaphragm: PTFE or tantalum.
    b) Lower housing: PVDF or titanium.
    c) Upper housing: Manufacturer's standard.
    d) Fill fluid: Halocarbon.
14) Sulfuric acid:

a) Diaphragm: PTFE or tantalum.
b) Lower housing: Hastelloy B2.
c) Upper housing: Manufacturer's standard.
d) Fill fluid: Halocarbon.

15) Engineer's approval.

B. Annular seals:
1. General:
a. Inside diameter of annular seal shall provide uninterrupted flow:
1) There shall be no dead ends or crevices.
2) Process flow shall be sufficient to make the annular seal self-cleaning.
b. Pressure sensing flexible cylinder shall measure pressure around the full inside circumference of the pipeline.
2. Requirements:
a. Pressure rating: Equivalent to the ANSI flanges.
b. Materials of construction:
1) Inner flexible cylinder: Manufacturer's standard.
2) Body:
a) Carbon steel with epoxy coating.
b) As indicated in the instrument datasheets.
c) Type 316 stainless steel.
3) Assembly flanges: To match adjacent piping.
4) Fill fluid: Silicone oil.
c. Nominal pipe size: As indicated on the Drawings.
d. Process connection:
1) As indicated in the instrument datasheets.
2) Wafer.
e. Instrument connection: 1/2-inch NPT.
f. Provide isolating needle valve between annular seal and pressure instrument.

2.05 ACCESSORIES (NOT USED).

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 INSTALLATION

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation System.

B. Coordinate the installation with trades to ensure that the mechanical system has necessary appurtenances, including weld-o-lets, valves, etc., for proper installation of instruments.

C. Do not use Teflon™ thread seal tape on pressure instruments with silicone oil fill fluid.

3.03 CALIBRATION AND TESTING

A. As specified in Section 17950 - Commissioning for Instrumentation and Controls.

END OF SECTION

SECTION 17402

PRESSURE/VACUUM MEASUREMENT: INSTRUMENT VALVES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Instrument valve tree.
   2. Valve manifolds.

1.02 REFERENCES

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

1.03 SUBMITTALS

A. Furnish Submittals as specified in Section 01330 - Submittal Procedures and Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Additional requirements:
   1. Product data:
      a. Instrument valve type.
      b. Body material.
      c. Size.
      d. Options.
   2. Shop Drawings:
      a. Mounting details for instrument valves.

1.04 QUALITY ASSURANCE

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

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

C. Provide valves manufactured at facilities certified to the quality standards of ISO 9001.

1.05 DELIVERY, STORAGE, AND HANDLING

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

B. Protect valve manifolds and protective coatings from damage during handling and installation. Repair coating where damaged.

1.06 PROJECT OR SITE CONDITIONS

A. As specified in Section 01850 - Design Criteria.

1.07 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
   1. Notify the Engineer if any installation condition does not meet the manufacturer's recommendations or specifications.

1.08 WARRANTY

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

1.09 MAINTENANCE

A. Furnish parts, materials, fluids, etc., necessary for operation, maintenance, and calibration purposes throughout the warranty period. Deliver these supplies before Project Substantial Completion.

PART 2 PRODUCTS

2.01 GENERAL

A. Provide valves and valve manifolds identified in the Contract Documents.

2.02 DESIGN AND PERFORMANCE CRITERIA

A. Provide valves and valve manifolds suitable for the installed Site conditions, including, but not limited to, material compatibility, process, and ambient temperatures.

2.03 MANUFACTURERS

A. Instrument valve tree as indicated in the Contract Documents.

B. Valve manifolds:
   1. One of the following or equal:
      a. Anderson Greenwood.
      b. Emerson, Rosemount.
      c. Hex Valve.
      d. Noshok.

2.04 MANUFACTURED UNITS

A. Instrument valve tree as indicated in the Contract Documents.

B. Valve manifolds:
   1. General:
      a. Provide 2-valve, 3-valve, blowdown type 5-valve, or metering type 5-valve manifolds, as indicated in the datasheets.
      b. Valve manifolds shall have 1-piece bonnet with a metal-to-metal seal to the valve body below the bonnet threads.
   2. Requirements:
      a. Bonnet lock pin to prevent accidental loosening.
      b. Gas leak tested metal-to-metal hard seat design for hard seat valves.
      c. Gas leak tested soft seat design with replaceable seat for soft seat valves.
      d. Manifold valves shall have straight through portion for bi-directional flow and easy roddable cleaning.
      e. Manifold valves shall allow for direct or remote instrument mounting.
      f. Shall be able to withstand pressures up to 6,000 psi for soft seat valves and 10,000 psi for hard seat valves at maximum 200 degrees Fahrenheit.
      g. Materials of construction:
         1) Body material: Type 316 stainless steel.
         2) O-ring: Teflon™.
      h. 2-valve manifolds:
         1) 1 isolation valve and 1 drain/vent and calibration valve.
      i. 3-valve manifolds:
         1) 2 isolation valves and 1 equalizing valve for differential pressure applications.
         2) Plugged vent connections used for vent/drain or calibration.
      j. Blowdown 5-valve manifold:
         1) 2 isolation valves, 1 equalizing valve, 2 blowdown valves for differential pressure applications.
      k. Metering 5-valve manifold:
         1) 2 isolation valves, 2 equalizing valves, 1 vent/drain and calibration valve for differential pressure applications.

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

2.05 ACCESSORIES

A. Provide tube fitting, female NPT, or pipe butt weld connections if necessary.

B. Provide stainless steel concentric or eccentric pipe nipples when necessary.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine the installation location and verify the valve will work properly when installed.

3.02 INSTALLATION

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

B. Coordinate the installation with trades to ensure that the mechanical system has necessary appurtenances, including weld-o-lets, valves, etc., for proper installation of valves.

END OF SECTION

SECTION 17404

PRESSURE/VACUUM MEASUREMENT: GAUGES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Pressure/vacuum gauges.

1.02 REFERENCES

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

B. Standards:
   1. American Society of Mechanical Engineers (ASME):
      a. B40.100 - Pressure Gauges and Gauge Attachments.

1.03 SUBMITTALS

A. Furnish Submittals as specified in Section 01330 - Submittal Procedures and Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Product data:
   1. Accessories.

1.04 QUALITY ASSURANCE

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

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

1.05 DELIVERY, STORAGE, AND HANDLING

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

1.06 PROJECT OR SITE CONDITIONS

A. As specified in Section 01850 - Design Criteria.

1.07 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
   1. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

1.08 WARRANTY

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

PART 2 PRODUCTS

2.01 GENERAL

A. Provide instruments specified in the Contract Documents.

2.02 DESIGN AND PERFORMANCE CRITERIA

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

2.03 MANUFACTURERS

A. One of the following or equal:
   1. Ashcroft:
      a. Maximum pressure less than 10 pounds per square inch: Model 1009.
      b. Maximum pressure greater than or equal to 10 pounds per square inch: Model 1009.[
      c. Removable Gauges:
         1) Model 1082.
   2. Wika, Model XSEL type 232.34.
   3. Ametek U.S. Gauge.

2.04 MANUFACTURED UNITS

A. General:
   1. Pressure gauge assembly shall include pressure sensing element, gauge case, and dial mechanism.

B. Performance requirements:
   1. Pressure range:
      a. As specified in the Contract Documents.
   2. Accuracy:
      a. Grade 2A, as defined by ASME B40.100.
      b. Within 1.0 percent of span after friction errors are eliminated by tapping or vibration.

c. Maximum allowable friction inaccuracy: Within 1.0 percent of span.

3. Element:
   a. Where the maximum pressure is less than 10 pounds per square inch, provide socket and bellows; for all other pressure ranges, employ a Bourdon® tube.
   b. Socket tips for bellows and Bourdon® tube:
      1) Materials: Type 316 stainless steel.
   c. Overpressure: Minimum 130 percent of maximum range pressure without damage to gauge or sensing element.
   d. Wetted materials:
      1) As indicated in the datasheets.
4. Dial gauge:
   a. Dial size: 3-1/2 inches.
   b. Dial case material:
      1) As indicated in the datasheets.
      2) Maximum pressure less than 10 pounds per square inch:
         a) Aluminum.
      3) Maximum pressure greater than or equal to 10 pounds per square inch:
         a) Stainless steel.
   c. Provide safety gauge with safety blow out through the back or top of the unit.
   d. Dial face: Gasketed shatterproof glass or polycarbonate.
   e. Provide gauge locks on pressure gauges directly connected to diaphragm seals.
   f. Provide gauge locks where possible.
   g. Hermetically sealed.
   h. Connection and mounting:
      1) Direct mounted and suitable for outdoor installation.
      2) 1/2-inch NPT.
      3) Connection material:
         a) As indicated in the datasheets.
         b) Stainless steel.
   i. Pointer: Externally adjustable.

2.05 ACCESSORIES

A. Pulsation dampeners and snubbers:
   1. As indicated in the datasheets.
   2. Provide pulsation dampener or snubber with each pressure gauge installed on discharge of positive displacement type pump.
   3. Provide piston-type snubber if pressure spikes will exceed 130 percent of gauge maximum range.
   4. Mount pulsation dampener or snubber integrally to the pressure gauge.
   5. Connection: 1/2-inch NPT.
   6. Provide diaphragm seals as specified in the Contract Documents and/or as indicated in the datasheets.
   7. Diaphragm seal and pressure gauge shall be assembled by manufacturer and shipped as an assembly.

B. Provide means for gauge isolation as specified in Section 17402 - Pressure/ Vacuum Measurement: Instrument Valves:
   1. Mount valve manifold integrally to the gauge.
   2. Valve manifold and pressure gauge shall be assembled by manufacturer and shipped as an assembly.

C. Provide stainless steel tags for each instrument. Tags shall be labeled as specified in the Contract Documents.

2.06 FINISHES (NOT USED)

2.07 SOURCE QUALITY CONTROL

A. Factory calibrate each pressure gauge at a facility that is traceable to the NIST.

B. Provide complete documentation covering the traceability of calibration instruments.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine the installation location for the instrument and verify that the instrument will work properly when installed.

3.02 INSTALLATION

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

B. Coordinate the installation with trades to ensure that the mechanical system has necessary appurtenances including weld-o-lets, valves, etc., for proper installation of instruments.

3.03 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

3.04 ADJUSTING

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

3.05 SCHEDULES

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

END OF SECTION

ATTACHMENT A - ISA DATASHEET - PRESSURE/VACUUM MEASUREMENT: GAUGES

A/E: Carollo Engineers	PRESSURE/VACUUM MEASUREMENT: GAUGES					
					Spec. No.	Rev.
Contractor:	No	By	Date	Revision	17404	
Project:					Contract	Date
Customer:						
Plant:					Req.	P.O.
Location:						
BOM No.:					By / Chk / App	
File:						

1	**Type**	Direct Rdg.: √		Receiver:		Other:
2	**Mounting**	Surface:		Local:		Flush:
3	**Dial**	Diameter: 4.5”			Color:	
4	**Case**	**Cast Iron:**	**Aluminum:**	**Phenolic: √**	**Polished SS**	**Other:**
5	**Ring**	Screwed:	Hinged:	Slip:	Std:	Other:
6	**Blowout Protection**	None:	Disc:	Front:	Other:	Mfr. Std.
7	**Lens**	Glass: √			Plastic:	
8	**Options**	Siphon: N/A			Material:	
9	**Other**	Snubber:				
10	**Other**	Pressure Limit Valve: N/A				
11	**Other**	Movement Damping: N/A				
12	**Nominal Accuracy Required**					
13	**Pressure Element**	Bourdon®: √		Bellows:		Other:
14	**Element Material**	Bronze:	Steel:		Type SS: 316 √	Other:
15	**Socket Material**	Bronze:	Steel:		SS: 316	Other:
16	**Connection**	¼ in.:	½ in.: √		Bottom:	Other:
17	**Movement**	Dampened:	Standard: √		Other:	
18	**Diaphragm Seal**	Mfr.:		Wetted Part Mat’l:		Type:
19	**Other**	Other Mat’l:		Fill Fluid:		Model:
20	**Manufacturer**					
21	**Model No.**					

Rev	Tag Number	Range	P&ID	Service	Notes

Notes:
Refer to Section 17402 - Pressure/Vacuum Measurement: Instrument Valves for additional instrument valve requirements.

Pressure Gauge

SPECIFICATION 17404

PROJECT INFORMATION

PLANT

PROJECT 200948

CUSTOMER CITY OF DELRAY BEACH

LOCATION

ELEMENT/SWITCH

GENERAL NOTE: FIELDS SHOWN WITH THE [*] SYMBOL ARE NOT SHOWN ON THE DATASHEET BUT MAY BE REQUIRED BY THE CONTRACT DOCUMENTS. THE CONTRACTOR SHALL SUBMIT COMPLETE ISA DATASHEETS FOR EACH INSTRUMENT PER ALL SPECIFIED REQUIREMENTS.

TAG	P&ID						
PI-050-225-21	22N01	**SERVICE**	PRESSURE INDICATOR				
		FLUID	WATER	**CONNECTION TYPE**	[*]	**BOTT. HOUSING MAT.**	MFR. STD.
		TEMPERATURE	75 DEG F	**ISOLATION SEALS**	N/A	**INSTRUMENT VALVES**	[*]
		MEASURING PRINCIPLE	DIRECT	**CASE MATERIAL**	SST	**DIAPHRAGM MAT.**	MFR. STD.
		PRESSURE RANGE:	[*]	**TYPICAL DETAILS**	[*]	**DIAL SIZE**	[*]
		GAUGE RANGE	0-15 PSI	**OPTIONS**	[*]	**AMBIENT TEMP**	95 DEG F
TAG	**P&ID**						
PI-050-512-21	51N01	**SERVICE**	PRESSURE INDICATOR				
		FLUID	[*]	**CONNECTION TYPE**	[*]	**BOTT. HOUSING MAT.**	MFR. STD.
		TEMPERATURE	[*]	**ISOLATION SEALS**	N/A	**INSTRUMENT VALVES**	[*]
		MEASURING PRINCIPLE	DIRECT	**CASE MATERIAL**	[*]	**DIAPHRAGM MAT.**	MFR. STD.
		PRESSURE RANGE:	[*]	**TYPICAL DETAILS**	[*]	**DIAL SIZE**	[*]
		GAUGE RANGE	0-100 PSIG	**OPTIONS**	[*]	**AMBIENT TEMP**	[*]
TAG	**P&ID**						
PI-050-512-22	51N01	**SERVICE**	PRESSURE INDICATOR				
		FLUID	[*]	**CONNECTION TYPE**	[*]	**BOTT. HOUSING MAT.**	MFR. STD.
		TEMPERATURE	[*]	**ISOLATION SEALS**	N/A	**INSTRUMENT VALVES**	[*]
		MEASURING PRINCIPLE	DIRECT	**CASE MATERIAL**	[*]	**DIAPHRAGM MAT.**	MFR. STD.
		PRESSURE RANGE:	[*]	**TYPICAL DETAILS**	[*]	**DIAL SIZE**	[*]
		GAUGE RANGE	0-100 PSIG	**OPTIONS**	[*]	**AMBIENT TEMP**	[*]
TAG	**P&ID**						
PI-050-513-11	51N02	**SERVICE**	PRESSURE INDICATOR				
		FLUID	[*]	**CONNECTION TYPE**	[*]	**BOTT. HOUSING MAT.**	MFR. STD.
		TEMPERATURE	[*]	**ISOLATION SEALS**	N/A	**INSTRUMENT VALVES**	[*]
		MEASURING PRINCIPLE	DIRECT	**CASE MATERIAL**	[*]	**DIAPHRAGM MAT.**	MFR. STD.
		PRESSURE RANGE:	[*]	**TYPICAL DETAILS**	[*]	**DIAL SIZE**	[*]
		GAUGE RANGE	0-160 PSIG	**OPTIONS**	[*]	**AMBIENT TEMP**	[*]

Pressure Gauge

SPECIFICATION 17404

PROJECT INFORMATION

PLANT

PROJECT 200948

CUSTOMER CITY OF DELRAY BEACH

LOCATION

ELEMENT/SWITCH

GENERAL NOTE: FIELDS SHOWN WITH THE [*] SYMBOL ARE NOT SHOWN ON THE DATASHEET BUT MAY BE REQUIRED BY THE CONTRACT DOCUMENTS. THE CONTRACTOR SHALL SUBMIT COMPLETE ISA DATASHEETS FOR EACH INSTRUMENT PER ALL SPECIFIED REQUIREMENTS.

TAG	P&ID						
PI-050-513-21	51N02	**SERVICE**	PRESSURE INDICATOR				
		FLUID	[*]	**CONNECTION TYPE**	[*]	**BOTT. HOUSING MAT.**	MFR. STD.
		TEMPERATURE	[*]	**ISOLATION SEALS**	N/A	**INSTRUMENT VALVES**	[*]
		MEASURING PRINCIPLE	DIRECT	**CASE MATERIAL**	[*]	**DIAPHRAGM MAT.**	MFR. STD.
		PRESSURE RANGE:	[*]	**TYPICAL DETAILS**	[*]	**DIAL SIZE**	[*]
		GAUGE RANGE	0-160 PSIG	**OPTIONS**	[*]	**AMBIENT TEMP**	[*]
TAG	**P&ID**	**SERVICE**	PRESSURE INDICATOR				
PI-050-513-31	51N03	**FLUID**	[*]	**CONNECTION TYPE**	[*]	**BOTT. HOUSING MAT.**	MFR. STD.
		TEMPERATURE	[*]	**ISOLATION SEALS**	N/A	**INSTRUMENT VALVES**	[*]
		MEASURING PRINCIPLE	DIRECT	**CASE MATERIAL**	[*]	**DIAPHRAGM MAT.**	MFR. STD.
		PRESSURE RANGE:	[*]	**TYPICAL DETAILS**	[*]	**DIAL SIZE**	[*]
		GAUGE RANGE	0-160 PSIG	**OPTIONS**	[*]	**AMBIENT TEMP**	[*]
TAG	**P&ID**	**SERVICE**	PRESSURE INDICATOR				
PI-050-513-41	51N03	**FLUID**	[*]	**CONNECTION TYPE**	[*]	**BOTT. HOUSING MAT.**	MFR. STD.
		TEMPERATURE	[*]	**ISOLATION SEALS**	N/A	**INSTRUMENT VALVES**	[*]
		MEASURING PRINCIPLE	DIRECT	**CASE MATERIAL**	[*]	**DIAPHRAGM MAT.**	MFR. STD.
		PRESSURE RANGE:	[*]	**TYPICAL DETAILS**	[*]	**DIAL SIZE**	[*]
		GAUGE RANGE	0-160 PSIG	**OPTIONS**	[*]	**AMBIENT TEMP**	[*]
TAG	**P&ID**	**SERVICE**	PRESSURE INDICATOR				
PI-050-513-51	51N03	**FLUID**	[*]	**CONNECTION TYPE**	[*]	**BOTT. HOUSING MAT.**	MFR. STD.
		TEMPERATURE	[*]	**ISOLATION SEALS**	N/A	**INSTRUMENT VALVES**	[*]
		MEASURING PRINCIPLE	DIRECT	**CASE MATERIAL**	[*]	**DIAPHRAGM MAT.**	MFR. STD.
		PRESSURE RANGE:	[*]	**TYPICAL DETAILS**	[*]	**DIAL SIZE**	[*]
		GAUGE RANGE	0-160 PSIG	**OPTIONS**	[*]	**AMBIENT TEMP**	[*]

Pressure Gauge

SPECIFICATION 17404

PROJECT INFORMATION

PLANT
PROJECT 200948
CUSTOMER CITY OF DELRAY BEACH
LOCATION

ELEMENT/SWITCH

GENERAL NOTE: FIELDS SHOWN WITH THE [*] SYMBOL ARE NOT SHOWN ON THE DATASHEET BUT MAY BE REQUIRED BY THE CONTRACT DOCUMENTS. THE CONTRACTOR SHALL SUBMIT COMPLETE ISA DATASHEETS FOR EACH INSTRUMENT PER ALL SPECIFIED REQUIREMENTS.

TAG	P&ID	SERVICE					
PI-050-542-21	54N01	PRESSURE INDICATOR					
		FLUID	[*]	CONNECTION TYPE	[*]	BOTT. HOUSING MAT.	MFR. STD.
		TEMPERATURE	[*]	ISOLATION SEALS	N/A	INSTRUMENT VALVES	[*]
		MEASURING PRINCIPLE	DIRECT	CASE MATERIAL	[*]	DIAPHRAGM MAT.	MFR. STD.
		PRESSURE RANGE:	[*]	TYPICAL DETAILS	[*]	DIAL SIZE	[*]
		GAUGE RANGE	0-100 PSIG	OPTIONS	[*]	AMBIENT TEMP	[*]
TAG	**P&ID**	**SERVICE**	PRESSURE INDICATOR				
PI-050-542-22	54N01	FLUID	[*]	CONNECTION TYPE	[*]	BOTT. HOUSING MAT.	MFR. STD.
		TEMPERATURE	[*]	ISOLATION SEALS	N/A	INSTRUMENT VALVES	[*]
		MEASURING PRINCIPLE	DIRECT	CASE MATERIAL	[*]	DIAPHRAGM MAT.	MFR. STD.
		PRESSURE RANGE:	[*]	TYPICAL DETAILS	[*]	DIAL SIZE	[*]
		GAUGE RANGE	0-100 PSIG	OPTIONS	[*]	AMBIENT TEMP	[*]
TAG	**P&ID**	**SERVICE**	PRESSURE INDICATOR				
PI-050-543-11	54N02	FLUID	[*]	CONNECTION TYPE	[*]	BOTT. HOUSING MAT.	MFR. STD.
		TEMPERATURE	[*]	ISOLATION SEALS	N/A	INSTRUMENT VALVES	[*]
		MEASURING PRINCIPLE	DIRECT	CASE MATERIAL	[*]	DIAPHRAGM MAT.	MFR. STD.
		PRESSURE RANGE:	[*]	TYPICAL DETAILS	[*]	DIAL SIZE	[*]
		GAUGE RANGE	0-160 PSIG	OPTIONS	[*]	AMBIENT TEMP	[*]
TAG	**P&ID**	**SERVICE**	PRESSURE INDICATOR				
PI-050-543-21	54N02	FLUID	[*]	CONNECTION TYPE	[*]	BOTT. HOUSING MAT.	MFR. STD.
		TEMPERATURE	[*]	ISOLATION SEALS	N/A	INSTRUMENT VALVES	[*]
		MEASURING PRINCIPLE	DIRECT	CASE MATERIAL	[*]	DIAPHRAGM MAT.	MFR. STD.
		PRESSURE RANGE:	[*]	TYPICAL DETAILS	[*]	DIAL SIZE	[*]
		GAUGE RANGE	0-160 PSIG	OPTIONS	[*]	AMBIENT TEMP	[*]

Pressure Gauge

SPECIFICATION 17404

PROJECT INFORMATION

PLANT

PROJECT 200948

CUSTOMER CITY OF DELRAY BEACH

LOCATION

ELEMENT/SWITCH

GENERAL NOTE: FIELDS SHOWN WITH THE [*] SYMBOL ARE NOT SHOWN ON THE DATASHEET BUT MAY BE REQUIRED BY THE CONTRACT DOCUMENTS. THE CONTRACTOR SHALL SUBMIT COMPLETE ISA DATASHEETS FOR EACH INSTRUMENT PER ALL SPECIFIED REQUIREMENTS.

TAG	P&ID	SERVICE	PRESSURE INDICATOR				
PI-050-543-31	54N03		**FLUID** [*]	**CONNECTION TYPE** [*]		**BOTT. HOUSING MAT.** MFR. STD.	
			TEMPERATURE [*]	**ISOLATION SEALS** N/A		**INSTRUMENT VALVES** [*]	
			MEASURING PRINCIPLE DIRECT	**CASE MATERIAL** [*]		**DIAPHRAGM MAT.** MFR. STD.	
			PRESSURE RANGE: [*]	**TYPICAL DETAILS** [*]		**DIAL SIZE** [*]	
			GAUGE RANGE 0-60 PSIG	**OPTIONS** [*]		**AMBIENT TEMP** [*]	
TAG	**P&ID**	**SERVICE**	PRESSURE INDICATOR				
PI-050-543-41	54N03		**FLUID** [*]	**CONNECTION TYPE** [*]		**BOTT. HOUSING MAT.** MFR. STD.	
			TEMPERATURE [*]	**ISOLATION SEALS** N/A		**INSTRUMENT VALVES** [*]	
			MEASURING PRINCIPLE DIRECT	**CASE MATERIAL** [*]		**DIAPHRAGM MAT.** MFR. STD.	
			PRESSURE RANGE: [*]	**TYPICAL DETAILS** [*]		**DIAL SIZE** [*]	
			GAUGE RANGE 0-60 PSIG	**OPTIONS** [*]		**AMBIENT TEMP** [*]	
TAG	**P&ID**	**SERVICE**	PRESSURE INDICATOR				
PI-050-543-51	54N03		**FLUID** [*]	**CONNECTION TYPE** [*]		**BOTT. HOUSING MAT.** MFR. STD.	
			TEMPERATURE [*]	**ISOLATION SEALS** N/A		**INSTRUMENT VALVES** [*]	
			MEASURING PRINCIPLE DIRECT	**CASE MATERIAL** [*]		**DIAPHRAGM MAT.** MFR. STD.	
			PRESSURE RANGE: [*]	**TYPICAL DETAILS** [*]		**DIAL SIZE** [*]	
			GAUGE RANGE 0-60 PSIG	**OPTIONS** [*]		**AMBIENT TEMP** [*]	

SECTION 17501

ANALYZERS: PH

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. pH instruments.

1.02 REFERENCES

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

B. Standards:
   1. CSA International (CSA).

1.03 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Provide complete documentation covering the traceability of all calibration instruments.

C. Furnish commissioning submittals listed below and specified in this Section as specified in Section 01756 - Commissioning:
   1. Manufacturer's representative qualifications.
   2. Owner training.

1.04 QUALITY ASSURANCE

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

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

C. Provide instruments manufactured at facilities certified to the quality standards of ISO 9001.

1.05 DELIVERY, STORAGE, AND HANDLING

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

1.06 PROJECT OR SITE CONDITIONS

A. Project environmental conditions as specified in Section 01850 - Design Criteria.

1.07 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
   1. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

1.08 WARRANTY

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

1.09 MAINTENANCE

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

PART 2 PRODUCTS

2.01 GENERAL

A. Provide all instruments identified in the Contract Documents.

2.02 DESIGN AND PERFORMANCE CRITERIA

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

2.03 MANUFACTURERS

A. One of the following or equal:
   1. Hach:
      a. Sensor Model DPD1P1.
      b. SC4500 Controller with EtherNet/IP communications signal output.
   2. Endress+Hauser:
      a. Sensor Model CPS11D.
      b. CM44x – Multiple channel with EtherNet/IP communications signal output.

2.04 MANUFACTURED UNITS

A. As specified in this Section including Attachment A - ISA Data Sheet - Analyzers: pH.

B. pH analyzers:
   1. General:
      a. pH measurement shall use the potentiometric measurement method utilizing a glass electrode. The pH sensitive glass membrane surface reacts to the acid content of the solution with a specific voltage, which is measured relative to a reference electrode.
   2. Performance requirements:
      a. Accuracy: Within 0.01 pH.
      b. Stability: Within 0.01 pH/month.
      c. Repeatability: Within 0.01 pH.
   3. Element:
      a. Sensor material:
         1) Glass pH sensor housed in a molded reinforced polypropylene body threaded for insertion, submersion, or flow-through installation as indicated on the Drawings and/or instrument data sheets.
         2) Built in temperature sensor.
         3) The reference electrode junction shall be capable of maintaining steady reference signal by resisting plugging in dirty applications.
      b. pH measuring range: 2 to 12 pH.
      c. Temperature measuring range: 0 to 70 degrees Celsius.
      d. Operating temperature range: 0 to 80 degrees Celsius.
      e. Operating pressure range: 0 to 87 pounds per square inch.
      f. Connections:
         1) Process: As specified in the Instrument Data Sheets.
   4. Transmitter:
      a. Power supply:
         1) 120 VAC.
         2) Power consumption: 73 VA maximum.
      b. Outputs:
         1) 2 isolated 4 to 20 milliamperes DC.
            a) Proportional to pH and temperature.
         2) EtherNet/IP communication protocol.
         3) Relay outputs:
            a) 3 Form C contact.
            b) Rated 3 amps at 250 VAC.
            c) Programmable.
         4) As indicated in the instrument datasheets.
      c. Display:
         1) Backlit LCD digital display.
      d. Measurement ranges: 0 to 14 pH.
      e. Temperature: 0 to 50 degrees Celsius.
      f. Displayed resolution: Within 0.01 pH.
      g. Ambient conditions:
         1) Operable from 0 to 50 degrees Celsius.
         2) Relative humidity 0 to 95 percent.
      h. Mechanical:
         1) Enclosure rating:
            a) NEMA Type 4X (IP65).
         2) Mounting:
            a) Panel mount suitable for mounting in an enclosure that includes gasket to maintain weather rating of the panel.

b) Surface mount enclosures: include self-tapping screws.
c) Pipe mounting accessories shall be included for mounting enclosures to a 2-inch pipe.

3) Provide all mounting hardware for proper installation and servicing of the sensor assembly.

i. Electrical certification: NRTL certified to UL and CSA standards, and CE approved.

5. Components:
   a. Sensor cable:
      1) Shall be provided with watertight sensor-to-cable connector that prevents cable twisting and eliminates rewiring when replacing the sensor.
      2) Cable length: As required to connect sensor to transmitter plus 10 percent.

2.05 ACCESSORIES

A. Sensor:
   1. Process assemblies:
      a. As specified on Instrument Data Sheets.
   2. Low flow cell:
      a. 1/4-inch NPT inlet and outlet tubing for connection to the process stream.
      b. Flow rate: 2 to 5 gallons per hour.
      c. Pressure range: 0 to 65 pounds per square inch gauge.
   3. Sensor cable:
      a. Hach Sensor Cable.
      b. Endress+Hauser CYK10.

B. Transmitter:
   1. DAT module.
   2. SD card (Endress+Hauser- CM44x series and Hach sc4500 series).
   3. Flat gasket.
   4. Mounting kit:
      a. Wall or panel mounting kit as indicated on the Drawings.
      b. Cable glands kit.
   5. Stainless steel tag:
      a. Marking specified on Instrument Data Sheets.

C. Preamplifier:
   1. Use Manufacturer recommended preamplifier on coaxial cable runs longer than 15 feet. Review the contractor drawings and verify the need for a preamplifier.

D. Provide a white powder coated NEMA4X 316 stainless steel enclosure with sunshields.

E. Provide and Ethernet surge suppression for outdoor installations.

2.06 FINISHES (NOT USED)

2.07 SOURCE QUALITY CONTROL

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

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine the installation location for the instrument and verify that the instrument will work properly when installed.

3.02 INSTALLATION

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

B. Install pH analyzers in a white powder coated NEMA4X 316 stainless steel enclosure with sunshields.

3.03 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

B. Owner Training:
   1. Perform Owner training as specified in Section 01756 - Commissioning.
   2. Number of sessions:
      a. Operations 2.
      b. Maintenance 2.

3.04 SCHEDULES

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

END OF SECTION

Analyzer Transmitter

PROJECT INFORMATION

PLANT		**CUSTOMER**	CITY OF DELRAY BEACH
PROJECT	200948	**LOCATION**	

GENERAL NOTE: FIELDS SHOWN WITH THE [*] SYMBOL ARE NOT SHOWN ON THE DATASHEET BUT MAY BE REQUIRED BY THE CONTRACT DOCUMENTS. THE CONTRACTOR SHALL SUBMIT COMPLETE ISA DATASHEETS FOR EACH INSTRUMENT PER ALL SPECIFIED REQUIREMENTS.

GENERAL

TAG	AIT-050-225-23 (AE-050-225-23)	**POWER LOCATION**	LOOP
SPECIFICATION NUMBER	17501	**MEASURING PRINCIPLE**	PH ANALYZER
DRAWING NUMBER	22N01	**PLC**	PLC-050-220-01
SERVICE	PH	**TYPICAL DETAILS**	[*]

FLUID

FLUID	WATER	**PRESSURE**	N/A
MEASUREMENT RANGE	0-14 PH	**TEMPERATURE**	75 DEG F

ELEMENT

ELEMENT TAG NO.	AE-050-225-23	**PROCESS CONNECTION**	SAMPLE LINE
ENCLOSURE CLASS	NEMA 4X	**MOUNTING KIT**	FLOW-THROUGH TEE
HAZARDOUS APPROVALS	N/A	**HEAD ASSY FOR CLEANING**	NO
PROCESS CONN. MAT'L	MFR. STD.		

TRANSMITTER

TRANSMITTER TAG NO.	AIT-050-225-23	**SIGNAL OUTPUT PRI**	EIP
ENCLOSURE CLASS	NEMA 4X	**PRIMARY OUTPUT**	ETHERNET/IP
TRANS. MOUNTING	REMOTE	**SIGNAL OUTPUT SEC**	EIP
POWER	[*]	**TEMPERATURE OUTPUT**	ETHERNET/IP
SURGE PROTECTION	YES	**TRANS. HAZ APPROVALS**	N/A
RELAY OPTIONS	YES	**AUTO. CLEANING RELAYS**	NO
AMBIENT TEMPERATURE	95 DEG F		

NOTES

[*]

Analyzer Transmitter

PROJECT INFORMATION

PLANT		**CUSTOMER**	CITY OF DELRAY BEACH
PROJECT	200948	**LOCATION**	

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GENERAL

TAG	AIT-050-225-24 (AE-050-225-24)	**POWER LOCATION**	LOOP
SPECIFICATION NUMBER	17501	**MEASURING PRINCIPLE**	PH ANALYZER
DRAWING NUMBER	22N01	**PLC**	PLC-050-220-01
SERVICE	PH	**TYPICAL DETAILS**	[*]

FLUID

FLUID	WATER	**PRESSURE**	5 PSI
MEASUREMENT RANGE	0-14 PH	**TEMPERATURE**	75 DEG F

ELEMENT

ELEMENT TAG NO.	AE-050-225-24	**PROCESS CONNECTION**	SAMPLE LINE
ENCLOSURE CLASS	NEMA 4X	**MOUNTING KIT**	FLOW-THROUGH TEE
HAZARDOUS APPROVALS	N/A	**HEAD ASSY FOR CLEANING**	NO
PROCESS CONN. MAT'L	MFR. STD.		

TRANSMITTER

TRANSMITTER TAG NO.	AIT-050-225-24	**SIGNAL OUTPUT PRI**	EIP
ENCLOSURE CLASS	NEMA 4X	**PRIMARY OUTPUT**	ETHERNET/IP
TRANS. MOUNTING	REMOTE	**SIGNAL OUTPUT SEC**	EIP
POWER	[*]	**TEMPERATURE OUTPUT**	ETHERNET/IP
SURGE PROTECTION	YES	**TRANS. HAZ APPROVALS**	N/A
RELAY OPTIONS	YES	**AUTO. CLEANING RELAYS**	NO
AMBIENT TEMPERATURE	95 DEG F		

NOTES

[*]

SECTION 17505

ANALYZERS: RESIDUAL CHLORINE

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Residual chlorine analyzers.

1.02 REFERENCES

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

1.03 SUBMITTALS

A. Furnish Submittals as specified in Section 01330 - Submittal Procedures and Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Provide complete documentation covering the traceability of calibration instruments.

C. Furnish commissioning Submittals listed below, as specified in this Section, and Section 01756 - Commissioning:
   1. Manufacturer's representative qualifications.
   2. Owner training.

1.04 QUALITY ASSURANCE

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

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

1.05 DELIVERY, STORAGE, AND HANDLING

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

1.06 PROJECT OR SITE CONDITIONS

A. Project environmental conditions as specified in Section 01850 - Design Criteria.

1.07 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
   1. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

1.08 WARRANTY

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

1.09 MAINTENANCE

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

PART 2 PRODUCTS

2.01 GENERAL

A. Provide instruments identified in the Contract Documents.

2.02 DESIGN AND PERFORMANCE CRITERIA

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

B. Analyzer and transmitter must be from the same manufacturer.

2.03 MANUFACTURERS

A. Colorimetric residual analyzers:
   1. The following or Engineer approved equal:
      a. Analyzer: HACH, CL17sc
      b. Transmitter: Hach SC4500 controller with EtherNet/IP communications option.

2.04 MANUFACTURED UNITS

A. As specified in this Section, including Attachment A - ISA Datasheet - Analyzers: Residual Chlorine.

B. Colorimetric residual analyzers:
   1. General:
      a. Residual chlorine analyzer utilizing the DPD colorimetric method to provide accurate measurements independent of swings in pH or alkalinity levels in the sample source.
      b. Convert from free to total chlorine by changing reagents:
         1) Measure a sample blank before each sample measurement to provide zero reference compensation for sample color and turbidity, changes in light intensity due to voltage fluctuations, or light intensity.
   2. Analyzer Performance requirements:
      a. Complete analysis every 2.5 minutes for free or total chlorine residual.
      b. Designed for 30 days of unattended operation, with less than 500 milliliters of reagent used per month.
      c. Accuracy:
         1) Within 5 percent of reading or within 0.035 milligrams per liter.
      d. Range:
         1) 0 to 5 milligrams per liter free or total residual.
      e. Repeatability:
         1) Within 5 percent or 0.05 milligrams per liter.
   3. Transmitter:
      a. Power supply:
         1) 120 VAC.
         2) Power consumption: 73 VA maximum.
      b. Outputs:
         1) 2 isolated 4 to 20 milliamperes DC.
            a) Proportional to pH and temperature.
         2) EtherNet/IP communication protocol.
         3) Relay outputs:
            a) 3 Form C contact.
            b) Rated 3 amps at 250 VAC.
            c) Programmable.
         4) As indicated in the instrument datasheets.
      c. Display:
         1) Backlit LCD digital display.
      d. Measurement ranges: 0 to 14 pH.
      e. Temperature: 0 to 50 degrees Celsius.
      f. Displayed resolution: Within 0.01 pH.
      g. Ambient conditions:
         1) Operable from 0 to 50 degrees Celsius.
         2) Relative humidity 0 to 95 percent.
      h. Mechanical:
         1) Enclosure rating:
            a) NEMA Type 4X (IP65).
         2) Mounting:
            a) Panel mount suitable for mounting in an enclosure that includes gasket to maintain weather rating of the panel.
            b) Surface mount enclosures: include self-tapping screws.
            c) Pipe mounting accessories shall be included for mounting enclosures to a 2-inch pipe.
         3) Provide all mounting hardware for proper installation and servicing of the sensor assembly.

4. Components:
    a. Sensor cable:
        1) Shall be provided with watertight sensor-to-cable connector that prevents cable twisting and eliminates rewiring when replacing the sensor.
        2) Cable length: As required to connect sensor to transmitter plus 10 percent.

2.05 ACCESSORIES

A. Provide a white powder coated NEMA4X 316 stainless steel enclosure with sunshields.

B. Provide and Ethernet surge suppression for outdoor installations.

2.06 FINISHES (NOT USED)

2.07 SOURCE QUALITY CONTROL

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

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine the installation location for the instrument and verify that the instrument will work properly when installed.

3.02 INSTALLATION

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

B. Install in a white powder coated NEMA4X 316 stainless steel enclosure with sunshields.

3.03 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

B. Owner Training:
    1. Perform Owner training as specified in Section 01756 - Commissioning.
    2. Number of sessions:
        a. Operations 2.
        b. Maintenance 2.

3.04 SCHEDULES

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

END OF SECTION

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Analyzer Transmitter

RESERVOIR

PROJECT INFORMATION

PLANT		**CUSTOMER**	CITY OF DELRAY BEACH
PROJECT	200948	**LOCATION**	

GENERAL NOTE: FIELDS SHOWN WITH THE [*] SYMBOL ARE NOT SHOWN ON THE DATASHEET BUT MAY BE REQUIRED BY THE CONTRACT DOCUMENTS. THE CONTRACTOR SHALL SUBMIT COMPLETE ISA DATASHEETS FOR EACH INSTRUMENT PER ALL SPECIFIED REQUIREMENTS.

GENERAL

TAG	AIT-050-225-21 (AE-050-225-21)	**POWER LOCATION**	LOOP
SPECIFICATION NUMBER	17505	**MEASURING PRINCIPLE**	COLORIMETRIC
DRAWING NUMBER	22N01	**PLC**	PLC-050-220-01
SERVICE	CHLORINE RESIDUAL ANALYZER	**TYPICAL DETAILS**	[*]

FLUID

FLUID	WATER	**PRESSURE**	N/A
MEASUREMENT RANGE	0 -10 MG/L	**TEMPERATURE**	75 DEG F
SAMPLE FLOW	60 - 200 ML/MIN	**SAMPLE TEMPERATURE**	40 - 80 DEG F
SAMPLE pH	1-14		

ELEMENT

ELEMENT TAG NO.	AE-050-225-21	**PROCESS CONNECTION**	SAMPLE LINE
ENCLOSURE CLASS	NEMA 4X	**HAZARDOUS APPROVALS**	N/A
CLEANING APPARATUS	NO	**ELEMENT MOUNTING KIT**	FLOW ASSEMBLY

TRANSMITTER

TRANSMITTER TAG NO.	AIT-050-225-21	**SIGNAL OUTPUT**	EIP
ENCLOSURE CLASS	NEMA 4X	**OUTPUT**	ETHERNET/IP
TRANS. MOUNTING	REMOTE	**TRANS. HAZ APPROVALS**	N/A
POWER	[*]	**RELAY OPTIONS**	YES
SURGE PROTECTION	NO	**AMBIENT TEMPERATURE**	104 DEG F
AIR CLEANING SYSTEM	NO		

NOTES

[*]

PROJECT INFORMATION

PLANT		**CUSTOMER**	CITY OF DELRAY BEACH
PROJECT	200948	**LOCATION**	

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GENERAL

TAG	AIT-050-225-22 (AE-050-225-22)	**POWER LOCATION**	LOOP
SPECIFICATION NUMBER	17505	**MEASURING PRINCIPLE**	COLORIMETRIC
DRAWING NUMBER	22N01	**PLC**	PLC-050-220-01
SERVICE	CHLORINE RESIDUAL ANALYZER	**TYPICAL DETAILS**	[*]

FLUID

FLUID	WATER	**PRESSURE**	N/A
MEASUREMENT RANGE	0- 500 ML/MIN	**TEMPERATURE**	75 DEG F
SAMPLE FLOW	200 - 500 ML/MIN	**SAMPLE TEMPERATURE**	40 - 80 DEG F
SAMPLE pH	1-14		

ELEMENT

ELEMENT TAG NO.	AE-050-225-22	**PROCESS CONNECTION**	SAMPLE LINE
ENCLOSURE CLASS	NEMA 4X	**HAZARDOUS APPROVALS**	N/A
CLEANING APPARATUS	NO	**ELEMENT MOUNTING KIT**	FLOW ASSEMBLY

TRANSMITTER

TRANSMITTER TAG NO.	AIT-050-225-22	**SIGNAL OUTPUT**	EIP
ENCLOSURE CLASS	NEMA 4X	**OUTPUT**	ETHERNET/IP
TRANS. MOUNTING	REMOTE	**TRANS. HAZ APPROVALS**	N/A
POWER	[*]	**RELAY OPTIONS**	NO
SURGE PROTECTION	NO	**AMBIENT TEMPERATURE**	104 DEG F
AIR CLEANING SYSTEM	NO		

NOTES

[*]

SECTION 17509

ANALYZERS: TURBIDITY

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Turbidity analyzers (turbidimeters).

1.02 REFERENCES

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

B. Standards:
   1. United States Environmental Protection Agency (USEPA):
      a. Federal Register Vol. 82 No. 143.
         1) 40 CFR Part 141 - National Primary Drinking Water Regulations.
      b. Method 180.1 - Determination of Turbidity by 360-degree Nephelometry.

1.03 SUBMITTALS

A. Furnish Submittals as specified in Section 01330 - Submittal Procedures and Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Provide complete documentation covering the traceability of calibration instruments.

C. Furnish commissioning Submittals listed below, as specified in this Section, and Section 01756 - Commissioning:
   1. Manufacturer's representative qualifications.
   2. Owner training.

1.04 QUALITY ASSURANCE

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

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

C. Provide instruments manufactured at facilities certified to the quality standards of ISO 9001.

1.05 DELIVERY, STORAGE, AND HANDLING

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

1.06 PROJECT OR SITE CONDITIONS

A. Project environmental conditions as specified in Section 01850 - Design Criteria.

1.07 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
   1. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

1.08 WARRANTY

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

1.09 MAINTENANCE

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

PART 2 PRODUCTS

2.01 GENERAL

A. Provide instruments identified in the Contract Documents.

2.02 DESIGN AND PERFORMANCE CRITERIA

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

B. Sensor probe and transmitter must be from the same manufacturer.

2.03 MANUFACTURERS

A. Probe:
   1. Low range turbidimeters:
      a. HACH - TU5300sc with flow sensor and automatic cleaning module, or Engineer approved equal.

B. Transmitter:
   1. Turbidimeter display/controller:
      a. HACH – SC4500 with EtherNet/IP communications signal output, or Engineer approved equal.

2.04 MANUFACTURED UNITS

A. As specified in this Section, including Attachment A - ISA Datasheet - Analyzers: Turbidity.

B. Low range, high precision turbidimeters:
   1. General:
      a. The turbidimeter shall be a microprocessor-based, continuous-reading, on-line nephelometric instrument with predictive diagnostics, meeting design and performance criteria in accordance with acceptable USEPA testing methods for contaminants listed at 40 CFR 141.74(a)(1). Each turbidity system shall consist of a 1 sensor and 1 transmitter.
      b. Optical components shall be mounted in a sealed head assembly that can be removed easily for calibration/service.
      c. The turbidimeter body shall be corrosion-resistant and shall include an internal bubble trap to vent entrained air from the sample stream.
   2. Performance requirements:
      a. Range: 0 to 20 NTU.
      b. Accuracy:
         1) Within 2 percent of reading within 0.01 NTU from 0 to 40 NTU based on Formazin primary standard at 25 degrees Celsius.
         2) Within 10 percent of reading from 40 to 1,000 NTU based on Formazin primary standard at 25 degrees Celsius.
      c. Resolution: 0.0001 NTU.
      d. Repeatability: Within 1 percent of reading or 0.002 NTU, whichever is greater based on Formazin primary standard at 25 degrees Celsius.
      e. Sample flow required: 100 to 1,000 mL/min. Optimal flow rate 200 to 500 mL/min.
   3. Element:
      a. The low range online laser turbidimeter consists of a Class 1 650 nanometer (EPA) laser light source and 360 degrees by 90 degrees detection system with predictive diagnostics designed to continuously monitor turbidity in a sample stream.

2.05 ACCESSORIES

A. Mounting brackets as required or as indicated on the Drawings.

B. Provide white powder coated NEMA4X 316 stainless steel enclosure with sunshields.

C. Provide and Ethernet surge suppression for outdoor installations.

D. Flushing solenoids for cleaning the probe as recommended by the manufacturer.

E. Low pressure kit: 0 to 50 pounds per square inch gauge at 68 degrees Fahrenheit.

2.06 FINISHES (NOT USED)

2.07 SOURCE QUALITY CONTROL

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

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine the installation location for the instrument and verify that the instrument will work properly when installed.

3.02 INSTALLATION

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

B. Coordinate the installation with trades to ensure that the mechanical system has necessary appurtenances including weld-o-lets, valves, etc., for proper installation of instruments.

C. Install controllers in a white powder coated NEMA4X 316 stainless steel enclosure with sunshields.

3.03 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

B. Owner Training:
   1. Perform Owner training as specified in Section 01756 - Commissioning.
   2. Number of sessions:
      a. Operations 2.
      b. Maintenance 2.

3.04 SCHEDULES

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

END OF SECTION

Engineers...Working Wonders With Water®

Analyzer Transmitter

RESERVOIR

PROJECT INFORMATION

PLANT		**CUSTOMER**	CITY OF DELRAY BEACH
PROJECT	200948	**LOCATION**	

GENERAL NOTE: FIELDS SHOWN WITH THE [*] SYMBOL ARE NOT SHOWN ON THE DATASHEET BUT MAY BE REQUIRED BY THE CONTRACT DOCUMENTS. THE CONTRACTOR SHALL SUBMIT COMPLETE ISA DATASHEETS FOR EACH INSTRUMENT PER ALL SPECIFIED REQUIREMENTS.

GENERAL

TAG	AIT-050-225-25 (AE-050-225-25)	**POWER LOCATION**	LOOP
SPECIFICATION NUMBER	17509	**MEASURING PRINCIPLE**	COLORIMETRIC
DRAWING NUMBER	22N01	**PLC**	PLC-050-220-01
SERVICE	TURBIDITY	**TYPICAL DETAILS**	[*]

FLUID

FLUID	WATER	**PRESSURE**	5 PSI
MEASUREMENT RANGE	0-1000 NTU	**TEMPERATURE**	75 DEG F
SAMPLE FLOW	200 - 500 ML/MIN	**SAMPLE TEMPERATURE**	40 - 80 DEG F
SAMPLE pH	1-14		

ELEMENT

ELEMENT TAG NO.	AE-050-225-25	**PROCESS CONNECTION**	INSERTION
ENCLOSURE CLASS	NEMA 4X	**HAZARDOUS APPROVALS**	N/A
CLEANING APPARATUS	NO	**ELEMENT MOUNTING KIT**	FLOW ASSEMBLY

TRANSMITTER

TRANSMITTER TAG NO.	AIT-050-225-25	**SIGNAL OUTPUT**	EIP
ENCLOSURE CLASS	NEMA 4X	**OUTPUT**	ETHERNET/IP
TRANS. MOUNTING	REMOTE	**TRANS. HAZ APPROVALS**	N/A
POWER	[*]	**RELAY OPTIONS**	YES
SURGE PROTECTION	YES	**AMBIENT TEMPERATURE**	95 DEG F
AIR CLEANING SYSTEM	NO		

NOTES

[*]

Analyzer Transmitter

PROJECT INFORMATION

PLANT		**CUSTOMER**	CITY OF DELRAY BEACH
PROJECT	200948	**LOCATION**	

GENERAL NOTE: FIELDS SHOWN WITH THE [*] SYMBOL ARE NOT SHOWN ON THE DATASHEET BUT MAY BE REQUIRED BY THE CONTRACT DOCUMENTS. THE CONTRACTOR SHALL SUBMIT COMPLETE ISA DATASHEETS FOR EACH INSTRUMENT PER ALL SPECIFIED REQUIREMENTS.

GENERAL

TAG	AIT-050-225-26 (AE-050-225-26)	**POWER LOCATION**	LOOP
SPECIFICATION NUMBER	17509	**MEASURING PRINCIPLE**	COLORIMETRIC
DRAWING NUMBER	22N01	**PLC**	PLC-050-220-01
SERVICE	TURBIDITY	**TYPICAL DETAILS**	[*]

FLUID

FLUID	WATER	**PRESSURE**	5 PSI
MEASUREMENT RANGE	0-1000 NTU	**TEMPERATURE**	75 DEG F
SAMPLE FLOW	200 - 500 ML/MIN	**SAMPLE TEMPERATURE**	40 - 80 DEG F
SAMPLE pH	1-14		

ELEMENT

ELEMENT TAG NO.	AE-050-225-26	**PROCESS CONNECTION**	INSERTION
ENCLOSURE CLASS	NEMA 4X	**HAZARDOUS APPROVALS**	N/A
CLEANING APPARATUS	NO	**ELEMENT MOUNTING KIT**	FLOW ASSEMBLY

TRANSMITTER

TRANSMITTER TAG NO.	AIT-050-225-26	**SIGNAL OUTPUT**	EIP
ENCLOSURE CLASS	NEMA 4X	**OUTPUT**	ETHERNET/IP
TRANS. MOUNTING	REMOTE	**TRANS. HAZ APPROVALS**	N/A
POWER	[*]	**RELAY OPTIONS**	YES
SURGE PROTECTION	YES	**AMBIENT TEMPERATURE**	95 DEG F
AIR CLEANING SYSTEM	NO		

NOTES

[*]

SECTION 17710

CONTROL SYSTEMS: PANELS, ENCLOSURES, AND PANEL COMPONENTS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Design, fabrication and assembly of instrumentation enclosures, control panels and components provided under this contract, including, but not limited to:
      a. Custom built instrumentation and control panels, including enclosures for hand stations controllers, low voltage power distribution and marshalling panels.
      b. Control panels furnished as part of equipment systems specified in other Divisions, such as vendor control panels (VCPs) and chemical feed panels.
      c. Control components.
      d. Control panel installation.

1.02 REFERENCES

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

B. Standards:
   1. Institute of Electrical and Electronics Engineers (IEEE):
      a. C62.41.1 - Guide on the Surge Environment in Low-Voltage (1,000 V and less) AC Power Circuits.
      b. 802.3af - Standard for Information Technology Telecommunications and Information Exchange Between Systems - Local and Metropolitan Area Networks - Specific Requirements Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications.
      c. 802.3at - Standard for Information Technology -- Local and Metropolitan area networks -- Specific requirements -- Part 3: CSMA/CD Access Method and Physical Layer Specifications Amendment 3: Data Terminal Equipment (DTE) Power via the Media Dependent Interface (MDI) Enhancements.
   2. International Electrotechnical Commission (IEC):
      a. 61643-11 - Low-Voltage Surge Protective Devices - Part 11: Surge Protective Devices Connected to Low-Voltage Power Systems - Requirements and test methods.
      b. 61643-21 - Low-Voltage Surge Protective Devices - Part 21: Surge Protective Devices Connected to Telecommunications and Signaling Networks - Performance Requirements and Testing Methods.
   3. Underwriters Laboratories Inc. (UL):
      a. 248-14 - Low-Voltage Fuses - Part 14: Supplemental Fuses.
      b. 497B - Standard for Protectors for Data Communications and Fire-Alarm Circuits.

c. 508 - Standard for Industrial Control Equipment.
d. 508A - Standard for Industrial Control Panel.
e. 698A - Standard for Industrial Control Panels Relating to Hazardous (Classified) Locations.
f. 1077 - Standard for Supplementary Protectors for Use in Electrical Equipment.
g. 1283 - Standard for Electromagnetic Interference Filters.
h. 1449 - Standard for Surge Protective Devices.

1.03 TERMINOLOGY

A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
   1. The term “panel” in this Section is interchangeable with the term “enclosure.”

1.04 DELEGATED DESIGN

A. As specified in Section 01357 - Delegated Design Procedures.

B. Anchoring and bracing.

1.05 SUBMITTALS

A. Provide Submittals as specified in Section 01330 - Submittal Procedures and Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Provide a control panel hardware Submittal for each control panel/enclosure being provided on this project, including, but not limited to:
   1. Product data:
      a. Enclosure construction details and NEMA type.
      b. Manufacturer’s literature and specification datasheets for each type of equipment to be installed within or on the panel or enclosure.
   2. Shop Drawings:
      a. Scaled, detailed exterior panel (front and side views) and interior panel layout showing equipment arrangement and dimensional information:
         1) Provide draft for review and approval by the Engineer. Engineer has the authority to substantially alter initial panel layouts.
      b. Complete nameplate engraving schedule.
      c. Structural details of fabricated panels.
   3. Calculations:
      a. Cooling calculations, including, but not limited to:
         1) Highest expected ambient temperature for the enclosure’s location.
         2) Internal heat load.
         3) Exposure to direct sunlight.
         4) Dimensions of the enclosure in inches.
         5) Maximum allowable temperature inside the enclosure, based on the lowest operating temperature limit of the installed components.

C. Delegated Design Submittals:
    1. Anchoring and bracing: Provide project-specific calculations based on support conditions and requirements to resist loads specified in Section 01850 - Design Criteria:
        a. To structures for equipment installed in structures designated as seismic design category C, D, E, or F.
        b. For equipment installed outdoors.
        c. For wall mounted equipment weighing 125 pounds or more.

1.06 QUALITY ASSURANCE

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

B. Assemble panels, enclosures, and rack systems along with internal and external devices, wiring, equipment, and materials in a facility that is recognized by UL to assemble and certify UL-labeled control panels:
    1. Provide components and equipment with UL 508 listing.
    2. Control panels shall be UL 508A labeled, unless the equipment in the panel and the design in the contract documents cannot be reasonably modified to meet the requirements for UL 508A labeling:
    3. Provide fuses for equipment that is not UL or UR listed.
    4. Install intrinsically safe circuits and equipment in accordance with UL 698A.

1.07 PROJECT OR SITE CONDITIONS

A. As specified in Section 01850 - Design Criteria.

1.08 ADMINISTRATIVE REQUIREMENTS (NOT USED)

1.09 WARRANTY

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

PART 2 PRODUCTS

2.01 GENERAL

A. Provide control panels identified in Contract Documents.

2.02 DESIGN AND PERFORMANCE CRITERIA

A. Panel dimensions:
    1. Minimum dimensions are scalable from or as indicated on the Drawings and are based upon manufacturer’s non-certified information. It is the responsibility of the Contractor or manufacturer to design and size panels:
        a. Size panels to provide space for equipment, wiring, terminations, and other items in the panel, including 20 percent of the total back panel area shall remain empty.

b. Panel sizes that substantially deviate (within 3 inches in any dimension) from the sizes indicated on the Drawings must be approved by the Engineer.
c. Maximum panel depth: 32 inches, unless otherwise indicated.

B. Provide equipment and components that are fully rated for the site elevation and operating environment where the equipment will be installed as specified in Section 01850 - Design Criteria and as indicated on the Drawings.

C. Non-conditioned spaces and outdoor installations:
1. Provide additional temperature conditioning equipment to maintain the equipment temperature within a band of 10 degrees Fahrenheit above the minimum operating temperature and 10 degrees Fahrenheit below maximum operating temperature.

D. As listed below in the individual component paragraphs.
1. Provide conditioning equipment incorporated into the equipment to maintain the enclosures within the equipment manufacturer's specified operating ranges.

2.03 MANUFACTURERS (NOT USED)

2.04 EXISTING PRODUCTS

A. Provide labor and materials for complete modifications to existing panels as required.

B. Field cut and refinish existing panel faces to original condition to accommodate installation of new instruments, removal of existing instruments, and fitting of blanks to suit new layouts. New instrument supports shall be provided as required for complete installation.

2.05 MATERIALS

A. Construct and finish enclosures using materials capable of withstanding the mechanical, electrical, and thermal stresses, as well as the effects of humidity and corrosion that are likely to be encountered in normal service:
1. Enclosures shall have the following properties:
a. NEMA Type 1: Steel.
b. NEMA Type 4: Steel with gasketed door, raintight.
c. NEMA Type 4X: Type 316 stainless steel (unless Type 304 is indicated on the Drawings).
d. NEMA Type 4X: Polycarbonate or fiberglass reinforced polyester (FRP) in corrosive areas where stainless steel is incompatible.
e. NEMA Type 12: Steel with gasketed door, dusttight.
f. NEMA Type 7: Cast aluminum.

B. Bolting material:
1. Commercial quality 1/2-inch diameter, stainless steel hex-head Grade 5 bolts, nuts, and washers, with unified coarse (UNC) threads.
2. Carriage bolts for attaching end plates.
3. Other bolted joints shall have S.A.E. standard lock washers.

2.06 MANUFACTURED UNITS

A. Panels/enclosures:
   1. Manufacturers: One of the following or equal:
      a. nVent/Hoffman.
      b. Saginaw Control & Engineering.
      c. Rittal.
   2. Panel assembly:
      a. General guidelines for panel fabrication include:
         1) Continuous welds ground smooth.
         2) Exposed surfaces free of burrs and sharp edges.
         3) Base formed of heavy channel iron, either galvanized or powder coated, minimum 1/2-inch holes at 12-inch spacing to accommodate anchoring of freestanding enclosures to floor.
      b. Construct enclosure and mounting panel using stretcher-level quality sheet metal having minimum thickness not less than the following sizes (U.S. Standard Gauge):

Enclosure Height (inches)	Minimum Enclosure Steel Thickness (gauge)	Minimum Back Mounting Panel Thickness (gauge)
Wall-mounted up to 48	14	14
Up to 57	12	12
57 to 69	12	10
69 to 82	12, except 10 on back	10
82 or more	10	10

         1) Use heavier sheet metal to meet seismic requirements at the project site or when required due to equipment requirements.
      c. For Rittal or engineer-approved equal free-standing modular enclosure, construct enclosure and mounting panel using stretcher-level quality sheet metal having minimum thickness not less than the following sizes (U.S. Standard Gauge):

Enclosure Height (inches)	Minimum Enclosure Steel Thickness (gauge)	Minimum Back Mounting Panel Thickness (gauge)
Wall-mounted up to 48	16	14
Up to 57	14	13
57 or more	16	11

      d. Construct supporting frame structure with angled, channeled, or folded rigid section of sheet metal, rigidly attached to and having essentially the same outer dimensions as the enclosure surface and having sufficient torsional rigidity to resist the bending moments applied via the enclosure surface when it is deflected.
      e. Provide stiffeners for back mounting or C folded back panels in enclosures larger than 4 feet. In addition, secure the panels in place by collar studs welded to the enclosure.

f. Door construction:
    1) Turned-back edges suitably braced and supported to maintain alignment and rigidity without sagging.
    2) Sufficient width to permit door opening without interference with rear projection of flush-mounted instruments.
    3) Heavy-gauge stainless steel hinges.
    4) For NEMA Type 12, Type 4, and Type 4X, provide oil-resistant neoprene sealing gasket and adhesive to seal cover to enclosure.
    5) Gasket installed to seal against roll lip on the enclosure opening.
g. Latches:
    1) For panels, provide each door with an oil tight 3-point latching mechanism and locking handle with rollers on the ends of the latch rods. Latch rods shall be connected to a common door handle, hold doors securely, and form a compressed seal between door and gasket, at the top, side, and bottom.
        a) Provide padlock for each enclosure with padlock provisions.
        b) Provide 2 keys per panel.
        c) All locks keyed alike.
    2) For Rittal or engineer-approved equal free-standing modular enclosure, provide each door with a 4-point latching mechanism, if available, or a 2-point latching mechanism if a 4-point is not available.
    3) For cabinets not available with 3-point latching hardware, provide multiple clips and padlock hasps.
h. Panel cut-outs:
    1) Cut, punch, or drill cutouts for instruments, devices, and windows. Smoothly finish with rounded edges.
    2) Allow a minimum of 3-inch envelope around displays, controllers, and monitors.
    3) Reinforce around cut-outs with steel angles or flat bars for the following:
        a) Large panel cutouts; for example, openings for local operator interfaces.
        b) Pilot device groupings, where the removed metal exceeds 50 percent of the available metal.

3. In addition to the requirements specified above, the following requirements for NEMA Type 4X powder coated stainless steel enclosures apply:
    a. Minimum 16-gauge, Type 304 stainless steel.
    b. Captive stainless steel cover screws threaded into sealed wells.
    c. Inside finish: White polyester powder coating.
    d. Specifically designed for use with flange-mounted disconnect handles where required or as indicated on the Drawings.
4. Outdoor panels. Supplementary requirements for panels located outdoors are as follows:
    a. Enclosures located outdoors shall be explicitly designed and rated for outdoor service by the manufacturer.
    b. Door hardware: Stainless steel.
    c. Provide factory installed rain canopy and sun shield for enclosures with operator interface panels.
    d. Bases: Heavy channel, gasketed stainless steel bases, flanges up, for anchoring to pad.

B. Arrangement of components:
   1. Arrange panel internal components for external conduit and piping to enter into panel either from above or below.
   2. Arrange panel instruments and control devices in a logical configuration, associating pushbutton and selector switches with related readout devices, or as indicated on the Drawings.
   3. Mount internal control components on an internal back panel. Devices may be mounted on the side panel only by special permission from the Engineer.
   4. Control panel mounted operator interface devices shall be mounted between 3 feet and 5 feet above finished floor.
   5. For enclosures containing PLCs or other heat sensitive electronics that require clean uninterruptable power, locate the UPS outside the control panel enclosure and provide separate incoming power terminal blocks for UPS backed up control power and auxiliary power (for lighting, utility power outlets, heating and cooling, etc.)

C. Overcurrent protection:
   1. Main overcurrent device:
      a. Where the electrical power supply voltage to the control panel is more than 120 VAC, provide the panel with a flange-mounted disconnect handle operating a molded-case circuit breaker and provide a control power transformer for 120-VAC circuits:
         1) Door-mounted disconnect handles are not acceptable.
         2) Mechanically interlock the disconnect switch with the control enclosure doors so that no door can be opened unless the power is disconnected, and the disconnect switch cannot be closed until all doors are closed.
         3) Provide means to defeat the interlock.
         4) Lockable in the off position.
      b. Control panels supplied with 120 VAC:
         1) Provide an internal breaker with the line side terminals covered by a barrier.
         2) Provide a nameplate prominently positioned on the control panel identifying the location of the power source and a warning statement requiring the source to be disconnected before opening the door to the enclosure.
         3) Provide a nameplate prominently positioned on the control panel stating “CAUTION Risk of Electric Shock - UPS equipment outputs remain energized with main disconnect in off position” for any panel containing a UPS.
   2. Provide circuit breakers as specified in Section 16412 - Low Voltage Molded Case Circuit Breakers.
   3. Selection and ratings of protective devices:
      a. Interrupting ratings: Not less than the system maximum available fault current at the point of application.
      b. Voltage rating: Not less than the voltage of the application.
      c. Select current rating and trip characteristics to be suitable for:
         1) Maximum normal operating current.
         2) Inrush characteristics.
         3) Coordination of the protective devices to each other and to the source breaker feeding the panel.

d. Circuit breakers, fuses, and motor overcurrent protection devices used for branch circuit protection must be UL 508A compliant.
    1) Circuit breakers listed under UL 1077 Standard for Supplementary Protectors that do not comply with UL 508A requirements are not acceptable.
    2) Miscellaneous, miniature, and micro fuses listed under UL 248 Part 14 that do not comply with UL 508A requirements are not acceptable.
    3) Manual motor controllers provided with an instantaneous-trip overcurrent mechanism listed under UL 508 that do not comply with UL 508A requirements are not acceptable.

4. Provide a separate protective device for each powered electrical device:
    a. An individual circuit breaker for each 120-VAC instrument installed within its respective control panel and clearly identified for function.
    b. An individual fuse for each PLC discrete output. Provide with individual blown fuse indication external of the I/O card:
        1) Size external fuse to open before any I/O-card-mounted fuses.
    c. Individual discrete inputs shall use a 1/2-amp fuse.
        1) Discrete output:
            a) Size external fuse to open before any I/O-card-mounted fuses.
        2) Analog loop powered from the control panel:
            a) 0.25-amp fuse.
        3) Analog loop powered from the control panel:
            a) 0.25-amp fuse.
    d. Install protective devices on the back mounting panel and identify by a service nameplate in accordance with the wiring diagrams.
5. Fuses for analog and discrete control loops:
    a. Provide durable, readily visible label for each fuse, clearly indicating the correct type, size, and ratings of replacement fuse:
        1) Label shall not cover or interfere with equipment manufacturer's instructions.
    b. Provide fuses rated for the voltage and available short-circuit current at which they are applied.
    c. Manufacturers: One of the following or equal:
        1) Ferraz Shawmut.
        2) Littelfuse.
        3) Bussmann.
6. Fuse holders:
    a. Modular type:
        1) DIN rail mounting on 35-millimeter rail.
        2) Touch-safe design: Connection terminals to be protected against accidental touch.
        3) Incorporates blown-fuse indicator.
        4) Plug-in style fuse terminals and fuse plugs are not acceptable.
    b. Provide nameplate identifying each fuse:
        1) As specified in Section 16075 - Identification for Electrical Systems.
    c. Manufacturers: One of the following or equal:
        1) Phoenix Contact, UT4-HESI Series.
        2) Allen-Bradley, 1492-FB Series B.
7. Control circuit breakers:
    a. DIN rail mounting on 35-millimeter rail.
    b. Manual OPEN-CLOSE toggle switch.

c. Rated for 250 VAC.
d. Interrupting rating: 10 kiloampere (kA) or available fault current at the line terminal, whichever is higher.
e. Current ratings: As required for the application.
f. Provide nameplate identifying each circuit breaker:
1) As specified in Section 16075 - Identification for Electrical Systems.
g. Manufacturers: One of the following or equal:
1) Phoenix Contact, TMC Series.
2) ABB.
3) Allen-Bradley.
4) Square D.

8. Electronic circuit protectors:
a. Used where a NEC Class 2 power circuit is required.
b. Confirms to NEC Class 2 according to UL 1310.
c. DIN rail mounting on 35-millimeter rail.
d. Power source:
1) Operating voltage: 24 VDC.
2) Output current ratings: As required for the application.
3) Maximum output current: 4 A.
4) Maximum nameplate rating: 100 VA.
e. LED for status indication.
f. Remote status contact.
g. When using multi-channel electronic circuit protectors, distribute devices such that a failure is limited to a single network or segment.
h. Provide nameplate identifying each circuit electronic circuit protector module:
1) As specified in Section 16075 - Identification for Electrical Systems.
i. Manufacturers: One of the following or equal:
1) Single channel:
a) Phoenix Contact, PTCB E1 series.
b) Allen-Bradley, 1694 series.
2) Multi-channel:
a) Phoenix Contact, CBMC series.
b) Puls PISA11 series.

D. Conductors and cables:
1. Power and control wiring:
a. Materials: Stranded, soft annealed copper.
b. Insulation: 600 VAC type MTW.
c. Minimum sizes:
1) Primary power distribution: 12 AWG.
2) Secondary power distribution: 14 AWG.
3) Control: 16 AWG.
d. Color:
1) AC power (line and load): Black.
2) AC power (neutral): White.
3) AC control: Red.
4) AC control: Orange for foreign voltages.
5) DC power and control (ungrounded): Blue.
6) DC power and control (grounded): White with Blue stripe.
7) Ground: Green.

2. Signal cables:
    a. Materials: Stranded, soft annealed copper.
    b. Insulation: 600 VAC, PVC outer jacket.
    c. Minimum size: 18 AWG paired triad.
    d. Overall aluminum shield (tape).
    e. Copper drain wire.
    f. Color:
        1) 2-conductor:
            a) Positive (+): Black.
            b) Negative (-): White and red.
        2) 3-conductor:
            a) Positive (+): Black.
            b) Negative (-): Red.
            c) Signal: White.
    g. Insulate the foil shielding and exposed drain wire for each signal cable with heat-shrink tubing.

E. Conductor identification:
    1. Identify each conductor and cable with unique wire numbers as specified in Section 16075 - Identification for Electrical Systems.
    2. Readily identified without twisting the conductor.

F. General wiring requirements:
    1. Wiring methods: Wiring methods and materials for panels shall be in accordance with the NEC requirements for General Purpose (no open wiring) unless otherwise specified.
    2. Install components in accordance with the manufacturer's instructions included in the listing and labeling.
    3. Provide a nameplate on the cover of the control panel identifying sources of power supply and foreign voltages within the control panel.
    4. Provide transformers, protective devices, and power supplies required to convert the supply voltage to the needed utilization voltage.
    5. Provide power surge protection for control panels.
    6. Provide signal surge protection within control panels for each analog I/O, discrete I/O, and data line (Copper Ethernet, Coax, Fieldbus signals) that originates from outdoor devices.
    7. Provide non-metallic ducts for routing and organization of conductors and cables:
        a. Provide wiring separation plan.
        b. Size ducts for ultimate build-out of the panel, or for 20-percent spare, whichever is greater.
        c. Provide separate ducts for signal and low voltage wiring from power and 120 VAC control wiring:
            1) 120 VAC: Grey colored ducts.
            2) 24 VDC: White colored ducts.
    8. Cables shall be fastened with cable-mounting clamps or with cable ties supported by any of the following methods:
        a. Screw-on cable tie mounts.
        b. Hammer-on cable-tie mounting clips.
        c. Fingers of the nonmetallic duct.

9. Wire ties:
    a. No wire ties inside wire duct.
    b. Use Panduit cable tie installation tool, with tension control/cutoff.
    c. Verify cut ends are cut flush filed smooth after installed.
10. Provide supports at the ends of cables to prevent mechanical stresses at the termination of conductors.
11. Support panel conductors where necessary to keep them in place.
12. Wiring to rear terminals on panel-mount instruments shall be run in nonmetallic duct secured to horizontal brackets run adjacent to the instruments.
13. Conductors and cables shall be run from terminal to terminal without splice or joints. Exceptions:
    a. Factory-applied connectors molded onto cables shall be permitted. Such connectors shall not be considered as splices or joints.
14. Control panel shall be the source of power for 120 VAC devices interconnected with the control panel, including, but not limited to:
    a. Solenoid valves.
    b. Instruments both mounted in the control panel and remotely connected to the control panel.

G. Provide power circuits for Contractor- and vendor-furnished PLC cabinets in accordance with the PLC and instrument power wiring diagrams indicated on the Drawings or as specified.

H. Thermal management:
1. Provide heating, cooling, and dehumidifying devices in order to maintain instrumentation and control devices to within a range as specified in Section 17050 - Common Work Results for Process Control and Instrumentation.
2. Heating:
    a. Provide panels located in areas that are not climate controlled with thermostatically controlled strip heaters, except where all of the following conditions apply:
        1) Panel is not supplied with 120 VAC power.
        2) There are no electronics or moisture-sensitive devices in the enclosure.
        3) Panel is smaller than 38-inches high.
3. Heat exchanger:
    a. Closed-loop design ensuring separation of ambient air and clean air inside the cabinet.
    b. Filterless design to facilitate easy cleaning of the core.
    c. Mounting: As indicated on the Drawings.
    d. Manufacturers: The following or equal:
        1) Noren, CC Series.
        2) ICEqube, Blade series.
4. Enclosure temperature sensor as indicated on the Drawings:
    a. Provide wall mounted RTD transmitter (to measure internal cabinet temperature) in enclosures containing electrical components such as PLCs, RTUs, RIO, and VFDs.
    b. Platinum RTD.
    c. 4 to 20 mA DC output.
    d. Sensor and electronic enclosure.

e. Accuracy: Within 2 degrees Fahrenheit.
f. Manufacturers: One of the following or equal:
1) Omega, EWS Series.
2) TCS Basys Controls, TS Series as indicated on the Drawings.

5. Enclosure temperature switch:
a. Provide wall-mounted bimetallic switch transmitter (to measure internal cabinet temperature in enclosures) containing electrical components such as PLCs, RTUs, RIO, and VFDs.
b. Sensor and electronic enclosure.
c. Accuracy: Within 2 degrees Fahrenheit.
d. Single contact:
1) Manufacturers: One of the following or equal:
a) nVent/Hoffman ATEMNC.
b) Pfannenberg FLZ.
c) Rittal.
e. Dual contact:
1) Manufacturers: The following or equal:
a) nVent/Hoffman ADLTEMP.
b) Rittal.

6. Status relays and discrete inputs for switches, power supplies, and fieldbus devices (if applicable):
a. Provide as indicated on the Drawings or as specified.

7. Fan ventilation:
a. Provide nVent/Hoffman or Rittal fan speed control:
1) Provide 2 door/cabinet-mounted vent fans for every 72 inches of cabinet width.
2) Provide finger-guard kit.
3) Filter kit with 2 spare filters for each intake fan.
4) Provide bezel and gasket kit.
5) Provide fan shroud.
6) Automatically adjust fan speed depending on remote temperature sensor input.
7) 120 VAC, 60 hertz.
8) NEMA Type 5-15R cord connections.

8. Control panel specific heating and cooling requirements:
a. PCM-050-220-01 (Clarifier Sludge Blowdown/4-Log Sampling)shall be equipped with a thermostatically controlled strip heater and air conditioner. The heater shall be disconnected and provided as a temporary backup humidity control device to the air conditioner. Air conditioner shall be 316SS EV Series® as manufactured by ICEqube or Engineer approved equivalent as manufactured by Kooltronic, Rittal, or Hoffman.
b. PCM-050-550-01 (CO_2 System) shall be equipped with a thermostatically controlled strip heater.
c. PCM-050-500-01 (Chemical Storage and Feed Systems) will not be equipped with any climate control devices.

I. Panel meters:
1. Pointer type:
a. Suitable for panel mounting.
b. Minimum scale length: 3 inches.

c. Calibrated in engineering units.
d. Accuracy: Within 2 percent of span.
e. NEMA Type 4/IP65 sealed front metal bezel.
f. Manufacturers: One of the following or equal:
    1) Yokogawa.
    2) Red Lion.

2. Digital process indicators:
    a. General:
        1) Integral provisions for scaling.
        2) Scale to process engineering units.
        3) Switch-programmable decimal points.
        4) NEMA Type 4/IP65 sealed front bezel.
    b. Current and voltage indicators:
        1) 3-1/2-digit minimum.
        2) Minimum character height: 0.5 inches.
        3) Accuracy:
            a) AC/DC volts: Within 0.1 percent of reading plus 2 digits.
            b) DC current: 4-to-20 mA; within 0.1 percent of reading plus 1 digit.
            c) DC voltage: 0 to 10 volts; within 0.1 percent of reading plus 1 digit.
    c. Operating voltage: 120 VAC.
    d. Operating temperature: 32 degrees to 140 degrees Fahrenheit.
        1) Manufacturers: One of the following or equal:
            a) Red Lion.
            b) Action Instruments, Visipak.

3. Digital bar graph meter:
    a. Self-contained instruments that display process signals directly in engineering units, both in decimal format and as a bar graph display.
    b. Suitable for panel mounting.
    c. LED display:
        1) Not less than 3 decimal digits.
        2) Not less than a 101-segment LED bar graph.
    d. Input signal:
        1) Conventional current loops and voltage control signals.
    e. Minimum sample rate of once per second.
    f. Provisions for field-adjustable scaling and/or offset.
    g. Accuracy shall be within 1 least-significant digit.
    h. Manufacturers: One of the following or equal:
        1) Ametek Dixson.
        2) Yokogawa.
        3) Weschler Instruments.

4. Counters:
    a. 6 digits.
    b. Switch-selectable inputs:
        1) Switch contacts.
        2) CMOS.
        3) TTL.
        4) Magnetic pickup.
        5) RLC sensors.
    c. Selectable up/down control via external signal.
    d. Remote reset.

e. Remote inhibit to prevent accumulating counts.
f. Programmable to enable or disable front panel reset.
g. Non-volatile memory to retain all data upon loss of supply power.
h. Sunlight readable.
i. Operating temperature: 32 degrees to 122 degrees Fahrenheit.
j. Manufacturers: The following or equal:
1) Red Lion, PAX Series.

J. Pilot devices:
1. General:
a. Provide operator pushbuttons, switches, and pilot lights, from a single manufacturer.
b. Size:
1) 30.5 millimeters.
c. Heavy duty.
d. Pushbuttons:
1) Contacts rated:
a) NEMA Type A600.
2) Furnish 1 spare normally open contact and normally closed contact with each switch.
e. Selector switches:
1) Contacts rated:
a) NEMA Type A600.
b) Knob type.
2) Furnish 1 spare normally open contact and normally closed contact with each switch.
3) Provisions for locking in the OFF position where lockout provisions are indicated on the Drawings.
f. Pilot lights:
1) Type:
a) LED for interior installations.
2) Push to test.
3) Lamp color:
a) On/Running/Start: Red.
b) Off/Stop: Green.
c) Power: White.
d) Alarm: Amber.
e) Status or normal condition: White.
f) Opened: Red.
g) Closed: Green.
h) Failure: Red.
2. Indoor and outdoor areas:
a. NEMA Type 4/13.
b. Manufacturers: One of the following or equal:
1) Allen-Bradley, Type 800T.
2) Schneider Electric, Class 9001, Type K.
3) General Electric, Type CR104P.
4) IDEC, TWTD Series.
3. Corrosive areas:
a. NEMA Type 4X.
b. Corrosion resistant.

c. Exterior parts of high-impact strength fiberglass-reinforced polyester or multiple-layer epoxy-coated zinc.
d. Manufacturers: One of the following or equal:
1) Cutler Hammer, Type E34.
2) Schneider Electric, Class 9001, Type SK.
3) Allen-Bradley Type 800H.
4) IDEC, TWTD Series.

4. Hazardous (classified) areas/Class I Division 2:
a. NEMA Type 4X.
b. Corrosion resistant.
c. Exterior parts of high-impact strength fiberglass-reinforced polyester or multiple-layer epoxy-coated zinc:
1) Contacts contained within a hermetically sealed chamber:
a) Pushbuttons.
b) Selector switches.
c) Push-to-test contacts on pilot lights.
2) UL listed and labeled for Class I Division 2 areas.
d. Manufacturers: One of the following or equal:
1) Cutler Hammer, Type E34.
2) Allen-Bradley, Type 800H.

K. Potentiometer and slidewire transmitters:
1. Provide a DC output in proportion to a potentiometer input.
2. Potentiometer input:
a. 100 ohms to 100 K ohms.
b. Impedance greater or equal to 1 M ohms.
c. Zero turn-up: 80 percent of full-scale input.
d. Span turn-down: 80 percent of full-scale input.
3. Field-configurable output:
a. Voltage and current: Conventional current loops and voltage control signals.
4. Accuracy including linearity and hysteresis within 0.1 percent maximum at 77 degrees Fahrenheit.
5. Operating temperature: 32 degrees to 131 degrees Fahrenheit.
6. Supply power: 9 to 30 VDC.
7. Manufacturers: The following or equal:
a. Phoenix Contact, Mini Analog Pro.
b. Allen Bradley Type 800T-U29.

L. Signal isolators and converters:
1. Furnish signal isolators that provide complete isolation of input, output, and power input:
a. Minimum isolation level: 1.0 kilovolts AC/50 hertz for at least 1 minute.
b. Adjustable span and zero.
c. Accuracy: Within 1.0 percent of span.
d. Ambient temperature range: -4 degrees to 149 degrees Fahrenheit.
2. Manufacturers: One of the following or equal:
a. Phoenix Contact, Mini Analog Pro.
b. Acromag, 1500, 600T, 800T, Flat Pack, or ACR Series.
c. Action Instruments, Q500 Series or Ultra SlimPakII.
d. AGM Electronics, Model TA-4000.

e. Moore Industries, MIT 4-Channel.

M. Relays:
1. General:
a. For all types of 120-VAC relays, provide surge protection across the coil of each relay.
b. For all types of 24-VDC relays, provide a free-wheeling diode across the coil of each relay.
c. For plug in type relays, provide a relay base from the same manufacturer as the relay manufacturer.
2. Control:
a. Magnetic style.
b. For use as standard control relay for motor and starter relay logic.
c. NEMA ratings:
1) 300 volts.
2) 10 amps thermal continuous test current.
3) 60 amps make.
4) 6 amps break.
d. Plug-in type.
e. LED indication for energization status.
f. Coil voltages: As required for the application.
g. Minimum poles: DPDT.
h. Touch-safe design: Connection terminals to be protected against accidental touch.
i. Enclose each relay in a clear plastic heat and shock-resistant dust cover.
j. Quantity and type of contact shall be as indicated on the Drawings or as needed for system compatibility.
k. Relays with screw-type socket terminals.
l. Provide additional relays when the following occurs:
1) Number or type of contacts shown exceeds the contact capacity of the specified relays.
2) Higher contact rating is required in order to interface with starter circuits or other equipment.
m. DIN rail mounting on 35-millimeter rail.
n. Ice-cube-type relays with retainer clips to secure relay in socket.
o. Integrated label holder for device labeling.
p. Manufacturers: One of the following or equal:
1) Potter and Brumfield: Type KRP or KUP.
2) IDEC: R* Series (* = H, J, R, S, U).
3) Allen-Bradley: Type 700 HC.
4) Square D: Type K.
3. Isolation:
a. Electromechanical style.
b. For use as an interposing relay for PLC based discrete I/O signals.
c. NEMA ratings:
1) Switching voltage: 250 volts AC/DC.
2) Limiting current: 6 amps continuous.
3) Interrupt: 1,500 volt-amperes.
d. Plug-in type.
e. LED indication for energization status.
f. Coil voltages: As required for the application.

g. Minimum poles: SPDT.
h. Touch-safe design: Connection terminals to be protected against accidental touch.
i. Quantity and type of contact shall be as indicated on the Drawings or as needed for system compatibility.
j. Relays with screw-type socket terminals.
k. DIN rail mounting on 35-millimeter rail.
l. Integrated label holder for device labeling.
m. Manufacturer: One of the following or equal:
1) Phoenix Contact PLC-INTERFACE Series.
2) Eaton XR TBR Series.
3) IDEC RV8H Series.
4) Allen-Bradley Type 700 HL TBR Series.

4. Latching:
a. Magnetic-latching control relays.
b. NEMA ratings:
1) 300 volts.
2) 5 amps continuous.
3) 360 volt-amperes make.
4) 320 volt-amperes break.
c. Plug-in type.
d. DIN rail mounting on 35-millimeter rail.
e. Coil voltage: As required for the application.
f. Minimum contacts: DPDT; as required for the application. Plus 1 spare contact.
g. Touch-safe design: Connection terminals to be protected against accidental touch.
h. Clear cover for visual inspection.
i. Provide retainer clip to secure relay in socket.
j. Manufacturers: One of the following or equal:
1) Square D, 8501, Type K.
2) IDEC, RR2KP Series.

5. Time delay:
a. Provide time-delay relays to control contact transition time.
b. Contact rating:
1) 240 volts.
2) 10 amps continuous.
3) 3,600 volt-amperes make.
4) 360 volt-amperes break.
c. Coil voltage: As required for the application.
d. Provide pneumatic or electronic type with on-delay, off-delay, and on/off-delay:
1) For off-delay, use true power-off time-delay relays. Where the required timing range exceeds capability of the off-delay relay use, signal off-delay where power loss will not cause undesirable operation or pneumatic time-delay relays.
e. Minimum contacts: DPDT.
f. Units include adjustable dial with graduated scale covering the time range in each case.
g. Minimum timing range: 0.1 second to 10 minutes, or as required for the application.

h. Manufacturers: One of the following or equal:
    1) IDEC, RTE Series.
    2) Tyco Electronics, Agastat 7000 Series (pneumatic).
    3) Allen-Bradley, Type 700-HR.

N. Terminal blocks:
    1. DIN rail mounting on 35-millimeter rail.
    2. Rated for 15 amps at 600 volts.
    3. Screw terminal type.
    4. Provide mechanism to prevent wire connection from loosening in environments where vibration is present. This mechanism shall not cause permanent deformation to the metal body.
    5. Finger-safe protection for terminals for conductors.
    6. Construction: Polyamide insulation material capable of withstanding temperature extremes from -40 degrees to 221 degrees Fahrenheit.
    7. Terminals: Plainly identified to correspond with markings on the diagrams:
        a. Permanent machine-printed terminal identification.
    8. Disconnect-type field signal conductor terminals with socket/screw for testing.
    9. Identify terminals suitable for use with more than 1 conductor.
    10. Position:
        a. So that the internal and external wiring does not cross.
        b. To provide unobstructed access to the terminals and their conductors.
    11. Manufacturers: One of the following or equal:
        a. Phoenix Contact, UT4 Series.
        b. Phoenix Contact UT6 Series, multi-level (screw terminal) terminal blocks.
        c. Allen-Bradley, 1492 Series.

O. DIN rail grounding:
    1. Grounding terminal blocks used exclusively for bonding each DIN rail section to panel grounding busbar shall:
        a. Mount to DIN rail via grounding foot with mounting screw.
        b. Connect to the panel grounding busbar shall be via a green insulated conductor sized in accordance with NEC.
        c. Not be used for grounding signal cable shields.
    2. Screw terminal type.
    3. DIN rail mounting on 35-millimeter rail.
    4. Provide mechanism to prevent wire connection from loosening in environments where vibration is present. This mechanism shall not cause permanent deformation to the metal body.
    5. Finger-safe protection for terminals for conductors.
    6. Terminals: Plainly identified to correspond with markings on the diagrams:
        a. Permanent machine-printed terminal identification.
    7. Manufacturers: One of the following or equal:
        a. Phoenix Contact, USKLG Series.
        b. Allen-Bradley, 1492-JG Series.

P. Wire duct:
    1. Provide flame retardant plastic wiring duct, slotted with dust cover.
    2. Type:
        a. Wide slot.
        b. Narrow slot.

c. Round hole.
3. Manufacturers: The following or equal:
   a. Panduit.
   b. Phoenix Contact.
   c. Thomas & Betts.
   d. Iboco.

Q. DIN rail:
1. Perforated steel.
2. 35 mm width.
3. 15 mm deep.
4. Provide 2-inch offset using one of the following:
   a. Offset brackets.
   b. Preformed standoff DIN Rail Channel.

R. Surge protection devices (SPD):
1. 120 VAC control panel power SPD:
   a. Provide SPD for panel 120 VAC power entrances:
      1) Non-faulting and non-interrupting design.
      2) Provide line to neutral and neutral to ground surge protection.
   b. Provide surge protection at secondary of main circuit breaker:
      1) Surge protection is not required for 120 VAC circuits that are only used for panel lights and receptacles.
      2) For panels receiving power at 480 VAC, provide surge protection on the 120 VAC control power transformer secondary.
   c. DIN rail mounting.
   d. Attach wiring to the SPD by means of a screw-type cable-clamping terminal block:
      1) Gastight connections.
      2) Visual status indication of MOV status on the input and output circuits.
      3) Dry contact rated for remote status indication.
   e. Approvals:
      1) Tested in accordance with IEC 61643-11.
      2) Tested in accordance with UL 1283.
      3) Tested in accordance with UL 1449.
      4) Surge protection minimum requirements: Withstand a minimum 10-kA test current of an 8/20 µs waveform in accordance with IEEE C62.41.1 Category C Area.
   f. Manufacturers: One of the following or equal:
      1) Phoenix Contact, Type SFP Filter.
      2) Sola HD, STFE Elite series.
      3) Rockwell, 4983-DC series.
      4) ASCO, Model 277.
2. 24 VDC control panel power SPD:
   a. Provide SPD for 24 VDC power circuits.
   b. Provide surge protection at DC power supply output.
   c. DIN rail mounting.
   d. Attach wiring to the SPD by means of a screw-type cable clamping terminal block:
      1) Optical status indicator.

2) Dry contact rated for remote status indication.

e. Approvals:
1) Tested in accordance with IEC 61643-11.

f. Manufacturers: One of the following or equal:
1) Field instruments that require auxiliary power:
a) Phoenix Contact, Plugtrab PLT--SEC-T3-24-FM-UT.
b) Emerson, Model 265 (SLAC) series.
2) Loop powered field instruments:
a) Emerson/Edco, Model SS65-036-2.

3. Panel mounted control, signal, and data line SPD:
a. General:
1) This section applies to SPD located in a control panel, field panel, network junction box, or marshalling panel.
2) Approvals:
a) Tested in accordance with IEC 61643-21.
b) Tested in accordance with UL 497B.
3) SPD shall consist of 2 parts:
a) Base module:
(1) DIN rail mounting.
(a) Grounded to DIN rail via mounting rail foot.
b) Plug protection module:
(1) Replacing a plug shall not require the removal of any wires nor interrupt the signal.
4) Provide indirect shield ground style SPD unless otherwise noted.
5) Provide ability to locally identify and indicate SPD health.
6) SPD shall be provided with controller module with dry contact for remote status monitoring of SPD device health.
7) SPD modules shall be compatible with signal, communication bus type, data type, or control power being protected.
8) Provide dedicated SPD for each signal, communication bus type, or data line being protected.

b. Manufacturers: One of the following or equal:
1) Phoenix Contact, Plugtrab PT-IQ Series.
2) Dehn, Blitzductor XTU Series.

4. Copper Ethernet SPD:
a. Protects network equipment from lightning or other surge events.
b. Suitable for Gigabit networks.
c. Shielded RJ-45 ports.
d. Compliant with PoE standards IEEE 802.3af and 802.3at.
e. Nominal discharge surge current: 10 kA.
f. Approvals:
1) Tested in accordance with IEC 61643-21.
2) Tested in accordance with UL 497B.
g. Manufacturers: One of the following or equal:
1) Phoenix Contact, DT-LAN-CAT6+.
2) Citel, MJ8-C6A.
3) Weidmuller, VDATA CAT6.
4) Eaton/MTL, ZoneBarrier High Energy Ethernet.

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

S. Horns and beacons:
    1. Beacons/horn combination units:
        a. Manufacturers: The following or equal:
            1) Edwards, Multi-Status LED 108i with tone module.
            2) Federal Signals, AV1ST Strobe Combination Audible/Visual Signal.
        b. LED Colors: Red, Green, and Amber.
        c. Power: 120 VAC.
        d. Provide accessories such as pipe mount flange, pipe extensions, corner mount brackets, or wall mount brackets as needed.
        e. Horn rated 80 dB minimum at 10 feet.
    2. Dedicated beacon unit:
        a. Manufacturers: One of the following or equal:
            1) Federal Signal Corp., Starfire Series.
            2) Allen-Bradley, 855 B *-* 10 Series.
            3) Edwards, 102 Series.
    3. Dedicated horn unit:
        a. Electromechanical:
            1) Manufacturers: One of the following or equal:
                a) Federal Signal, 350 or 31X Series.

b) Edwards, 878EX or 879EX Series.

b. Electronic:
   1) Manufacturers: One of the following or equal:
      a) Federal Signal, 300GCX or 300X Series.
      b) Allen-Bradley, 855H or 855XH Series.
      c) Edwards, 5530M or 5533MD Series.
   c. Rated for 80 dB minimum at 10 feet.

T. Power supplies:
   1. Configure power supply system so that either the primary or backup supply can be removed, repaired or replaced, and returned to service without disrupting the system operation.
   2. Convert 120 VAC to 24-volt DC or other DC voltages required or as required for the application.
   3. Provide redundant backup 24 VDC power supply units to automatically supply the load upon failure of the primary supply.
   4. Provide power supply arrangement that is configured with several modules to supply adequate power in the event of a single module failure in either a 1+1 or N+1 configuration as required:
      a. Provide automatic switchover upon module failure.
      b. Alarm contacts monitored by the PLC.
   5. Provide protective isolation between power supply units either by means of Diodes, Diode Modules, MOSFET Modules, or use power supplies with built in redundancy. Power supplies with built in redundancy must actively isolate each power supply and be designed as such.
   6. Sized to provide 40-percent excess rated capacity.
   7. UL 508 listed to allow full-rated output without de-rating.
   8. Provide fuse or short-circuit protection.
   9. Provide a minimum of 1 set of dry contacts for each power supply configured to change state on failure for monitoring and signaling purposes.
   10. Output regulation: Within 0.05 percent for a 10-percent line change or a 50-percent load change.
   11. Operating temperature range: 32 degrees to 140 degrees Fahrenheit.
   12. Touch-safe design: Connection terminals to be protected against accidental touch.
   13. DIN rail mounting on 35-millimeter rail:
      a. Mount the power supply in the proper orientation as recommended by the manufacturer to ensure adequate thermal dispersion without derating the power supply.
   14. Provide self-protecting power supplies with a means of limiting DC current in case of short circuit.
   15. Manufacturers: One of the following or equal:
      a. Fully redundant:
         1) Phoenix Contact, Quint Power Supply with SFB technology.
            a) Phoenix Contact, Quint.
         2) IDEC, PS5R Series:
         3) Sola.
         4) PULS.
      b. Redundancy module:
         1) Phoenix contact, O-ring redundancy module.

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

V. Proximity switches:
   1. Power supply: 24 VDC supply voltage.
   2. 1 normally open and normally closed contacts.
   3. LED optical sensing, polar-retro.
   4. Distance: 6 meters (19.8 feet).
   5. Manufacturers: The following or equal:
      a. Banner T30 or equal.

W. Current switches:
   1. Power supply: 120 VAC supply voltage.
   2. 1 normally open and normally closed contacts.
   3. Adjustable current setting.
   4. Manufacturers: The following or equal:
      a. Zelio®, RM35.
      b. Phoenix Contact, EMD Series.

X. Current transmitters:
   1. Input current range: As indicated on the Drawings.
   2. Output: 4 to 20 mA.
   3. Power supply: 24 VDC supply voltage.
   4. Output overload protected.
   5. Accuracy: Within 0.5 percent full-scale.
   6. Ripple and Noise: 1 percent max., peak to peak.
   7. Frequency: 50/60 hertz.
   8. Manufacturer:
      a. Phoenix Contact: Mini Analog Pro Series.
      b. CR Magnetics: CR4320 series.
      c. American Aerospace: 1070 Series.

Y. Panel mount quick connector:
   1. Keyed insertion plug.
   2. Threaded cap to protect connection when not in use.
   3. Material: Stainless steel.
   4. Pre-wired pigtails.

5. Indoor/outdoor:
    a. Rating: Meets or exceeds panel rating.
    b. Manufacturers: One of the following or equal:
        1) Amphenol.
        2) Sealcon.
6. Hazardous (classified) areas:
    a. UL listed and labeled for area as indicated on the Drawings.
    b. Manufacturers: The following or equal:
        1) Amphenol HDE Series.

2.07 ACCESSORIES

A. Provide panels with an inside protective pocket to hold the panel drawings. Ship panels with 1 copy of accepted Shop Drawings, including, but not limited to, schematic diagram, connection diagram, and layout drawing of control wiring and components in a sealed plastic bag stored in the panel drawing pocket.

B. Provide floor stands or legs with a minimum height of 12 inches where needed or as indicated on the Drawings.

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

D. Provide nameplate to each panel as indicated on the Drawings:
1. As specified in Section 16075 - Identification for Electrical Systems on internal and external instruments and devices.
2. With the following markings that is plainly visible after installation:
    a. Manufacturer’s name, trademark, or other descriptive marking by which the organization responsible for the panel can be identified.
    b. Supply voltage, phase, frequency, and full-load current.
    c. Power source or circuit ID.
    d. Short-circuit current rating of the panel based on one of the following:
        1) A listed and labeled assembly.
        2) Established utilizing an approved method.

E. Provide a window kit where indicated on the Drawings or where a transmitter with display is mounted inside a control panel. Window shall meet the following requirements:
1. Safety plate glass.
2. Secured by rubber locking seal.
3. Allow full viewing of devices issuing visual process data or diagnostics.

F. Lighting:
1. Provide 1 luminaire for each section, on the interior of the panel, spaced evenly along the top-front of the enclosure door opening(s):
    a. Covered or guarded.
    b. Provide On-Off door-activated switches where indicated on the Drawings.
    c. 120-volt, single-phase, 15-amp style plug.
    d. Provide 4,000 K, 900 Lumens LED fixture.
        1) Provide additional fixtures for every 36 inches of width.

G. Receptacles:
   1. Provide 1 duplex receptacle located every 6 feet of enclosure width, spaced evenly along the back mounting panels.
   2. GFCI, 120-volt, single-phase, 15-amp style plug.
   3. Provide circuit breaker or fuse to limit receptacle draw to 5 amps.

H. Grounding:
   1. Provide the following:
      a. Grounding strap between enclosure doors and the enclosure.
      b. Equipment grounding conductor terminals.
      c. Provide equipment grounding busbar with lugs for connection of equipment grounding wires.
      d. Bond multi-section panels together with an equipment grounding conductor or an equivalent grounding busbar.
   2. Identify equipment grounding conductor terminals with the word “GROUND,” the letters “GND”, the letter “G”, or the color green.
   3. Signal cable shields shall only be grounded at a single point in the loop. Unless otherwise noted, ground signal cable shields at control panel.
   4. Ensure the continuity of the equipment grounding system by effective connections through conductors or structural members.
   5. Design so that removing a device does not interrupt the continuity of the equipment-grounding circuit.
   6. Provide an equipment-grounding terminal for each incoming power circuit, near the phase conductor terminal.
   7. Size ground wires in accordance with NEC and UL Standards, unless noted otherwise.
   8. Unless otherwise noted, connect exposed, noncurrent-carrying conductive parts, devices, and equipment to the equipment-grounding circuit.
   9. Connect the door stud on the enclosures to an equipment-grounding terminal within the enclosure using an equipment-bonding jumper.
      a. Control Panel ground lugs and ground bar shall be copper mechanical or compression connection type. Aluminum connectors or lugs are not acceptable for use with copper conductors.

I. Provide sunshades and insulation for outdoor installations.

J. Automatic transfer switches (ATS):
   1. Manufacturers: The following or equal:
      a. Eaton, EATS series.
      b. APC; Schneider, Rack ATS series.
   2. Properties:
      a. Dual redundant power source inputs.
      b. Voltage shall be 120 VAC, unless otherwise indicated on the Drawings.
      c. User selectable primary power source.
      d. LED status indicators.
      e. Command line interface.
      f. Horizontal rack mounted.
      g. Connections to match UPS connections and as indicated on the Drawings.

h. Communication:
1) Ethernet:
a) ATS shall include Ethernet network communication card.
b) Network protocols: SNMP and Modbus TCP.
c) Network interface: RJ45.

3. Mounting:
a. DIN rail mounting.

2.08 FINISHES

A. Finishes:
1. Metallic (non-stainless):
a. Metal surfaces of panels shall be prepared by chemical cleaning and mechanical abrasion in accordance with the finish manufacturer's recommendations to achieve a smooth, well-finished surface.
b. Scratches or blemishes shall be filled before finishing. 1 coat of zinc phosphate shall be applied according to the manufacturer's recommended dry-film thickness and allowed to dry before applying the finish coat.
c. Finish coat shall be a baked polyester-urethane powder, aliphatic air-dry polyurethane, or epoxy enamel to meet NEMA rating specified application.
d. Exterior of enclosures located outdoors shall be UV-resistant polyester powder coating. Total dry film thickness shall be 3 mils, minimum.
2. Stainless steel:
a. Stainless enclosures shall be provided with a Number 4 brushed finish - not painted.

B. Colors:
1. Exterior color of panels mounted indoors shall be manufacturer's standard light gray.
2. Exterior of panels mounted outdoors shall be manufacturer's standard white.
3. Panel interiors shall be manufacturer's standard white.

PART 3 EXECUTION

3.01 PREPARATION

A. Equipment support and anchoring to structures:
1. As specified in Section 01850 - Design Criteria, including, but not limited to:
a. Anchor bolt layout.
b. Equipment templates.
c. Anchor installation.

3.02 INSTALLATION

A. Install enclosures so that their surfaces are plumb and level within 1/8-inch over the entire surface of the panel: Anchor securely to wall and structural supports at each corner, minimum. Direct attachment to drywall is not permitted.

B. Install the equipment in accordance with the accepted installation instructions and anchorage details.

C. Provide floor stand kits for wall-mounted enclosures larger than 48-inches high.

D. Provide concrete housekeeping pads for freestanding enclosures.
   1. Refer to the structural typical details.

E. Install gasket and sealing material under panels with floor slab cutouts for conduit:
   1. Undercoat floor-mounted panels.

F. Provide a full-size equipment-grounding conductor in accordance with NEC included with the power feeder. Terminate to the incoming power circuit-grounding terminal.

G. Holes for field conduits, etc., shall be cut in the field. No additional holes, factory cut holes, or hole closers allowed. Incorrect holes, additional holes, or miscut holes shall require that the entire enclosure be replaced.

H. Protect wiring from sharp edges and corners.

I. Control panels that are adjacent to motor control centers shall be fully wired to the motor control centers using wireways integral to the motor control center or additional conduits as needed. These interconnections are not shown or reflected on the Conduit Schedule but shall be shown on the loop drawings prepared by the Contractor.

J. Provide individually fused analog input module points with blown-fuse indicator lights, mounted external of the module on the output terminal strip.

K. Side panels:
   1. Side panels shall be kept free of control equipment and devices. Any deviation must be sent to the Engineer in writing asking for a deviation.

3.03 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

END OF SECTION

SECTION 17712

CONTROL SYSTEMS: UNINTERRUPTIBLE POWER SUPPLIES 10 KVA AND BELOW

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Single-phase double conversion uninterruptible power supplies rated 10 kVA and below.

1.02 REFERENCES

A. As specified in Sections 16050 - Common Work Results for Electrical and 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Abbreviations:
   1. MOV: Metal oxide varistor.

C. Definitions:
   1. Critical load: Load supplied by the UPS.

D. Standards:
   1. Federal Communications Commission (FCC):
      a. FCC Part 15, Class A.
      b. FCC Part 15, Class B.
   2. Institute of Electrical and Electronic Engineers (IEEE):
      a. 519 - IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems.
      b. 1184 - IEEE Guide for Batteries for Uninterruptible Power Supply Systems.
      c. C62.41 - IEEE Recommended Practice for Surge Voltages in Low-Voltage AC Power Circuits.
   3. National Electrical Manufacturers Association (NEMA):
      a. 250 - Enclosures for Electrical Equipment (1000 V Maximum).
   4. Underwriters Laboratories, Inc. (UL):
      a. UL 1778 - Standard for Uninterruptible Power Supply Systems and Equipment.

1.03 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Product data:
   1. Manufacturer and model number.
   2. Catalog data.

3. Dimensions:
    a. Height.
    b. Width.
    c. Depth.
    d. Weight.
4. Ratings:
    a. Input voltage.
    b. Output voltage.
    c. Input/output power factor.
    d. Efficiency.
    e. Harmonic distortion.
    f. Runtime.
5. Noise specifications.
6. Heat dissipation.
7. Warranties and maintenance contracts:
8. All communications requirements such as software, cards, etc.
9. Alarms and status available for remote monitoring and system health.

C. Shop drawings:
1. Power distribution block diagrams.
2. Front and rear views of equipment enclosures:
    a. Front elevation including all control and indicating devices.
3. Support points and weight of overall equipment.
4. Schematic and control wiring diagrams including, but not limited to:
    a. Line and load terminals.
    b. Alarm and status terminals.
    c. Manual maintenance bypass switch terminals.
    d. External Battery or Step-down/Step-up Transformers if any.
    e. External wiring requirements for all communication signals.
5. Switching and overcurrent protective devices.

D. Calculations:
1. Include derating for temperature and elevation as necessary.
2. UPS sizing computation:
    a. Apply safety factors as specified in this Section.
    b. Provide itemized list of critical loads, including individual VA and watt ratings.
3. Battery time calculation based on specified runtime for total load with the safety factor multiplied to it. Table/graph for back-up time calculation.
4. Load calculation shall include power for all shown in the power distribution drawing, which include but not limited to PLC power supply, field instruments (120VAC and 24VDC), Instrument power, Ethernet switches, and I/O modules. Refer to Network Drawings for additional information and notes.
5. Total battery recharge time as a function of capacity utilized.

E. Design data:
1. Design mounting and anchorage for seismic design criteria specified in Section 01850 - Design Criteria:
    a. Provide seismic kits as required to meet design criteria.

F. Record documents:
   1. Provide Record Drawings of installed unit(s) including layout and wiring.

G. Manufacturer's field reports.

H. Operation and maintenance manuals:
   1. System instruction manuals that describe troubleshooting, installation, operations, and safety procedures.
   2. Recommendations for maintenance procedures and intervals.
   3. Battery data/replacement information.
   4. Parts list.

1.04 QUALITY ASSURANCE

A. Manufacturer qualifications:
   1. A minimum of 10 years' experience in the design, manufacture, and testing of solid-state UPS systems.
   2. ISO 9001 certified.

B. Regulatory requirements for complete UPS system:
   1. UL listed per UL Standard 1778.
   2. IEEE C62.41, Categories B.
   3. FCC 15:
      a. Greater than 2,000 VA - Class A.
      b. Less than 2,000 VA - Class B.

1.05 DELIVERY, STORAGE, AND HANDLING

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

1.06 PROJECT OR SITE CONDITIONS

A. As specified in Section 01850 - Design Criteria.

1.07 ADMINISTRATIVE REQUIREMENTS (NOT USED)

1.08 WARRANTY

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

PART 2 PRODUCTS

2.01 GENERAL

A. Provide complete, factory-assembled, wired, and tested, true on-line double conversion UPS equipment including, but not limited to, rectifier, DC bus, inverter, battery charger, batteries, automatic bypass, and ancillary components as specified in this Section and as indicated on the Drawings.

2.02 DESIGN AND PERFORMANCE CRITERIA

A. Critical loads as indicated on the Drawings.

2.03 MANUFACTURERS

A. Double conversion true online UPS system:
   1. One of the following or equal:
      a. Vertiv, Liebert GXT5 Series.
      b. Eaton, 9PX Series.

2.04 EXISTING PRODUCTS (NOT USED)

2.05 MATERIALS (NOT USED)

2.06 MANUFACTURED UNITS

A. Design requirements:
   1. The minimum VA rating of the UPS shall be greater than or equal to the safety factor (as indicated in the UPS schedule) times the connected load or 700 VA, whichever is greater.
   2. UPS System Input:
      a. Input Voltage:
         1) Less than or equal to 3 kVA UPS:
            a) 120VAC within 3 percent, single-phase, 2-wire plus ground (L1, N, G).
         2) Greater than 3 kVA UPS:
            a) 208VAC within 5 percent, single-phase, 3-wire plus ground (L1, L2, N, G).
         3) Frequency: 60 hertz:
            a) Auto sensing on initial power up.
            b) User configurable.
      b. Input current harmonic distortion (THDi%):
         1) Less than or equal to 5 percent at full load operation.
      c. Input power factor:
         1) Greater than or equal to 0.99 lagging at rated load.
      d. Input connections:
         1) As specified and as indicated on the Drawings.
   3. UPS Inverter:
      a. Output Voltage:
         1) Less than or equal to 3kVA UPS:
            a) Standard:
               (1) 120VAC.
            b) User selectable:
               (1) 100VAC, 110VAC, 120VAC, 125VAC.
         2) Greater than 3kVA UPS:
            a) Standard:
               (1) 208VAC.
            b) User selectable: A.
               (1) 200VAC, 208VAC, 220VAC, 230VAC, 240VAC.

b. AC-AC Efficiency:
    1) Greater than or equal to 89 percent at full rated resistive linear load.
c. Transient recovery time:
    1) To nominal voltage within 100 milliseconds.
d. Voltage regulation:
    1) Within1 percent steady state.
e. Output Voltage Distortion (THDV%):
    1) Linear load: Less than 2 percent.
    2) Non-linear load: Less than 5 percent.
f. Output power factor:
    1) The load power factor range shall be 0.65 lagging to 1.0 (unity) leading without power derating.
g. Current overload capability:
    1) The UPS shall attempt to clear overloads while maintaining normal operation before transferring to bypass.
    2) Bypass transfer thresholds shall follow inverse time-current characteristic that operates when the load exceeds the nameplate rating of the UPS.
    3) Transfer load to bypass when overload capacity is exceeded.

4. Batteries:
    a. Internal battery shall utilize lithium-ion cells.
    b. UPS shall have capability for connection of external battery modules to extend total available run time. External batteries shall match the UPS in aesthetics and color.
5. Mounting:
    a. Configurable for rack and tower mounting applications.
    b. Provide manufacturer's standard mounting kit as required by the application.
6. Cooling:
    a. UPS shall have integral forced air cooling.
7. Output connections:
    a. Receptacles:
        1) Less than or equal to 3kVA UPS:
            a) Provide a minimum of four NEMA Type 5-15R or Type 5-20R receptacles.
            b) Provide at least one NEMA Type L5-30R receptacle.
        2) Greater than 3kVA UPS:
            a) Provide a minimum of four NEMA Type 5-20R receptacles.
            b) Provide at least one NEMA Type L14-30R receptacle.
        3) Provide hardwired connections as required and as indicated on the Drawings.

B. Environmental requirements:
    1. Operating ambient temperature:
        a. UPS module: 50 degrees Fahrenheit to 104 degrees Fahrenheit (10 degrees Celsius to 40 degrees Celsius).
        b. Battery: 68 degrees Fahrenheit to 86 degrees Fahrenheit (20 degrees Celsius to 30 degrees Celsius).

2. Operating altitude:
3. Project site conditions as specified in Section 01850 - Design Criteria Surge Protection:
    a. UPS shall confirm to ANSI C62.41, Category B.
4. Audible noise:
    a. Less than 46 dB at 1 meter.

C. Communications:
1. Relay outputs:
    a. The UPS shall contain on the rear panel a terminal block to provide low voltage signals for On Battery, Low Battery, Any Mode Shutdown and Battery Mode Shutdown.
2. Ethernet:
    a. UPS shall include one communication slot that will allow the operator to field install a network communication card.
    b. Network protocol: EtherNet/IP or Ethernet TCP/IP.
    c. Network interface: RJ45.
3. Serial:
    a. The UPS shall provide a RS232 serial connection.
4. USB:
    a. The UPS shall provide a USB connection that is HID compliant for network connection.

2.07 ACCESSORIES

A. External maintenance bypass:
1. Manufacturers: One of the following or equal:
    a. Vertiv, Liebert Micropod Series.
    b. Eaton HotSwap MBP Series.
2. Properties:
    a. Provides isolation of the UPS for maintenance purposes.
    b. Provide maintenance bypass from the same manufacturer as the UPS manufacturer.
    c. UL 1778 listed.
    d. Provide manufacturer’s recommended mounting kit as required by the application.
    e. Make-before-break design so that UPS can be isolated from the critical loads by placing these loads on source power without interruption of operation.
    f. Utility and UPS status indications.
    g. Rated to carry the full input current of the UPS.
    h. Connections to match UPS connections and as indicated on the Drawings.
    i. Supply necessary input/output cords and receptacles for connections with power source and UPS.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 INSTALLATION

A. Install equipment in accordance with manufacturer's instructions.

B. Do not utilize extension cords, adapters, or other electrical connectors for UPS input.

3.03 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

3.04 FIELD QUALITY CONTROL

A. Perform inspections and test procedures before UPS startup:
   1. Inspect equipment for signs of damage.
   2. Verify installation as indicated on the Drawings and specified in the Specifications.
   3. Inspect cabinets for foreign objects.
   4. Verify neutral and ground conductors are properly sized and terminated.
   5. Inspect battery cases.
   6. Inspect batteries for proper polarity.
   7. Check power and control wiring for tightness.
   8. Check terminal connectors for tightness.
   9. Ensure connection and voltage of the battery string(s).

3.05 SCHEDULES

TAG	MINIMUM RUNTIME	INPUT VOLTAGE / CONNECTION	SAFETY FACTOR	NOTES
UPS-050-901-01	30 minutes	120Vac	1.5	Rackmount
UPS-050-220-01	20 minutes	120Vac	1.25	
UPS-050-550-01	20 minutes	120Vac	1.25	
UPS-050-500-01	20 minutes	120Vac	1.25	

END OF SECTION

SECTION 17720

CONTROL SYSTEMS: PROGRAMMABLE LOGIC CONTROLLERS

PART 1 GENERAL

1.01 SUMMARY

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

1.02 REFERENCES

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

B. Abbreviations:
   1. CPU: Central processing unit.
   2. I/O: Input/Output.

C. Standards:
   1. Institute of Electrical and Electronics Engineers (IEEE).

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. Application software: The software that is programmed specifically for the Project.
   2. Development operating software: The software provided by the PLC manufacturer for use in programming the PLC.

1.04 SUBMITTALS

A. Furnish submittals as specified in Section 01330 - Submittal Procedures and Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Product data:
   1. CPU:
      a. Processor type.
      b. Processor speed.
      c. Memory.
      d. Internal processor battery backup time.
   2. I/O modules:
      a. Type.
      b. Standard wiring diagram.

3. Programming languages.
4. Operating system requirements.

C. Calculations:
1. Submit calculations or documented estimate to verify that memory requirements of this Section are met, including spare requirements. If possible, use PLC manufacturer's calculation or estimating worksheet.
2. Submit calculations to verify that spare I/O requirements of this Section are met.
3. Submit calculations to verify that PLC power supply requirements of this Section are met.

D. Control logic:
1. Fully annotated copy of programmed PLC logic.
2. Cross-referenced index of PLC registers or points.

E. Provide application software for the specific Project process requirements:
1. Fully annotated copy of programmed PLC logic in its native format.
2. Cross-referenced index of PLC registers or points.

1.05 QUALITY ASSURANCE

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

B. Provide PLC hardware manufactured at facilities certified to the quality standards of ISO 9001.

1.06 DELIVERY, STORAGE, AND HANDLING

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

1.07 PROJECT OR SITE CONDITIONS

A. As specified in Section 01850 - Design Criteria.

1.08 ADMINISTRATIVE REQUIREMENTS (NOT USED)

1.09 WARRANTY

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

1.10 MAINTENANCE

A. Furnish the following:
1. CPU: 1 spare for each type of CPU in the system.
2. I/O cards: 3 spares for each type of I/O card in the system.
3. Power supplies: 2 spares for every power supply in the system.
4. Network/communications cards: 1 spare for every network or communications card in the system.
5. Remote adapter: 1 spare for every remote adaptor in the system.

6. Chassis: 1 spare for each chassis size in the system.
7. Communication cable: 1 spare for each type of cable used in the system.
8. Compact RIO: 1 spare for each type furnished.

B. Installed spare requirements:
1. I/O points:
a. Provide total of 25 percent spare I/O capacity for each type of I/O at every PLC/RIO rack using the following calculation:

$$\left(1 - \frac{\text{UTILIZED IO POINT COUNT}}{\text{TOTAL IO POINT COUNT}}\right) * 100 = \%\text{SPARE}$$

b. Wire spare I/O points to field terminal blocks in the same enclosure the PLC/RIO resides in.
2. PLC backplane capacity:
a. Provide 25-percent or 3 spare backplane slots, whichever is greater, in racks containing I/O.
3. PLC memory:
a. Provide 50-percent spare program volatile memory.

PART 2 PRODUCTS

2.01 GENERAL

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

2.02 DESIGN AND PERFORMANCE CRITERIA

A. Provide PLC system components by a single manufacturer:
1. Third-party communication modules may be used only for communication or network media functions not provided by the PLC manufacturer.

B. Use PLC manufacturer approved hardware, such as cable, mounting hardware, connectors, enclosures, racks, communication cable, splitters, terminators, and taps.

C. PLC hardware, CPUs, I/O devices, and communication devices shall be new, free from defects, and produced by manufacturers regularly engaged in the manufacture of these products.

2.03 MANUFACTURERS

A. Provide the following:
1. Rockwell Automation:
a. At a minimum PLCs shall be ControlLogix 5580 Series model 1756-L81E. Provide ControlLogix 5580 Series PLCs with greater memory and processing power where required, as described in Section 2.04 Manufactured Units herein below.

B. Furnish one (1) Rockwell Automation Studio 5000 Logix Designer Professional Edition PLC programming software license. Coordinate with the City to register the software to the City of Delray Beach, FL. The PLC development software shall be installed on the Engineering Laptop computer specified in Section 17730 – PCS Computer Equipment.

2.04 MANUFACTURED UNITS

A. Programmable logic controller:
   1. Construction:
      a. Furnish plug-in modular system.
      b. The PLC hardware shall be conformally coated.
      c. Provide PLCs capable of operating in a hostile industrial environment without fans, air conditioning, or electrical filtering:
         1) Temperature: 0 to 55 degrees Celsius.
         2) RFI: 80 to 1,000 MHz.
         3) Vibration: 10 to 500 hertz.
         4) Humidity: 0 to 95 percent.
      d. Provide internal power supplies designed to protect against overvoltage and frequency distortion characteristics frequently encountered with the local power utility.
      e. Design the PLC system to function as a standalone unit that performs all of the control functions described in this Section completely independent from the functions of the HMI system PC-based operator interfaces:
         1) Failure of the HMI system shall not impact data acquisition, control, scaling, alarm checking, or communication functions of the PLC.
   2. CPU:
      a. Configure each CPU so that it contains all the software relays, timers, counters, number storage registers, shift registers, sequencers, arithmetic capability, and comparators necessary to perform the specified control functions.
      b. Capable of interfacing with discrete inputs, analog inputs, discrete outputs, analog outputs, and communication cards to meet the specified requirements.
      c. Capable of supporting and implementing closed-loop floating-point math and PID control that is directly integrated into the CPU control program.
   3. Memory:
      a. Non-volatile memory: On-board complementary metal-oxide-semiconductor (CMOS), electrically erasable programmable read-only memory (EEPROM), PCMCIA, compact flash card, or SD card.
      b. Supply with sufficient memory to implement the specified control functions plus a reserve capacity as specified with the requirements of this Section:
         1) Reserve capacity:
            a) Totally free from any system use.
         2) Programmed in a multi-mode configuration with multiple series or parallel contacts, function blocks, counters, timers, and arithmetic functions.
   4. Programming:
      a. Provide a system where processors are programmed by:
         1) Portable laptop computer both locally and via the PLC control network.

5. PLC power supply:
    a. Input: 120 VAC.
    b. Mounted in the PLC housing.
    c. Sized to power modules mounted in that housing including an average module load for any empty housing slots plus 50 percent above that total.
6. PLC input/output, I/O modules: Maximum 16 channel for discrete and 4 channel for analog.
    a. General:
        1) Compatible with all PLCs being furnished under the contract and by the same manufacturer as the PLCs.
        2) All discrete and analog I/O modules shall be conformally coated. The only exception is where a conformally coated version of the required I/O module is not available from the manufacturer.
        3) Provide I/O modules that:
            a) Isolate in accordance with IEEE Surge Withstand Standards and NEMA Noise Immunity Standards.
            b) Provide A/D and D/A converters with optically or galvanically isolated inputs and outputs.
            c) Accept dual-ended inputs.
        4) Use of common grounds between I/O points is not acceptable.
        5) Provide modules that are removable without having to disconnect wiring terminals:
            a) Utilize a swing-arm or plug-in wiring connector.
        6) Provide at each PLC the I/O modules for the following:
            a) Designated future I/O points contained in the I/O Lists and/or shown on the P&IDs, control schematics, or described in the control strategies.
            b) Installed spare capacity in accordance with the requirements of this Section.
            c) Wire spares provided to the field terminal strip.
        7) Condition, filter, and check input signals for instrument limit conditions.
        8) Filter, scale, and linearize the raw signal into an engineering-units-based measurement.
        9) Alarm measurements for high, low, rate-of-change limits, and alarm trends.
        10) Provide external fuses mounted on the field connection terminal block for discrete input, discrete output, and analog input I/O points.
        11) When multiple cards of the same I/O type are provided and parallel equipment, instrumentation, or redundant processes exist, distribute I/O among cards to ensure that a single card failure will not render an entire process unavailable.
    b. Discrete input modules:
        1) Defined as contact closure inputs from devices external to the input module.
        2) Provide inputs that are optically isolated from low-energy common-mode transients to 1,500 volts peak from users wiring or other I/O modules.
        3) Where digital inputs to PLC card are wetted contacts, provide individually isolated inputs for the discrete Input card.
        4) With LEDs to indicate status of each discrete input.
        5) Input voltage: 24 VDC.

6) For all 120Vac discrete input signals migrated from the existing DFS RTUs to the new PLC cabinets installed under this Contract, interposing relays are to be installed in the PLC cabinet for compatibility with existing field equipment.
7) is required based on existing DFS RTU signals.
8) Provide input module points that are individually fused with blown-fuse indicator lights, mounted external of the module on the output terminal strip:
   a) Coordinate external fuse size with the protection located on the module so that the external fuse opens first under a fault condition.

c. Discrete output modules:
   1) Defined as contact closure outputs for ON/OFF operation of devices external to the output module:
      a) Triac outputs may be used, with the permission of the Engineer. Care must be used in applying this type of module to ensure that the leakage current through the output device does not falsely signal or indicate an output condition.
   2) Optically isolated from inductively generated, normal mode and low-energy common-mode transients to 1,500 volts peak.
   3) LEDs to indicate status of each output point.
   4) Output voltage: 24 VDC.
   5) For all 120Vac discrete output signals migrated from the existing DFS RTUs to the new PLC cabinets installed under this Contract, interposing relays are to be installed in the PLC cabinet for compatibility with existing field equipment.
d. Analog input modules: single-ended:
   1) Signal type: Provide 4 to 20 mA for most applications; other levels are acceptable to interface to vendor control panels.
   2) Analog-to-digital conversion: Minimum 12-bit precision with the digital result entered into the processor.
   3) Analog-to-digital conversion updated with each scan of the processor.
   4) Individually isolated each input.
   5) Coordinate the size of the external fuse with the protection located on the module, so that the external fuse opens first under a fault condition.
   6) Provide field mounted surge suppression modules for analog signals that are located outside the building that houses the PLC node:
      a) Manufacturers: One of the following, or equal:
         (1) Phoenix Contact, PLUGTRAB SEC series, or similar, for field instruments that require auxiliary power (24 VDC/VAC, 120 VAC, 230 VAC).
e. Analog output modules:
   1) Signal type: Provide 4 to 20 mA for most applications; other levels are acceptable to interface to vendor control panels.
   2) Individual isolated output points each rated for loads of up to 1,000 ohms.

7. Communications modules:
    a. Remote I/O adapter module:
        1) For any PLC location requiring more than 1 housing to mount all of the I/O modules or that is identified as a RIO, provide the appropriate remote I/O adapter module for communication with the secondary housing(s).
        2) Install the RIO adapter module in the PLC backplane and the RIO backplane.
        3) Provide adapter modules that support all available types of I/O modules required.
        4) Provide network taps, connectors, termination resistors, drop cables, and trunk cables necessary for remote I/O communications.
        5) Complete diagnostic LEDs.
    b. Network communications modules:
        1) General:
            a) Install communications modules in the PLC backplane.
        2) Ethernet:
            a) Ports: 2 RJ-45.
            b) Communication rate: 10 Mbps/100 Mbps/1 Gbps
        3) Provide network taps, connectors, termination resistors, drop cables, and trunk cables necessary for remote I/O communications.
8. PLC backplane housing:
    a. Mount the PLC power supply, CPU, communications module, and I/O modules in a suitable standard PLC backplane or housing.
    b. Provide spare slots in each PLC and RIO location in accordance with the requirements of this Section.
    c. Provide a blank slot filler module for each spare slot.

B. HMI system interface:
    1. As specified in Section 17733 - Control Systems: Network Materials and Equipment and Section 17762 - Control Systems: PCS Software.

C. PLC programming software:
    1. Furnish operating software capable of monitoring and/or controlling the PLCs via the PLC data network:
        a. Contain diagnostics to collect troubleshooting and performance data and display it in easy to understand graphs and tables.
        b. Monitor devices at each drop on the PLC data network for proper communications.
        c. Provide the ability to program PLCs on the PLC data network from the Engineer’s console.
    2. PLC programming laptop/desktop operating system:
        a. Microsoft Windows 10.
    3. Suitable for the PLCs specified above.
    4. For programming, monitoring, searching, and editing:
        a. Usable both on-line, while connected to the PLC, and off-line.
        b. Operating software shall display multiple series and parallel contacts, coils, timers, counters, and mathematical function blocks.
        c. Capable of disabling/forcing inputs, outputs, and coils to simulate the elements of the ladder logic; forced elements shall be identifiable by means of color change.

d. Include a search capability to locate any address or element and its program location.
e. Display at the EC, PLC status information, such as faults and communication errors and amount of memory remaining.

5. Support IEC-61131-3 compliant programming languages:
6. Generate a PLC program printout, which is fully documented, through the PLC programming software:
   a. Fully documented program listings include, as a minimum, appropriate rungs, address, and coils shown with comments to clarify to a reader what that segment of the program accomplishes on an individual line-by-line basis.
   b. Include a sufficient embedded comment for every rung of the program explaining the control function accomplished in said rung.
   c. Use a mnemonic associated with each contact, coil, etc., that describes its function.
   d. Utilize the tag and loop identification as contained in the P&IDs:
      1) If additional internal coils, timers, etc., are used for a loop, they shall contain the loop number.
   e. Provide a cross-reference report of program addresses.
7. Software functions automatically without operator intervention, except as required to establish file names and similar information:
   a. Furnish the operating system software that is the standard uncorrupted product of the PLC manufacturer with the following minimum functions:
      1) Respond to demands from a program request.
      2) Dynamic allocation of the resources available in the PLC. These resources include main memory usage, computation time, peripheral usage, and I/O channel usage.
      3) Allotment of system resources based on task priority levels such that a logical allocation of resources and suitable response times are ensured.
      4) Queuing of requests in order of priority if one or more requested resources are unavailable.
      5) Resolution of contending requests for the same resource in accordance with priority.
      6) Service requests for execution of 1 program by another.
      7) Transfer data between programs as requested.
      8) Management of information transfers to and from peripheral devices.
      9) Control and recovery from program fault conditions.
      10) Diagnose and report real-time hardware device errors.
8. Program execution:
   a. Application software - program execution scheduled on a priority basis:
      1) A multilevel priority interrupt structure is required.
      2) Enter into a list of pending programs a program interrupted by a higher priority program:
         a) Resume its execution once it becomes the currently highest priority program.
      3) Schedule periodic programs.
      4) Base the allocation of resources to a time-scheduled program on its relative priority and the availability of resources.

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

4) Lead, lag, dead time, and ratio compensators.
5) Integration and totalization of analog process variables.

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

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

5) New conversions must not require the services of a special programmer and/or special, high-level, programming training.

l. Control modules:
1) For each control function configured, whether processed at the RTU, PLC, or operator interface, maintain a file of necessary data including input values, setpoints, constants, intermediate calculated values, output value and limit clamps, etc.
2) Input and output assignments, setpoints, and constants must be adjustable by the operator through the operator interface.
3) Provide control algorithms for manual control with output values adjustable by the operator.

m. Analog outputs:
1) Analog outputs must be maintained as part of the database.
2) These outputs must be adjustable manually by the operator through the operator interface or through automatic control algorithms.

18. Some of the above functions may be better accomplished in the data acquisition and graphic display software package; it is the responsibility of the ICSC to optimize the location of the various functions between all software packages.

D. General control functions:
1. Analog control functions:
a. PID, lead/lag, signal select, alarm, limit, delay, and time base.
b. Furnish the control system complete with a library of mathematical/calculation software to support averaging, weighted average, addition, subtraction, multiplication, division, square root extraction, exponential, AND, OR, NAND, NOR, XOR, and NXOR functions.
c. Math utilities must be linkable to process data points or manual inputs via control block configuration.
d. By linking control blocks to data points, the math library must support system unit conversion and calculation requirements.

2. Discrete control functions:
a. AND, OR, NOT, EXCLUSIVE OR, comparators, delays, and time base.

3. Software support:
a. Retain in firmware all control and logic functions at each RTU and PLC and in RAM at the operator interface.
b. Call each function as required by the configured controls to perform the intended function.

4. Control and status discrepancies:
a. Generate a discrepancy/fail alarm for any pump, valve, or final control element if a discrepancy exists between a system or operator command and the device status:
1) For example, the system commands to start (call), and the pump fails to start (run status report back), within predetermined operator-programmable time delay (time disagree), then a discrepancy (fail) alarm shall be generated.
b. Involuntary change in the device's status must also generate an alarm:
1) For example, a pump starts when not commanded to do so, or a pump shuts down while running even though it still has a command to run.
c. Each command, status, and alarm must cause the color of the symbol to change.

d. Because many discrete final control elements have a cycle time in excess of the scan interval, provide each control output with an associated delay period selected to be longer than the operating period of the control element:
    1) Delay periods for each final control element must be adjustable at the operator interface.
    2) List time delays in the final documentation.

5. Some of the above functions may be better accomplished in the data acquisition and graphic display software package; it is the responsibility of the ICSC to optimize the location of the various functions between all software packages.

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

F. PLC Remote inputs and outputs (RIOs):
1. RIO hardware shall be compatible with all PLCs being furnished under this Contract
2. RIO units installed in the same enclosure as a PLC to provide additional PLC inputs and outputs shall be produced by the same manufacturer as the PLCs, and, as a minimum, include:
    a. Power supply.
    b. Rack.
    c. Backplane.
    d. Communications module.
    e. I/O modules.
    f. Enclosure.
3. Compact RIO units:
    a. RIO units installed in field mounted enclosures and described as “Compact RIOs” on the Drawings shall be MOXA ioLogik E1200 Series.
    b. Each unit shall be fully configured by the Contractor for EtherNet I/P communications with the Allen-Bradley (Rockwell Automation) ControlLogix PLC specified in this Section herein above.
    c. Each Compact RIO unit shall be equipped with a minimum of 4 Digital and 4 Analog inputs.
    d. Each Compact RIO unit shall be furnished in a complete enclosure that meets the requirements of all Division 17 specifications and the Drawings and at a minimum shall include:
        1) Wall mounted NEMA 4X 316 SS Enclosure with back plate.

2) 24VDC power supply.
3) DIN rail.
4) Fiber optic patch panel.
5) I/O terminals.
6) Fuses/Breakers.
7) Fiber to Copper Media Converter or Managed Industrial LAN switch, as indicated on the drawings.
8) Intrusion switch.
9) High ambient temperature alarm relay.

4. Provide cables and software needed for a complete and operational RIO system as specified in the Contract Documents.
5. Provide a group of pre-assigned diagnostic registers to report RIO system faults to the driver PLC.
6. Control system must continue operation should a fault occur on a single RIO drop:
   a. Upon clearing the fault, restart communications to that drop automatically.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 INSTALLATION

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

B. Utilize personnel to accomplish or supervise the physical installation of all elements, components, accessories, or assemblies:
   1. Employ installers who are skilled and experienced in the installation and connection of all elements, components, accessories, and assemblies.

C. All components of the control system, including data network cables, are the installation responsibility of the ICSC unless specifically noted otherwise.

D. General:
   1. Control system logic program shall reside at the PLC level.

E. Use the tag and loop identifications found on the P&IDs for all tags used and/or assigned as part of the application software work provided by the ICSC.

F. Program the PLC logic using the following language(s):
   1. Ladder Diagram.
   2. Function Block Diagram.

3.03 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

B. Owner Training:
   1. As specified in Section 17950 - Commissioning for Instrumentation and Controls.

END OF SECTION

SECTION 17730

CONTROL SYSTEMS: PCS COMPUTER EQUIPMENT

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. PC-based PCS system hardware, including:
      a. PCS Virtualized SCADA Management/Backup Server.
      b. PCS Virtualized SCADA HMI Servers.
      c. Network Time Servers.
      d. Engineering Laptop Computers.
      e. Industrial Panel Computers (IPC)s.
      f. Computer accessories.

1.02 REFERENCES

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

B. Abbreviations:
   1. CAL: Client access license.
   2. RAID: Redundant array of independent disks.
   3. SNMP: Simple network management protocol.

1.03 SYSTEM DESCRIPTION

A. Provide all PCS computer equipment and associated licensed software identified in the Contract Documents. License all software under Owner’s name.

1.04 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Shop drawings.

1.05 QUALITY ASSURANCE

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

1.06 DELIVERY, STORAGE, AND HANDLING

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

1.07 PROJECT OR SITE CONDITIONS

A. As specified in Section 01850 - Design Criteria.

1.08 ADMINISTRATIVE REQUIREMENTS (NOT USED)

1.09 WARRANTY

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

1.10 MAINTENANCE

A. All PCS Servers:
   1. Provide a 5-year onsite manufacturer's service plan, with 5-year unlimited phone support.

PART 2 PRODUCTS

2.01 GENERAL

A. Provide all PCS computer equipment identified in the Contract Documents.

B. The Contractor shall provide PCS server computer equipment of the current available technology of advertised retail price at the time of shop drawing submittal and approval equivalent in value to the advertised retail price at the time of bid for the herein-specified equipment to reflect technology advances during the elapsed construction period.

2.02 DESIGN AND PERFORMANCE CRITERIA

A. All material used in satisfying the equipment requirements shall be new and unused and must be actively marketed by the original equipment manufacturer for new applications at the time of the factory demonstration test. The Contractor shall not use equipment destined for installation or spare parts for the Owner's system for any reason other than development and testing of the system.

2.03 MANUFACTURERS

A. Commonality:
   1. The PCS system shall utilize the same brand and type of computer for like functions throughout the system.
   2. Where possible, use the same processor family throughout.
   3. Use a single PC computer manufacturer throughout the Project, including those used for diagnostics and maintenance.

B. Manufacturers:
   1. As indicated below.

C. Systems management architecture:
    1. All processors, servers, workstations, network software, bridges, and other manageable objects shall have simple network management protocol (SNMP) agents included.

2.04 MANUFACTURED UNITS

A. General:
    1. The hardware identified in this Section is considered the minimum, acceptable configuration. It is the Contractor's responsibility to upgrade and expand the hardware configuration if necessary to satisfy software and system performance requirements of the Project.
    2. Proposed substitutions must meet or exceed the specifications of the equipment listed.

B. PCS Servers: Redundant Virtualized SCADA HMI Servers A and B (SVR-050-901-01 and SVR-050-901-02) and Virtualized Management/Backup Server (SVR-050-901-03):
    1. General:
        a. PCS Servers: Intel-based, 19-inch rack mounted, server-class PCs.
        b. Provide a complete set of backup/restore recovery VMs on redundant USB 3.0 portable backup hard drive for the PCS Virtualized Management/Backup Server(s) and PCS Virtualized HMI Server(s), such that each server may be restored to factory condition in the event of a catastrophic hard drive failure. Software recovery from a partition on the hard disk drive is not acceptable. Portable backup hard drives shall be the following: Seagate Backup Plus Portable 4TB External Hard Drive HDD or Engineer approved equivalent.
        c. Virtualization: Microsoft HyperV. Coordinate virtualization system version and licensing with the Owner:
            1) Provide host machine hardware that meets or exceeds the meet the minimum requirements of the Virtualized Operating System(s) and the server specifications described in this Section.
                a) If multiple virtual environments are used on the same host or in a cluster, a hypervisor should be used to manage resource pool and memory allocation such that each virtual operating system has the recommended minimum hardware resources.
        d. Operating system: Windows Server 2022 or latest version available at time of purchase by Contractor and compatible with associated software.
            1) Coordinate OS system licensing with the Owner.
            2) Provide operating system software as a clean install. Where workstations have been loaded with OEM versions of software containing trial software or other advertisements, remove the OEM software and reinstall the operating system and drivers from the original installation disks.
    2. The PCS servers shall meet the following minimum requirements:
        a. Manufacturers: One of the following or equal:
            1) Dell, PowerEdge Series.
            2) HPE, ProLiant.
        b. Form factor: Rack Mount.

c. Processor: Intel® Xeon® Gold 6444Y 3.6G, 16C/32T, 16GT/s, 45M Cache, Turbo, HT (270W) DDR5-4800 minimum or Engineer approved equal.
d. Main memory:
    1) Four (6) 32GB RDIMM, 4800MT/s Dual Rank for a minimum total of 192GB of memory
    2) Populate all used memory channels with the same rank, size, and speed of DIMMs.
e. Hard disk(s): 3.84TB SSD SATA Read Intensive 6 Gbps 512 2.5 in Hot-plug AG Drive,3.5in HYB CARR, 1 DWPD
f. Hard disk quantity: 4
g. Hard disk configuration: RAID 10.
h. Network cards:
    1) The following, whichever is greater:
        a) 2 each 100/1000-Base-T.
        b) 1 for each virtual machine and connection shown in the Contract Documents.
i. Power supply: Fully Redundant, 1400Watts minimum.
j. Mouse: Optical, wheel-type, 3-button (count wheel click as 1 button).
k. Keyboard: Windows 104-key.

3. Applicable equipment: This list may not be fully inclusive. Software selection by the Contractor and version changes may require additional hardware elements to support the system.
4. PCS Server Virtual Machines (VM)s
    a. At a minimum, servers shall be capable of running the virtual machines listed below. Provide additional virtual machines as required to provide all software functionality described in Division 17. At the time of bidding, the Contractor shall coordinate with manufacturer to verify that server make, and model described herein can run all virtual machines and all required software running within the virtual machines. Individual server computer components shall be upgraded or server computer unit itself shall be upgraded to a more powerful model as required to meet system software processing, memory, and storage requirements at no additional cost to Owner.
    b. SVR-050-901-01, Server A
        1) VM1 – Read Only Domain Controller – WinServer 2022
        2) VM2 – VTScada HMI Development/Runtime (Primary) – WinServer 2022
        3) VM3 – Engineering Workstation – Windows 11
    c. SVR-050-901-02, Server B
        1) VM1 - Read Only Domain Controller – WinServer 2022
        2) VM2 - VTScada HMI Development/Runtime (Secondary) – WinServer 2022
        3) VM3 – Engineering Workstation – Windows 11
    d. SVR-050-901-03, Server C – Management Server
        1) VM1 – Active Directory Server – WinServer 2022
        2) VM2 – Windows Admin Center – WinServer 2022
        3) VM3 – Firewall Management Server – Manufacturer provided OS
        4) VM4 – Network Management Server – Manufacturer provided OS
        5) VM5 – Update Server WSUS/Endpoint Protection Management – WinServer 2022

e. SVR-050-901-04, Server D
    1) VM1 - Read Only Domain Controller – WinServer 2022
    2) VM2 - VTScada Runtime (View Only client and alarm notification server) – WinServer 2022
    3) VM3 – Engineering Workstation – Windows 11
    4) VM4 - Update Server WSUS/Endpoint Protection Management – WinServer 2022.

C. Network time server:
    1. Manufacturers: The following or equal:
        a. TimeTools, T550.
        b. Mircochip/Microsemi, SyncServer, S650.
    2. General:
        a. Network: 10/100-Base-TX, RJ45 connector.
        b. Mounting: 19-inch rack mount.
        c. Power: 120 VAC, 60 hertz.
        d. Operating temperature: 32 to 140 degrees Fahrenheit.
        e. Relative humidity: 0 to 95 percent, non-condensing.
        f. GPS antenna input: TNC female.
    3. Antenna:
        a. T-3740 Multi-GNSS.
    4. Timing:
        a. Timing protocols:
            1) NTP v2, v3, v4.
            2) SNTP v3, v4.
        b. Timing functionality:
            1) NTP peering.
            2) NTP broadcast.
        c. Timing requirements:
            1) GPS accuracy: 60 nanoseconds UTC.
            2) LF accuracy: 1 to 20 milliseconds.
            3) NTP accuracy: Less than 1 microsecond.

D. Engineering Laptop Computer(s):
    1. Furnish a minimum of 1 engineering laptop computer. Additional engineering laptop computers shall be furnished where shown on the Instrumentation Drawings. Engineering laptop computers shall be supplied with all hardware, software, cables, and other appurtenances as required to function as a PLC programmer, OIU/OIT programmer, SCADA HMI programmer, remote Operator Workstation (phone and 100/1000Base-T Ethernet), and a configuration/programming device for all digital equipment furnished.
    2. The Contractor shall provide a laptop of the current available technology of advertised retail price at the time of shop drawing submittal and approval equivalent in value to the advertised retail price at the time of bid for the herein-specified equipment to reflect technology advances during the elapsed construction period.
    3. The engineering laptop computer shall be a Precision 7680 Workstation, or latest version at the time of purchase and at no additional cost to Owner, as manufactured by Dell or Engineer approved equal by HP or Lenovo with the following features:

Processor:	Intel® Core™ i9-13950HX vPro® (36 MB cache, 24 cores, 32 threads, up to 5.5 GHz, 55 W)
Operating System:	Windows 10 Pro (Windows 11 Pro license included), English, French, Spanish
Graphics Card:	Intel® UHD Graphics
Display:	16" FHD+ 1920x1200 WLED, WVA, 60Hz, anti-glare, non-touch, 100% DCI-P3, 500 nits, IR Camera with Mic
Memory:	64GB, 2x32GB 5200MT/s SODIMM, ECC
Hard Drive:	2 TB, M.2 2280, Gen 4 PCIe NVMe, SSD
Wireless:	Intel® Wi-Fi 6E AX211, 2x2, 802.11ax, Bluetooth® wireless card
Primary Battery:	83 Wh, 6 Cell, Lithium Ion Polymer, Long Lifecycle, 3-year warranty
Power	180W Power Adapter
Extended Support:	ProSupport and Next Business Day Onsite Service, 60 Month(s)
Accidental Damage Service:	60 Month(s)
Office Software:	Microsoft Office Professional 2021 (or most current software version at time of purchase by Contractor).
Docking Station:	Dell Performance Dock - WD19DCS (or most current equivalent version at time of purchase by Contractor).
Laptop Backpack:	Ballistic nylon construction.

E. Industrial Panel Computer (IPC)
   1. Provide a minimum of 3 IPCs, not including required spares: IPC-050-220-01, IPC-050-500-01, and IPC-050-550-01. Provide additional IPCs as indicated on the Drawings or listed in the Specifications.
   2. Industrial panel-mounted computer running the Windows 11 operating system.
      a. Provide a complete set of all required cables and software.
      b. Provide manufacturer's user and maintenance manuals.
      c. Industrial panel-mounted PC:
         1) Processor: i5-12500T - 2.00GHz (up to 4.40GHz) Intel Core CPU - 6 Cores, 18MB Cache.
         2) Graphics: UHD Graphics 770 (Base 35W, Max 74W).
         3) Memory: 32GB DDR4, 3200MHz minimum.
         4) Hard Drive: 1TB NVMe SSD M.2 3.5GB/3.0GB minimum.
         5) Display
            a) Size: 22.0 inch diagonal (widescreen).

b) Aspect ratio: 16:10.
c) Resolution: 1680x1050.
d) Brightness: 1,000 nits minimum (ultra bright).
e) Type: Thin-film Transistor (TFT) Active Matrix LCD resistive touch screen.
f) Faceplate/bezel material: NEMA 4X stainless steel.

6) Fanless Design.
7) MTBF: Minimum 30,000 hours.
8) Operating temperature: 0 - 50 Degrees Celsius.
9) Operating relative humidity: 20 - 90 percent non-condensing.
10) Power supply: 120VAC / 12Vdc
11) Manufacturers: One of the following:
a) SuperLogics SL-PPC-22A-LLH610I-S18-NF series.
b) Engineer approved equivalent by Arista.
c) Engineer approved equivalent by Phoenix Contact.

F. Computer Accessories:
1. Furnish the following accessories for the Engineering Laptop and Rackmount Workstation Computer:
a. MX Master 3S - Wireless Performance Mouse with Ultra-fast Scrolling, Ergo, 8K DPI, Track on Glass, Quiet Clicks, USB-C, Bluetooth, Windows, Linux, Chrome - Graphite as manufactured by Logitech or Engineer approved equal.
b. Memory Foam Mouse Pad/Wrist Rest - Black Model 9176501 as manufactured by Fellowes or Engineer approved equal.
c. MX Keys Advanced Wireless Illuminated Keyboard, Tactile Responsive Typing, Backlighting, Bluetooth, USB-C, Apple macOS, Microsoft Windows, Linux, iOS, Android, Metal Build - Graphite or Engineer approved equal.
d. MX Palm Rest for MX Keys as manufactured by Logitech or Engineer approved equal.
e. Furnish 10-foot USB-C cable for mouse and keyboard charging.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 INSTALLATION

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

B. General:
1. Each display monitor shall be secured to the console or other work surface.
2. Install equipment and cabling so that, in the event of an earthquake, seismic movement will not damage cables. In particular, provide appropriate slack in cables.
3. Configure all device management and SNMP traffic on the management network.

4. Coordinate with Owner and change all default authentication for devices such as remote management interfaces such as iDRAC, UPS, Ethernet switches, PLCs, instrumentation, and other network connected hardware. Coordinate username/password combinations with the Owner of sufficient complexity or integrate with Active Directory where possible. Sufficient complexity for passwords includes a minimum of 12 characters and use of lowercase, uppercase, number, and special character.

3.03 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

B. Owner Training:
   1. As specified in Section 17950 - Commissioning for Instrumentation and Controls.

END OF SECTION

SECTION 17733

CONTROL SYSTEMS: NETWORK MATERIALS AND EQUIPMENT

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Materials and equipment used in process control and LAN networks including:
      a. Network switches.
      b. Media converters.
      c. Routers.
      d. Patch panels and other data network hardware.
      e. Related accessories.

1.02 REFERENCES

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

B. Standards:
   1. Electronic Industries Alliance (EIA):
      a. 310-E - Cabinets, Racks, Panels, and Associated Equipment.
   2. Institute of Electrical and Electronics Engineers (IEEE):
      a. 802.1X - Standard for Local and Metropolitan Area Networks—Port-Based Network Access Control.
      b. 802.3 - Standard for Ethernet.
      c. 802.11b - Standard for Information Technology - Telecommunications and information exchange between systems - Local and Metropolitan networks - Specific requirements - Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) specifications: Higher Speed Physical Layer (PHY) Extension in the 2.4 GHz band.
   3. National Electrical Code (NEC).
   4. National Electrical Manufacturers Association (NEMA):
      a. 250 - Enclosures for Electrical Equipment (1000 V Maximum).
   5. Telecommunications Industry Association (TIA):
      a. 569 - Telecommunications Pathways and Spaces.
      b. 607 - Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises.
   6. Underwriters Laboratories, Inc. (UL).

1.03 DELEGATED DESIGN

A. As specified in Section 01357 - Delegated Design Procedures.

B. Anchoring and bracing.

1.04 SUBMITTALS

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

B. Product data:
   1. Include information on all network equipment.
   2. Manufacturer’s operation and installation instructions.

C. Shop drawings:
   1. Complete set of drawings including but not limited to:
      a. System block diagram showing relationship and connections between devices provided under this Contract, including connections to any existing equipment.
      b. Include manufacturer and model information, and address settings.
      c. Network riser diagram.
      d. Network port diagram, which physically locates all ports within the facility, and identifies their patch panel and switch port.
      e. Construction drawings for all equipment cabinets, including dimensions, identification of all components, preparation and finish data, and nameplates.
      f. Electrical connection diagrams.
      g. Complete grounding requirements.
   2. Furnish data sheets for each component together with a technical product brochure or bulletin:
      a. Manufacturer's model number.
      b. Project equipment tag.
   3. Complete and detailed bills of materials broken up by each cabinet. Each bill of material item will include the following:
      a. Quantity.
      b. Description.
      c. Manufacturer.
      d. Part numbers.

D. Delegated design submittals:
   1. Anchoring and bracing: Provide project-specific calculations based on support conditions and requirements to resist loads specified in Section 01850 - Design Criteria.
      a. To structures for equipment installed in structures designated as seismic design category C, D, E, or F.

E. Calculations:
   1. Cooling calculations, including but not limited to:
      a. Highest expected ambient temperature for the enclosure's location.
      b. Internal heat load.
      c. Exposure to direct sunlight.
      d. Dimensions of the enclosure in inches.
      e. Maximum allowable temperature inside the enclosure, based on the lowest operating temperature limit of the installed components.

F. Test reports:
   1. As specified in Section 16125 - Fiber Optic Cable and Appurtenances and Section 17950 - Commissioning for Instrumentation and Controls.
   2. Signed test results as described in this Section.
   3. Test results shall include:
      a. Narrative describing the test procedures followed.
      b. Block diagram of test set up.
      c. Manufacturer's information on test equipment used.
      d. Detailed test results.
      e. A narrative summarizing the results of the testing and identifying any further action required.

G. Operating manuals:
   1. Complete installation, operation, calibration, and testing manuals as specified in Section 01756 - Commissioning.

H. Record drawings:
   1. As specified in Section 17950 - Commissioning for Instrumentation and Controls.
   2. Electrical connection diagrams shall be revised to reflect any changes made in the field and submitted as record drawings.

1.05 QUALITY ASSURANCE

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

1.06 PROJECT OR SITE CONDITIONS

A. As specified in Section 01850 - Design Criteria.

1.07 ADMINISTRATIVE REQUIREMENTS (NOT USED)

1.08 WARRANTY

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

PART 2 PRODUCTS

2.01 GENERAL (NOT USED)

2.02 DESIGN AND PERFORMANCE CRITERIA

A. The vendor shall manufacture using low VOC-based materials to provide superior indoor air quality demonstrated by Greenguard certification.

2.03 MANUFACTURERS

A. As listed below in the individual component paragraphs.

2.04 MANUFACTURED UNITS

A. Ethernet switches:
   1. Managed, Layer 3, Stacked Enterprise Ethernet switches:
      a. Manufacturers: One of the following no equal:
         1) Cisco, Catalyst 9300.
         2) Fortinet, FS-1024E.
      b. Properties:
         1) Hardware:
            a) 19-inch rack mountable switch.
            b) Power supply:
               (1) Provide redundant power supplies.
               (2) 120 VAC, 60 hertz, 1 phase 1,600 watts.
            c) Console management port.
            d) Open module slots for the addition of modules as described below.
            e) Full Power over Ethernet (PoE+) enabled.
         2) Performance:
            a) Switching capacity: 92 Gbps, minimum.
            b) Address table size: 8,000 entries, minimum.
            c) Gigabit throughput.
         3) Environment:
            a) Operating temperature range: 32 to 113 degrees Fahrenheit.
            b) Humidity:10 to 90 percent, non-condensing.
         4) Capable of performing basic switching without special programming or configurations. Additional features available through software setup includes but not limited to:
            a) Layer 3 routing.
            b) Port Monitoring.
            c) Remote switch management.
            d) Port Security.
            e) Rapid Spanning Tree Protocol (RSTP).
            f) Resilient Ethernet Protocol (REP).
         5) Connections:
            a) Copper: RJ-45.
               (1) Standard: 1000-BASE-T.
               (2) Auto-negotiating.
               (3) Quantity: As required to provide network connections indicated on the Drawings plus 20 percent spare.
            b) Fiber: SFP port.
               (1) Quantity: As required to provide network connections indicated on the Drawings plus 20 percent spare, or 4 total, whichever is greater.
            c) Digital Optical Monitoring (DOM).
            d) Provide modules required to provide network connections as indicated on the Drawings.
         6) Spare parts:
            a) Provide the following spare components:
               (1) 1 spare module of each type provided.
               (2) 2 spare SFP transceivers of each type provided.

2. Managed, Modular Layer 2 Process Floor Ethernet switches:
    a. Products: One of the following, no equal:
        1) Stratix 5800 series, model 1783-MMS10A, by Rockwell Automation.
    b. Properties:
        1) Hardware:
            a) Power supply:
                (1) Accepts redundant power feeds.
                    (a) Provide NEC Class 2 power circuit.
                    (b) 24 VDC, 100VA maximum rating.
            b) No fans or moving parts.
        2) Performance:
            a) Enclosure:
                (1) All metal housing.
            b) Capable of performing basic switching without special programming or configurations. Additional features available through software setup includes but not limited to:
                (1) Layer 2 Routing.
                (2) Resilient Ethernet Protocol (REP).
                (3) Rapid Spanning Tree Protocol (RSTP).
                (4) NAT.
                (5) SNMP.
                (6) VLAN.
                (7) QoS.
                (8) Port Mirroring.
                (9) DHCP Server.
            c) IGMP Snooping with EtherNet/IP plug & play compatibility.
            d) 802.1d, 802.1w, 802.1D RSTP.
        3) Environment:
            a) Operating temperature range: 32 to 140 Degrees Fahrenheit.
            b) Humidity:10 to 95 percent, non-condensing.
        4) Onboard Connections:
            a) Copper: RJ-45.
                (1) Auto-negotiating.
                (2) Quantity: As required to provide network connections indicated on the Drawings plus 20 percent spare.
            b) Fiber: Gigabit Single Mode SFP ports.
                (1) Quantity: As required to provide network connections indicated on the Drawings, minimum 2.
        5) Mounting:
            a) DIN Rail mounting.
        6) Spare parts:
            a) Provide the following spare components:
                (1) 1 spare Ethernet switch.
                (2) 2 spare SFP transceivers of each type provided.
3. Port Expansion Modules (Floor Ethernet Switches Only):
    a. For managed, modular layer 2 process floor Ethernet switches where additional ports are required to provide all copper and fiber optic network connections to the switch, as shown on the Drawings, provide up to one port expansion module per switch.
    b. Products: One of the following, no equal:
        1) Stratix 5800 1783-MMX8SA by Rockwell Automation.

c. Properties:
1) Hardware:
a) Power supply:
(1) Accepts redundant power feeds.
(a) Provide NEC Class 2 power circuit.
(b) 24 VDC, 100VA maximum rating.
b) No fans or moving parts.
2) Performance:
a) Enclosure:
(1) All metal housing.
3) Environment:
a) Operating temperature range: 32 to 140 Degrees Fahrenheit.
b) Humidity:10 to 95 percent, non-condensing.
4) SFP Ports:
a) Eight (8) Small Form-factor Pluggable (SFP)
5) SFP Modules:
a) Gigabit copper SFP modules: RJ-45.
(1) Auto-negotiating.
(2) Quantity: As required to provide network connections indicated on the Drawings plus 1 spare.
(3) Products: One of the following, no equal:
(a) Model 1783-SFP100T as manufactured by Rockwell Automation.
b) Gigabit single mode fiber optic SFP modules:
(1) Quantity: As required to provide network connections indicated on the Drawings plus 1 spare.
(2) Provide fiber optic transceivers that adhere to the requirements described in this Section, herein below, titled “SFP Fiber Optic Transceivers.”
6) Mounting:
a) DIN Rail mounting.
7) Spare parts:
a) Provide the following spare components:
(1) 1 spare module of each type provided.
(2) 2 spare SFP transceivers of each type provided.

B. Firewalls
1. Next Generation Firewall, Enterprise Firewall:
a. Manufacturers: One of the following no equal:
1) Fortinet, FortiGate 200G.
2) Cisco, 1220 CX.
3) Palo Alto, PA-1410
b. Properties:
1) Hardware:
a) 19-inch rack mountable switch.
b) Power supply:
(1) Provide redundant power supplies.
(2) 120 VAC, 60 hertz, 1 phase 1,600 watts.
c) Provide Firewall management console virtual machine.
d) Console management port.

2) Performance:
    a) Intrusion Prevention System (IPS): 5Gbps, minimum
    b) Next Generation Firewall (NGFW): 3.5Gbps, minimum.
    c) Threat Protection: 3 Gbps, minimum.
    d) Firewall throughput: 16.5 Mpps (packets per second).
    e) Concurrent Sessions (TCP): 3 Million.
    f) Gateway-to-Gateway IPSec VPN Tunnels: 2000.
    g) Client-to-Gateway IPSec VPN Tunnels: 16,000.
    h) Concurrent SSL-VPN Users: 500
    i) SSL-VPN Throughput: 2 Gbps
3) Environment:
    a) Operating temperature range: 32 to 113 degrees Fahrenheit.
    b) Humidity:10 to 90 percent, non-condensing.
4) Capable of performing next generation firewall security functions including:
    a) AI integrated security services.
    b) Real-time SSL inspection.
    c) Implementation of Access Control List policies.
    d) Intrusion detection and prevention.
    e) Anti-malware protection.
    f) Web/DNS Security.
    g) Zero-day threat prevention.
    h) OT Security for threat detection and protocol recognition.
5) Connections:
    a) Copper: RJ-45.
        (1) Standard: 1000-BASE-T.
        (2) Auto-negotiating.
        (3) Quantity: As required to provide network connections indicated on the Drawings plus 20 percent spare.
    b) Fiber: SFP port.
        (1) Quantity: As required to provide network connections indicated on the Drawings plus 20 percent spare, or 4 total, whichever is greater.
    c) Provide modules required to provide network connections as indicated on the Drawings.
6) Spare parts:
    a) Provide the following spare components:
        (1) 1 spare module of each type provided.

C. SFP Fiber Optic Transceivers:
    1. Provide Gigabit transceivers unless otherwise indicated, or as required to interface with other equipment:
        a. Single-mode: 1000BASE-LX10.
        b. Multi-source agreement compliant.
    2. Products:
        a. For Managed, Modular Layer 2 Process Floor Ethernet switches provide one of the following, no equal: Model 1783-SFP1GLX by Rockwell Automation.
        b. For Managed Enterprise Ethernet switches transceivers shall be manufactured by Cisco.

3. Optical Attenuators:
    a. For shorter distances of single-mode fiber where the transceiver can be overloaded, furnish, and insert an inline optical attenuator in the link. If the fiber-optic cable span loss is less than 8 dB, insert a10-dB inline optical attenuator between the fiber-optic cable plant and the receiving port on the SFP module at each end of the link.

D. Media converters:
    1. Copper to fiber transceiver:
        a. Manufacturers: One of the following or equal:
            1) N-Tron.
            2) Black Box.
            3) Phoenix Contact.
        b. Transceiver shall be used to convert Ethernet communication between copper and fiber optic cables:
            1) Match protocol, speed, and media of attached equipment.
            2) Meets requirements of IEEE 802.3 Ethernet standard.
            3) Connector type:
                a) Fiber: SFP with gigabit single-mode transceiver(s) with LC connector(s).
                b) Copper: RJ-45.
            4) Power supply:
                a) 24 VDC.
            5) Mounting:
                a) DIN Rail mounting.
            6) Spare parts:
                a) Provide the following spare components:
                    (1) 1 spare media converter of each type provided.

E. Fiber optic patch panels:
        a. General:
            1) All optical fiber cables shall be provided with strain relief and terminated at a fiber patch panel. Final connections between the patch panel and the fiber optic network equipment shall be made via factory tested fiber optic patch cords.
            2) Terminate 12-strands of each 24-strand fiber optic cable in the following PCM patch panels. PCM-050-220-01, PCM-050-550-01 and PCM-500-01, leaving 12 loose strands for each cable. At a minimum, PCM-050-220-01 shall be equipped with the capacity to terminate 64 fiber optic cable strands in the PCM cabinet. At a minimum, PCM-050550-01 and PCM-500-01 shall be equipped with the capacity to terminate 36 fiber optic cable strands in the PCM cabinet. Terminate 6-strands of each 24-strand fiber optic cable in the following PCM patch panels: PCM-050-145-11, PCM-050-145-31 and PCM185-01, leaving 18 loose strands for each cable. Patch panels for PCM-050-145-11, PCM-050-145-31, PCM-185-01 shall be equipped with the capacity for a minimum of 16 fiber optic cable strands in the PCM cabinet. Provide space for excess fiber and provide strain relief for the fiber cable.

3) Fiber cables shall be installed such that the outer sheath of the cable is carried into the interconnect enclosure or patch panels before breaking out buffer tubes.
4) Fiber connectors: LC.

b. 19-inch rack mounted:
1) Manufacturers: One of the following or equal:
a) Corning.
b) Panduit.
c) Optical Cable Corporation (OCC).
2) Properties:
a) Housing:
(1) Use for combination of splicing and termination of fiber-optic building cable or outside plant cables.
(2) Up to 4U rack units in height.
(3) Fully enclosed.
(4) Interconnect and cross-connect capability.
(5) Modules shall be interchangeable.
(6) Compatible with connector panels, modules, and cassettes.
3) Accessories:
a) Hinged front doors.
b) Front cable management trough.
c) Top cover panel.
d) Configurable internal strain relief.
e) Blanks for unused connector panels.
f) Splice tray.

c. DIN Rail mounted:
1) Manufacturers: One of the following or equal:
a) DINSpace, SNAP XL.
b) Corning.
c) Hirschmann, MIPP.
2) Properties:
a) Use for the termination of a single cable inside of cabinets, in small enclosures or as indicated on the plans.
b) DIN rail mounted fiber patch panels shall be provided as complete unit including the housing, connector panels, splice trays, and fiber connectors.

d. Wall mounted:
1) Manufacturers: One of the following or equal:
a) Corning.
b) Optical Cable Corporation (OCC).
2) Properties:
a) Use for the termination of a single cable outside of cabinets, in small enclosures or as indicated on the plans.
b) Wall mounted fiber patch panels shall be provided as a complete unit including the housing, connector panels, splice trays, and the fiber connectors.
c) Physical protection for all incoming and outgoing cables and patch cords.
3) Accessories:
a) Door lock.
b) Blanks for unused connector panels.

F. Copper patch panels:
    1. General:
        a. All equipment and premises cables shall be terminated at a patch panel, except for field equipment connections.
        b. Final connections between the patch panel and network equipment shall be by patch cords.
        c. Provide factory tested copper patch cords as required to support all network devices.
            1) Provide 25 percent spare copper patch cords.
        d. Cables shall be installed such that the outer sheath of the cable is carried into the patch panel before breaking out conductors.
        e. Maintain twist of broken out conductors in accordance with TIA standards.
        f. UL listed.
        g. Properties:
            1) Modular, all metal construction with built-in strain relief.
            2) Compatible with both shielded and unshielded jack modules.
            3) Patch panel and jack modules shall be by same manufacturer.
            4) Utilizes jack modules for copper Ethernet cable termination.
            5) Provided shielded jack modules with a 360-degree conductive path to ground as required by the installation. Install per manufacturer's recommendation.
            6) Patch panel and jack modules shall meet or exceed category cable standard.
            7) Jack module shall be capable of at least 20 termination cycles.
            8) Provide 25 percent spare jack modules of each type.
        h. Accessories:
            1) Removable rear cable management bracket.
            2) Rear individual port labels.
            3) Front color-coded individual port labels.
            4) Termination tool.
    2. Manufacturers: One of the following or equal:
        a. 19-inch rack mounted:
            1) Panduit, Mini-Com series.
            2) OCC, DCC series.
            3) CommScope, SL series.
        b. DIN Rail mounted:
            1) DINSpace, SNAP XL.
            2) OCC, DTC.

G. Network and server cabinets:
    1. Conditioned space:
        a. Manufacturers: One of the following or equal:
            1) nVent; Schroff Varistar series.
            2) APC; Schneider NetShelter AR series.
            3) Panduit Net-Access N-Type series.
        b. Properties:
            1) In accordance with EIA-310-E - Cabinets, Racks, Panels, and Associated Equipment.
            2) Dimensions:
                a) Height: 42 rack units.

b) Width: 30 inches.
c) Depth: 42 inches.

3) Rack:
a) 19-inch mounting brackets.
b) Enclosed.
c) Fully welded frame.
d) Minimum static load-carrying capacity: 1,000 pounds.
e) Seismic rated as specified in Section 01850 - Design Criteria.

4) Doors:
a) Perforated.
(1) Minimum 65 percent open area perforation pattern.
b) Lever handle single point lock.
c) 180-degree opening angle.
d) Reversible.

5) Top:
a) Flat top with optional cut-out zones.

6) Side panels:
a) Removable.

7) Base plate:
a) As required by the installation.

c. Accessories:
1) Assembly kit.
2) Grounding kit.
3) Vertical ground bar for equipment grounding.
4) Accessory mounting brackets as needed.
5) Cable strain relief bars and organization hardware.
6) Cut-out edge protectors.
7) Leveling feet.
8) Horizontal and vertical cable management.
9) Hook and loop cable wraps, plastic cable ties are not acceptable.
10) LED light controlled by a door switch with an additional manual toggle switch for turning off the lights when the door is open.
11) Provide any additional accessories as needed for a fully functional installation.
12) Provide thermal load management as required by thermal heat calculations.
13) Provide quiet variable speed exhaust fan tray controlled by cabinet temperature.

H. Automatic transfer switches (ATS):
1. Manufacturers: The following or equal:
a. Eaton, EATS series.
b. APC; Schneider, Rack ATS series.
2. Properties:
a. Dual redundant power source inputs.
b. Voltage shall be 120VAC, unless otherwise indicated on the Drawings.
c. User selectable primary power source.
d. LED status indicators.
e. Command line interface.
f. Horizontal rack mounted.

g. Connections to match UPS connections and as indicated on the Drawings.
h. Communication:
1) Ethernet:
a) ATS shall include Ethernet network communication card.
b) Network protocols: SNMP.
c) Network interface: RJ45.

I. Power distribution units (PDU):
1. Manufacturers: The following or equal:
a. Eaton.
b. APC; Schneider.
c. Tripp-lite.
2. Properties:
a. UL listed.
b. Voltage shall be 120VAC, unless otherwise indicated on the Drawings.
c. Rack height: 0U.
d. Tool-less rack mounting.
e. Cable connections shall be coordinated with network rack devices (UPS, ATS, network switch, servers, etc.).
f. Communication:
1) Ethernet:
a) ATS shall include Ethernet network communication card for remote management.
b) Network protocols: SNMP.
c) Network interface: RJ45.

J. Hardware SMS Gateway (HSG):
1. Products: The following:
a. MultiTech LTE Cat 4 USB Modem with Accessory Kit (MTCM2-L4G1D-B03-KIT); Engineer knows of no equivalent. If at the time of bidding a 4G/5G modem is listed by Trihedral as approved for use with Owner's version of VTScada, that make/model shall be provided.
2. Purpose: USB-to-cellular modem for sending SCADA system alarm notifications via SMS text message.
3. Requirements:
a. Contractor shall confirm hardware and firmware compatibility with Owner's version of VTScada HMI software.
4. Chassis
a. Material: Aluminum.
b. Dimensions: (LxWxH) 2.45" x 1.79" x 0.78" (6.22 x 4.54 x 1.98 cm)
5. Wireless Performance:
a. Modem: Cat 4 LTE Worldwide LTE, UMTS/HSPA+ and GSM/GPRS/EDGE coverage
b. Packet Data: Up to 150 Mbps downlink / Up to 50 Mbps uplink
c. Diversity /MIMO: Rx Diversity and MIMO DL 2x2
6. Operating System Support: Windows 10
7. Operating Environment:
a. Operating Temperature: -40°C to +85°C
b. Operating Humidity: -40°F to +185°F (-40°C to +85°C)
8. Power Requirement: USB Powered (5V)

9. Connections:
    a. RF Antenna: External 50ohm SMA (female connector)
    b. SIM: Micro SIM (3FF); 1.8 and 3V
    c. USB: USB Type A
10. Antennas
    a. Indoor Antennas: One (1) omnidirectional with antenna cable.
    b. Outdoor Antennas: Provide one (1) Omni directional 10dBi outdoor rated antenna with a minimum 10m low loss coaxial cable with all required connectors and adapters.
11. Certifications:
    a. Regulatory Compliance - CE Mark, RED, FCC, RCM, IC, JATE/TELEC, KC, UKCA
    b. Safety - IEC 60950-1 2nd ED, IEC 62368-1
    c. Carrier - AT&T, T-Mobile and Verizon
    d. Quality - MIL-STD-810G: High Temp, Low Temp, Cold Dwell,Random Vibration and Sine Vibration SAE J1455: Random Vibration and Sine Vibration
12. Spare parts:
    a. Provide the following spare components:
        1) 1 spare Hardware SMS Gateway of each type provided.
13. Wireless Plan (SIM Card): Contractor shall provide one (1) AT&T or Verizon sim card with an unlimited SMS data plan for the duration of the construction period and for one year following substantial completion.

2.05 ACCESSORIES

A. Provide duplex patch cords to connect the interface cards provided with the associated patch panels.

B. Provide dust covers or plugs for all unused ports.

C. Furnish accessories as specified in Section 17730 - Control Systems: PCS Computer Equipment.

PART 3 EXECUTION

3.01 PREPARATION

A. Equipment support and anchoring to structures:
    1. As specified in Section 01850 - Design Criteria including but not limited to:
        a. Anchor bolt layout.
        b. Equipment templates.
        c. Anchor installation.

3.02 INSTALLATION

A. Provide installation and configuration for the new and existing managed Ethernet switches. Provide configuration of the Ethernet switch network for a complete, functioning plant control system as indicated on the Drawings and as specified in this Section:

1. Refer to SCADA block diagrams for all new network connections.
2. Provide configurations for all managed Ethernet switches and other components including but not limited to VLAN (virtual local area network), additional Plant PLC communication cards, and separate managed Ethernet switches as required, such that there is isolation of the following networks:
    a. PLC network: This includes the Plant PLC system below the core switches including the following:
        1) Plant PLCs.
        2) Plant PLC remote I/O (RIO) racks.
        3) Ethernet I/O Modules.
        4) Plant Instrumentation.
    b. HMI network: This includes the connections between the Plant HMI System and:
        1) Industrial Panel Computers (IPC).
    c. Process control network: This network includes the connections between the I/O server(s) and other equipment including but not limited to servers, workstations, and printers. Equipment in this network includes:
        1) Server A, all VMs
        2) Server B, all VMs
    d. Management network: This network includes the connections between network device management ports and the network management server. Equipment in this network includes:
        1) Server C, all VMs.
        2) Server management ports such as iDRAC or similar.
        3) UPS.
        4) ATS.
        5) Ethernet switch management,
        6) Network connected equipment device management ports.
    e. DMZ Network: This network includes the connections between the DMZ network and the Process Control Network. Equipment in this network includes:
        1) Server D, all VMs.
3. Provide a default deny policy on all firewalls. Use the following requirements to develop an access control list of allowed communication on the network for each firewall and routing configuration for layer 3 switches:
    a. Firewall FW-050-901-02:
        1) Allow remote VPN connection to Server D VM3 Engineering Workstation. Engineering workstation requires two factor authentication for login and customize available access based on user policy coordinated with the Owner.
        2) Allow remote VPN connection to Server D VM2 Webserver client. Authentication for login to the VTScada webclient requires two factor authentication for login and view only access.
        3) Allow Server D VM4 Update Server WSUS/Endpoint Protection Management access to Windows updates and selected endpoint protection system updates.
    b. Firewall FW-050-901-01:
        1) Allow connection between Server A VM2 VTScada Primary and Server B VM2 Secondary Servers and Server D VM2 VTScada Runtime server for data synchronization. Block all other ports and services not required for data synchronization between servers.

2) Allow remote desktop connection between Server D VM 3 Engineering Workstation and Server A VM3 and Server B VM3 to allow access to the engineering workstations on the process control network. Limit access to specific users coordinated with the City. The engineering workstation on Server D VM3 acts as a jump server into the process control network, but cannot access any other resources.
3) Allow connection between Server D read only domain controller and Server C Active Directory Server for updating active directory, DNS, DHCP, and other critical network administrative policies. Block all other communication between these servers.

c. Core switches ESW-050-901-01 and ESW-050-901-02:
1) Block all ports not necessary to obtain the required functionality. Implement port blocking at the firewall where available. Where firewall access control lists cannot be used, limit routing to specific devices and further control using TLS where available.
2) Allow management access between Server C VM4 Network Management Server and network connected devices on the process control network, PLC Network, and HMI network for devices that do not support separate management network IP addresses.
3) Allow access between Server C Windows Admin Center and server management network IP addresses for management of virtualized server systems.
4) Allow access between Server C VM5 and servers and industrial panel computers on the process control network and HMI network for updating operating system and endpoint protection software.
5) Allow access between the VTScada servers and HMI network for VTScada Internet Client (VIC) access.
6) Allow access between the PLC network and VTScada servers for I/O exchange.
7) Allow access between the PLC network and Server A and Server B Engineering workstations for PLC programming access.
8) Allow NTP server access to the process control network and PLC network. Set network time for all other servers and workstation using the local domain controllers that inherit their time from the Active Directory server.

4. Configure firewalls with geographic fencing and blocking.
5. The process floor managed Ethernet switches for the process control network shall be configured and programmed for rapid fail over protection.
6. The enterprise level managed Ethernet switches shall be configured for a communication protocol that is compatible with the process control network's rapid fail over protocol.

B. All racks shall be level and plumb.

C. All work shall be performed in a neat and workmanlike manner.

D. Cable management:
1. All cables and equipment shall be installed in strict conformance with the manufacturer's recommendations.
2. Install cable using lubricant designed for cable pulling.

3. Install hook-and-loop wrap on all cable bundles within the network rack/enclosure. Plastic tie-wraps are not acceptable.
4. Install network cables without splices.
5. Installed bend radius shall be a minimum of 10 times the cable diameter.
6. Terminate all pairs at the jack and patch panel.
7. Route all cables through cable management or other form of containment. No loose, unsupported cables are permitted to span across network equipment.
8. Use corner strips to protect cables from edges inside ducts and to maintain bend radius requirements.

E. Internal rack wiring:
1. Cables shall be installed avoiding sharp bends.
2. Provide enough working space inside rack or cabinets such that closing enclosure doors does not crush or compress cabling.
3. Bundle cables together in groups of no more than 12.
4. Route cables from both sides of the rack to patch panels. Do not bring all bundles from a single side.
5. No cabling shall obstruct equipment ventilation.
6. Individual pairs will be untwisted less than 1/2-inch at termination points.
7. Ground enclosure and equipment in accordance with TIA-607.
   a. Individually bond all network equipment chassis to rack's grounding busbar. Do not daisy-chain bonding conductors.
   b. Size the bonding conductor per network equipment manufacturer's recommendation, or #10 AWG, whichever is larger.

F. External rack wiring:
1. Do not install fiber cables in non-continuous cable supports such as cable ladders or wire baskets without radius cable supports or solid bottoms.
2. Maintain cable separation in accordance with TIA-569.
   a. Install cables a minimum of 40 inches away from electrical motors and transformers.
   b. Install cables a minimum of 12 inches away from fluorescent lighting.

G. All cables and terminations shall be labeled with cable designations as specified in Section 16075 - Identification for Electrical Systems.

H. Each data port shall be individually labeled with its patch panel/switch port ID:
1. Labeling must be printed - no handwritten labels will be allowed.

I. At the completion of the wiring installation, provide the following documentation:
1. A plan-view of the premise(s) showing the jack numbering scheme.
2. A printed certification report for the entire wiring installation showing compliance with all TIA specifications for data cable.
3. Reports such as those generated by Fluke DSP cable certification equipment meet this requirement.

J. Managed Ethernet switches:
1. Configure switches to prevent broadcast storms.
2. All installations shall employ IGMP snooping to limit multicast messaging.

3.03 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

B. Owner Training:
   1. As specified in Section 17950 - Commissioning for Instrumentation and Controls.

3.04 FIELD QUALITY CONTROL (NOT USED)

3.05 ADJUSTING

A. Perform all firmware installations, configuration and other set up, as required, to place the network into proper operation.

END OF SECTION

SECTION 17762

CONTROL SYSTEMS: PCS SOFTWARE

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. PCS system software to be used for application software development and real time operation of the PCS system.
   2. Network Management Software.
   3. Endpoint Protection Software.

B. Existing Conditions:
   1. The Owner maintains an existing VTScada SCADA HMI platform installation installed on two workstation PCs, primary (WS-050-901-91) and secondary (WS-050-901-92), located in the City administration building next to the WTP as indicated on the Instrumentation Drawings. The workstations are configured as redundant VTScada HMI/Historian servers that are dual purpose, also functioning as HMI clients.
   2. An existing workstation PC, WS-050-901-11, installed in the WTP Control Room, runs as a VTScada web client displaying finished water quality analyzer values.

C. General requirements:
   1. Programmer shall install and configure PCS software, as indicated on the Drawings, and as required for a complete and functional PCS system and as specified in this Section.
   2. Install endpoint protection software on all operating systems.
   3. Programmer shall configure all network devices and computer equipment in SCADA Network rack, SNR-901-050-01, furnished under this Contract by the Contractor. Refer to Section 17730 for hardware requirements.
   4. Programmer to convert Owner's existing workstation PC based servers, WS-050-901-91 and WS-050-901-92, with a virtualized redundant SCADA HMI server pair. The workstation PCs shall be reconfigured for use a VTScada virtual internet clients (VICs) that connect to the new server via Ethernet.
   5. The new VTScada server (SVR-050-901-04) shall be configured by the Programmer as a VTScada Runtime client that provides the Owner with configurable SMS alarm notifications from VTScada. Refer to subsection herein below titled "Remote Alarm Notification System".
   6. Server (SVR-050-901-04) VM3 Engineering Workstation shall be configured by the Programmer to serve as a "jump station" for secure remote access to the SCADA system by Owner designated staff.
   7. The City currently has an existing WTP SCADA HMI software licensed to the latest version of the VTScada 5K Dual Server Premium license bundle installed on the existing workstations. VTScada and the existing license shall be installed by the Programmer on the new virtualized, redundant SCADA HMI server described in this Section.

8. Virtualized redundant SCADA HMI servers, SVR-050-901-01 and SVR-050-901-02:
    a. Virtualized redundant SCADA HMI server, SVR-050-901-01 and SVR-050-901-02, hardware and software shall be furnished by the Contractor.
    b. Programmer shall install and configure all SVR-050-901-01 and SVR-050-901-02 software described herein below, in this Section.
9. Virtualized management server, SVR-050-901-03:
    a. Virtualized management/backup server, SVR-050-901-03, hardware and software shall be furnished by the Contractor.
    b. Programmer shall install and configure all SVR-050-901-03 software described herein below, in this Section.
    c. Programmer shall install and configure Network Management Server software on this server.
10. Virtualized DMZ server, SVR-050-901-04
    a. In addition to Owner's existing VTScada license, Contractor shall furnish a VTScada 5K HMI tag runtime license for SVR-050-901-04.
    b. Programmer shall install and configure a new VTScada 5K HMI tag runtime license on Contractor furnished DMZ Server SVR-050-901-04.
11. Programmer shall install and configure virtualization software for each SCADA server. Where multiple applications, such as VTScada and Active Directory, are installed on the same physical host, each software application will run on a dedicated virtual machine (VM).
12. Programmer shall develop new VTScada SCADA HMI screens for all WTP processes and equipment shown on the P&ID Drawings and the existing WTP VTScada HMI dashboard screens.
13. SCADA HMI screen graphics and overall screen functions provided by Programmer shall adhere to Owner's standards and input from Owner during the graphical system workshops.
14. Programmer shall migrate existing VTScada historical data from the existing workstation PC servers to the new VTScada SCADA servers.
15. Software configured under this Contract by the Programmer represents a complete and operating monitoring and control software system. Programmer shall achieve the functionality specified in this and other sections through a combination of standard control system software and application software developed specifically for this Project.
16. The standard control software listed in this Section does not represent a comprehensive list of software necessary to implement the functional requirements of the Contract Documents. Contractor shall provide all necessary supplemental drivers, utility software, and application software, as required, to meet the functional requirements of the Contract Documents.
17. Programmer shall strictly adhere to applications software requirements are described in Section 17100 - Control Strategies.
18. Contractor and ICSC, in close coordination with the Programmer, shall hold workshops with the Owner to review graphic screens.
19. Contractor, in coordination with Programmer, shall license all software for proper operation as described in the Contract Documents.
20. Contractor shall license all software provided under this Contract to the Owner.

D. Provide copies of all software on a portable SSD Drive, or equivalent media in accordance with Section 17950. For completely developed systems, provide a copy of the virtual machines developed on portable SSD Drive.

1.02 REFERENCES

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

1.03 SYSTEM DESCRIPTION

A. System Configuration Requirements:
   1. Programmer shall provide PCS software, as required for a complete and functional PCS system as indicated on the Drawings and as specified in this Section:
      a. Provide, at a minimum, the following SCADA server software general configurations. Provide additional configuration and testing to ensure a fully functional system that meets all requirements of this Division.
         1) WTP SCADA HMI Servers A & B:
            a) The WTP physical SCADA HMI servers, WTP SCADA HMI Server A (SVR-050-901-01) and WTP SCADA HMI Server B (SVR-050-901-02), shall be configured as a redundant pair with hot-backup auto-failover from the primary to secondary mirror server. WTP SCADA Server A shall be configured as the primary SCADA HMI server and WTP SCADA Server B shall be configured as the secondary SCADA HMI server for the WTP.
            b) WTP SCADA HMI Server A (SVR-050-901-01) – The physical server shall, at a minimum, host the following virtual machines:
               (1) VTScada HMI software shall be installed on a virtual machine server, VTScada WTP Server VM 2. The VM server shall serve as the WTP Primary SCADA HMI server.
               (2) Read only domain controller software shall be Active Directory by Microsoft, installed on a virtual machine server, Active Directory Server VM 1 (Backup). Domain Controller Server VM 1 shall serve as a backup domain controller for the WTP should communication with the primary server fail.
               (3) Engineering workstation.
            c) WTP SCADA HMI Server B (SVR-050-901-02) – The physical server shall, at a minimum, host the following virtual machines:
               (1) VTScada HMI software shall be installed on a virtual machine server, VTScada WTP Server VM 2. The VM server shall serve as the WTP Secondary SCADA HMI server.
               (2) Read only domain controller software shall be Active Directory by Microsoft, installed on a virtual machine server, Active Directory Server VM 1 (Primary).
               (3) Engineering workstation.
         2) WTP Management SCADA Server (SVR-050-901-03):
            a) Redundancy and Virtualization - The WTP physical Management/Backup Server (SVR-050-901-03) shall be virtualized and shall host the Microsoft Admin Center for management of SVR-050-901-01, SRV-050-901-02 and SRV-050-901-03, and SVR-050-901-04 VMs.
            b) Backup and Recovery– Management/Backup SCADA Server shall store all backup files.

c) Active Directory Server - The Management/Backup SCADA server shall serve as the Active Directory domain controller for the WTP that allows for configuration and management of the Active Directory system and domain controllers.
d) Update server for the process control system and HMI networks. The update server pulls updates from the DMZ update server. Updates are automatically downloaded by each system OS but require manual installation and reboots if necessary. Updates include OS updates, endpoint protection updates, and file transfer of other software updates such as network management software, SCADA software, and device firmware updates.
e) Management/Backup Server A (SRV-050-901-03):
(1) The physical server shall, at a minimum, host the following virtual machines:
(a) Active Directory Server - Domain controller software shall be Active Directory by Microsoft.
(b) Microsoft Admin Center.
(c) Windows Security Update Server (WSUS) VM with Anti-Virus Manager or Agent.
(d) Network Monitoring Server VM.
(e) Firewall Management Server VM.

3) WTP DMZ SCADA Server (SVR-050-901-04):
a) VTScada Runtime HMI software shall be installed on a virtual machine server. This server will serve as a view only VTScada Web Client, alarm notification server, and backup historian.
b) Read only domain controller - The DMZ SCADA server shall serve as the Active Directory domain controller for the WTP DMZ for authentication.
c) Update server to pull in necessary updates for the following systems. Only allow access to the necessary sites for specific system updates directly from the software vendor approved update locations:
(1) Operating Systems
(2) Endpoint Protection Updates
(3) Network Management Software Updates
(4) SCADA software updates
(5) PLC programming software updates.
(6) Firewall system updates.
(7) All other software updates should be manually loaded.
d) DMZ Server A (SRV-050-901-04):
(1) The physical server shall, at a minimum, host the following virtual machines:
(a) Read only domain controller - Domain controller software shall be Active Directory by Microsoft.
(b) VTScada Runtime Server.
(c) Windows Security Update Server (WSUS) VM with Anti-Virus Manager or Agent.
(d) Engineering Workstation.

4) Network Time Protocol (NTP) Server (SVR-050-901-05) shall be a dedicated GPS hardware-based time synchronization device and shall serve as the real time clock (RTC) for the WTP SCADA system.

5) All SCADA HMI screens developed for the systems shown on the Instrumentation Drawings shall adhere to Owner standards based on ISA 101 and best practices for HMI screen design, including but not limited to menu hierarchies, screen navigation conventions, graphics and color conventions, dynamic elements, alarming conventions, security methods and electronic signature attributes, interfaces with background programming and historical databases, popup conventions, help screens and methods used to work with alarms, and program object interfaces. In addition, the SCADA HMI screens shall also include the requirements described in this Section, in other Division 17 Sections and all Owner preferences and requirements established during the software workshops, which may include deviations from the ISA101 standards requested by the Owner.

B. System Security:
   1. Active Directory:
      a. Develop a new, Active Directory based domain controller infrastructure for user authentication for the WTP, integrating all of the Owner's existing software systems and software systems provided under this project.
      b. Coordinate with Owner any required whitelisting of applications or ports for proper operation of software.
   2. Remote Access:
      a. Remote access to the WTP SCADA system shall be provided only through the Owner-approved remote access architecture and shall terminate within the SCADA DMZ. Remote access shall use the Engineering Workstation virtual machine hosted on SVR-050-901-04 as the designated jump station for access by Owner-designated staff and approved support personnel.
      b. Direct remote access from external networks to PLCs, SCADA HMI servers, historian servers, management servers, network switches, firewalls, control panels, process control VLANs, or other process control network devices shall not be permitted.
      c. Remote access shall require unique user authentication, Owner-approved authorization, and role-based permissions. Shared remote access accounts shall not be used unless specifically approved by the Owner. Remote access privileges shall be limited to the minimum access necessary for the assigned user role.
      d. Remote access connections shall be controlled by firewall rules, access control lists, routing restrictions, and user group policies reviewed and approved by the Owner. Allowed communications shall be limited to the specific protocols, ports, source addresses, destination addresses, and systems required for the approved remote access functions.
      e. Remote access shall be configured to support monitoring, troubleshooting, software maintenance, and Owner-approved engineering activities. Remote access shall not bypass local SCADA security, application-level user permissions, alarm acknowledgement permissions, control permissions, or electronic signature requirements.
      f. All remote access sessions shall be logged. Logs shall include, at a minimum, user identification, connection time, disconnection time, source address, destination system, and remote access method. Remote access logs shall be available for review by the Owner.

g. Programmer shall coordinate with the Owner to define approved users, user groups, authentication method, remote access method, allowable communications, firewall rules, access control lists, routing requirements, session logging requirements, and remote access operating procedures.
h. Programmer shall demonstrate the complete remote access configuration during the Network and Server System review meetings and shall update the Network and Server System submittal to document the final Owner-approved remote access architecture, allowed communications, security configuration, and operating procedures.

3. User Groups:
   a. The system will use User Groups to assign screen access and control action permissions within the system dependent on the login credentials of the user.
   b. A user group with minimal permissions will always be logged in if no other user group is logged in. This user group will be limited to view only and basic screen navigation.
   c. Coordinate user groups with the Owner and provide the following user groups at a minimum:
      1) View Only – Allows for viewing of SCADA screens, historical data, and alarms but no alarm acknowledgement. Historical data may be downloaded.
      2) Maintenance – All access from View Only and ability manually start and stop pumps and open and close valves. No access to setpoint changes.
      3) Operator – All access from maintenance with the ability to modify control setpoints.
      4) Supervisor – All access from operator with the ability to modify alarm setpoints and reset counters.
      5) Developer – All access from supervisor with the ability to modify graphics.
      6) Administrator / Super User – Full system functionality including security setting changes.

C. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 17050 - Common Work Results for Process Control and Instrumentation Systems.

D. Remote alarm database:
   1. After development of the PCS system database but before system start-up, provide a list of points configured for alarming and submit to the Owner and the Engineer. The Owner/Engineer will identify critical alarms for use in the extended alarming system (e.g., dialer system, paging) and provide response descriptions.

E. Alarm descriptions shall be of sufficient detail for an accurate review by the Owner.

F. After all shop drawings submittals required in this Section have been favorably reviewed by the Engineer, the Programmer shall submit the following items, which must also be favorably reviewed and implemented prior to the start of system

testing, the entire control system including all required software packages must be operational prior to the required factory acceptance test:

1. All operator interface display submittals shall be in full color as they will appear on the display screen:
    a. This submittal shall be prepared after the requisite graphics meetings.
    b. The submittal shall include:
        1) Graphic displays.
        2) Trend displays.
        3) Alpha numeric displays.
        4) Alarm displays.
2. Each display shall be uniquely titled:
    a. Locations for process data shall be clearly identified either through the use of simulated data or by showing variables on the displays and providing a reference list describing those variables.
    b. All dynamic points shall be identified by tag number as a minimum and their operation shall be described on separate sheets:
        1) Color change.
        2) Symbol change.
    c. Three sets of submittals, with screen prints in color on a white background, are required for review by the Owner and Engineer.
    d. One set will be returned with comments.
3. All periodic and custom reports for the entire control system:
    a. Locations for process data shall be clearly identified, either through the use of simulated data or by showing variables on the report and providing a reference list describing those variables.
    b. Three sets of reports shall be submitted for review by the Engineer.
    c. One set will be returned with comments.

G. Pre-acceptance test documentation as specified in the Sequencing article of this Section.

H. Operator's reference manual:
1. The Programmer shall prepare and submit a user reference manual for the operator interface system for use by the operators. This manual shall be bound in a 3-ring binder and meet the following minimum requirements:
    a. An index to the manual.
    b. A list of operator interface:
        1) Display screens.
        2) Trends.
        3) Reports.
        4) With display name and description.
    c. A summary of all possible commands and operator inputs to these screens including setpoints:
        1) All control actions shall be included.
    d. A control system block diagram with names and locations of major components.
    e. Instructions for manually printing screens or reports:
        1) Real time.
        2) Historical.
    f. A summary of security levels and their privileges and limitations.
    g. Spaces for operators to make notes.

2. A copy of this manual shall be provided to each operator during training on the operator interface operations:
    a. The training class shall include a review of this manual with the operators in addition to more detailed instruction on the operator interface configuration and its use.

I. Review meeting minutes submittals:
    1. Graphics review meeting:
        a. Minutes of Graphic Review Meeting No. 1.
        b. Minutes of Graphic Review Meeting No. 2.
    2. Report review meeting:
        a. Minutes of Report Review Meeting No. 1.
        b. Minutes of Report Review Meeting No. 2.
    3. Alarm review meeting:
        a. Minutes of Alarm Review Meeting No. 1.
        b. Minutes of Alarm Review Meeting No. 2.
    4. Network and Server System review meeting:
        a. Minutes of Network and Server System Review Meeting No. 1.
        b. Minutes of Network and Server System Review Meeting No. 2.

1.04 QUALITY ASSURANCE

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

B. The manufacturer must have a formal and documented set of quality assurance procedures that are applied to the engineering design, development, and documentation of the software:
    1. The presence of a formal quality assurance department is required.

C. Software provided under this Section shall be included in the testing specified in Section 17950 - Commissioning for Instrumentation and Controls.

1.05 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.06 PROJECT OR SITE CONDITIONS (NOT USED)

1.07 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
    1. License all software for proper operation as described in the Contract Documents.
    2. License all software provided under this Contract to the Owner.
    3. Provide copies of all software on a portable SSD Drive, or equivalent media. For completely developed systems, provide a copy of the virtual machine developed on portable SSD Drive

B. The following items shall be submitted with the final sets of technical manuals required as specified in the Submittals article of this Section, 15 working days

before the pre-commissioning test as specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems:

1. All program manuals supplied by the manufacturers with the standard software packages.
2. All original program disks supplied by the manufacturers with the standard software packages, including any program revisions or updates issued by the manufacturers during the construction period.
3. All PLC program and operator interface application program files stored on labeled disks:
    a. The PLC program and operator interface application program file disks shall also be updated as required if any changes or corrections are required in this programming before Project completion.

C. Operator interface graphics generation:
1. The Programmer, through the Contractor, shall schedule the operator interface graphics meetings.
2. Topics shall include graphics for:
    a. HMI graphics.
    b. Data acquisition and graphics display system.
3. The Owner and Engineer shall attend these meetings.
4. Graphics Meeting No. 1: Held in conjunction with the Preliminary Meeting as specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems:
    a. The Programmer shall chair and develop an agenda 3 weeks in advance of the meeting, which shall address the basic criteria to be adhered to in the configuration and development of graphic displays:
        1) At this meeting, the Programmer shall distribute sample display formats for illustration purposes.
        2) As a minimum, this meeting shall address the following issues:
            a) All in-plant and remote site areas and conventions for identifying tag names and descriptors.
            b) Designation of groups within each plant area along with tag names and descriptors.
            c) The assignment of individual control loops and inputs to specific groups.
            d) Organization of the systems universal display hierarchy.
            e) Paging schemes to be used to enable the movement from one display to another.
            f) An itemization of the type of display to be used at each level in the graphic hierarchy, i.e., pre-formatted displays, templates, custom graphics, etc.
            g) Color convention to be employed on all graphics for the annotation of various status information, differentiation between alarms based on alarm priority, background colors, static field colors, and dynamic field colors.
            h) The utilization of blinking and conditional text.
            i) Definition of graphic symbolism to be used on the Project. This listing shall include but not be limited to symbols to be used for

process instrumentation, process equipment, piping, vessels and valves:
(1) All symbolism must be specific as opposed to generic in that shapes must define both function and type, i.e., specific symbols for each valve design, each pump design, each type of flowmeter, etc.
(2) If the Programmer's library of shapes does not adequately describe plant or field conditions, the Programmer shall develop additional shapes to meet the plant or field requirements.
(3) Shapes and symbols used on the P&IDs shall be used as a guideline.

j) Definition of all display select commands that enable the operator to move within the display hierarchy.
k) The utilization of cursor movement commands which enable the operator to move within a display.
l) Definition of control input commands which enable the operator to interact with face plates control stations and custom graphic displays to implement control functions.
m) Definition of data input commands which enable the operator to enter numeric values into the control system.
n) Definition of the utilization of "poke" points or fields that are dynamically sensitive to operator inputs to facilitate operator entry directly into graphic displays.
o) A review of graphic generation procedures.

b. Subsequent to the adjournment of Graphics Meeting No. 1, the Programmer shall prepare and formalize a document titled "Graphics Criteria" which shall contain detailed meeting minutes and a definition of all graphic guidelines to be adhered to:
1) This report shall be supplemented by graphic examples which illustrate the incorporation and application of each graphic criteria.
2) The report shall be submitted within 30 calendar days of the meeting's adjournment.

5. Graphics Meeting No. 2: Held in conjunction with the intermediate review meeting as specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems:
a. Subsequent to the finalization of the overall system-wide graphics criteria, the Programmer shall develop graphic packages for the entire operator interfaces being furnished under this Project.
b. At this meeting the Programmer shall submit 5 copies including:
1) A review of the graphic package developed for the process areas for content and completeness.
2) A review of all data fields that display automatically updated process information.
3) A review of all required input commands associated with the graphic access and control manipulation.
c. Subsequent to the adjournment of Graphics Meeting No. 2, the Programmer shall prepare a formalized submittal of the graphic package for review along with the detailed meeting minutes:
1) The report shall be submitted within 30 calendar days of the meeting adjournment.

6. 10 additional displays shall be configured on-line during the pre-commissioning test period.

D. Report generation:
   1. The Programmer through the Contractor shall schedule the report generation meetings.
   2. The Owner and Engineer shall attend these meetings.
   3. Reports Meeting No. 1: Held in conjunction with the preliminary meeting as specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems:
      a. The Programmer shall chair and develop an agenda 3 weeks in advance for a meeting, which shall address the basic criteria to be adhered to in the configuration and development of the reports:
         1) At this meeting, the Programmer shall distribute sample formats for illustration purposes.
         2) As a minimum, this meeting shall address the following issues:
            a) All in-plant and remote site data and conventions for identifying tag names and descriptors.
            b) Designation of groups within each plant area along with tag names and descriptors.
            c) The assignment of inputs to specific categories.
            d) Organization of the systems universal report categories.
            e) An itemization of the type of report available.
            f) Definition of terms to be used on the reports.
            g) Definition of all report commands that enable the operator to move within the report editor.
            h) The utilization of cursor movement commands which enable the operator to move within a report.
            i) Definition of data input commands which enable the operator to enter numeric values into the system.
            j) A review of report generation procedures.
         3) Subsequent to the adjournment of the Report Meeting No. 1, the Programmer shall prepare and formalize a document titled "Report Criteria" which shall contain detailed meeting minutes and a definition of all report guidelines to be adhered to:
            a) This report shall be supplemented by report examples.
            b) The report shall be submitted within 30 calendar days of the meeting's adjournment.
   4. Reports Meeting No. 2: Held in conjunction with the intermediate review meeting as specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems:
      a. Subsequent to the finalization of the overall report format criteria, the Programmer shall develop report packages for review.
      b. At this meeting the Programmer shall submit 5 copies including:
         1) A review of the report package developed for the process area(s) for content and completeness.
         2) A review of all data fields for process information.
         3) A review of all required input commands associated with the report access and control manipulation.

c. Subsequent to the adjournment of Report Meeting No. 2, the Programmer shall prepare a formalized submittal of the report package for review along with the detailed meeting minutes:
    1) The report shall be submitted within 30 calendar days of the meetings adjournment.

5. 5 additional reports shall be configured on-line during the pre-commissioning test period.

E. Alarming priority:
1. The Programmer through the Contractor shall schedule the alarming priority meetings.
2. The Owner and Engineer shall attend these meetings.
3. Alarming Priority Meeting No. 1: Held in conjunction with the preliminary meeting as specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems:
    a. The Programmer shall chair and develop an agenda 3 weeks in advance for a meeting, which shall address the basic criteria to be adhered to in the prioritization of alarms:
        1) At this meeting, the Programmer shall distribute a listing of all plant alarms identified by tag names and descriptors.
        2) As a minimum, this meeting shall address the following issues:
            a) Criteria for prioritizing alarms including alarming priority levels. (i.e., Priority 3 - alarm at PCS; Priority 2 - alarm at PCS and autodialer; Priority 1 - alarm at PCS, autodialer, and plant shutdown.)
            b) Alarm display banner basic criteria.
        3) Subsequent to the adjournment of the Alarming Priority Meeting No. 1, the Programmer shall prepare and formalize a document titled "Alarm Criteria" which shall contain detailed meeting minutes and a definition of all alarming guidelines to be adhered to:
            a) The report shall be submitted within 30 calendar days of the meeting's adjournment.
4. Alarming Priority Meeting No. 2: Held in conjunction with the intermediate review meeting as specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems:
    a. Subsequent to the finalization of the overall alarm criteria, the Programmer shall develop an alarming priority spreadsheet that will be populated at this meeting.
    b. At this meeting the Programmer shall provide a spreadsheet including:
        1) A listing of all plant alarms identified by tag names and descriptors.
        2) For each alarm listed include a location to enter the alarm priority assignment.
        3) For each alarm listed include a location to enter specific comments related to that alarm.
    c. Subsequent to the adjournment of Alarming Priority Meeting No. 2, the Programmer shall prepare a formalized submittal of the alarming priority spreadsheet for review along with the detailed meeting minutes:
        1) The spreadsheet and meeting minutes shall be submitted within 30 calendar days of the meeting’s adjournment.

F. Network and Server System:
    1. The Programmer through the Contractor shall schedule the Network and Server System meetings.
    2. The Owner and Engineer shall attend these meetings.
    3. Network and Server System Meeting No. 1: Held in conjunction with the preliminary meeting as specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems:
        a. The Programmer shall chair and develop an agenda 3 weeks in advance for a meeting, which shall address the basic criteria to be adhered to in the prioritization of alarms:
            1) At this meeting, the Programmer shall distribute a listing of all VMs to be deployed and allowed communications.
            2) As a minimum, this meeting shall address the following issues:
                a) IP Addressing.
                b) VLAN Assignments.
                c) Operator systems and hardening of operating systems.
                d) Allowed network communication.
                e) Authentication practices.
                f) General software configuration methods.
            3) Subsequent to the adjournment of the Network and Server System Meeting No. 1, the Programmer shall prepare and formalize a document titled " Network and Server System " which shall contain detailed meeting minutes and a definition of all communication and authentication guidelines to be adhered to:
                a) The report shall be submitted within 30 calendar days of the meeting's adjournment.
    4. Network and Server System Meeting No. 2: Held in conjunction with the intermediate review meeting as specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems:
        a. Subsequent to the finalization of the Network and Server System design, the Programmer shall develop Network and Server System communication draft ACL and Routing guidelines as well as a draft of User and Group policies for authentication. A demonstration of remote access shall be prepared and final decisions completed by the Owner.
        b. At this meeting the Programmer shall discuss and finalize the following:
            1) Access Control Lists.
            2) VLAN assignments, routing, and device specific routing.
            3) Network Management system assets and naming convention.
            4) Cellular service providers.
        c. Subsequent to the adjournment of Network and Server System Meeting No. 2, the Programmer shall prepare a formalized submittal of the Network and Server System access control configurations and guidelines for review along with the detailed meeting minutes:
            1) The guidelines and meeting minutes shall be submitted within 30 calendar days of the meeting’s adjournment.

1.08 WARRANTY

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

1.09 MAINTENANCE

A. Provide 5-year extended manufacturer's warranty as follows:
   1. Dedicated technical support department or handled by programming staff or distributor.
   2. Telephone support available M-F normal business hours per day.
   3. Email and web support addresses.
   4. FTP download area.
   5. Knowledge base.
   6. Bulletin board service.
   7. Field service.

B. Provide system upgrades and maintenance fixes for a period of 1 year from Substantial Completion.

PART 2 PRODUCTS

2.01 GENERAL

A. Software provided under this Contract represents a complete and operating control software system. Achieve the functionality specified in this and other sections through a combination of standard control system software and application software developed specifically for this Project.

2.02 DESIGN AND PERFORMANCE CRITERIA

A. The standard control software listed in this Section does not represent a comprehensive list of software necessary to implement the functional requirements of the Contract Documents. Provide all necessary supplemental drivers, utility software, and application software, as required, to meet the functional requirements of the Contract Documents.

B. PCS system node descriptors:
   1. PCS runtime client:
      a. Client workstations or servers shall be provided with all graphic display and related software for interacting with the PCS system data.
      b. PCS client's displays shall operate on data maintained by the PCS server.
      c. Display capabilities shall include, but not be limited to:
         1) Process mimic displays.
         2) Real time and historical trend displays.
         3) Alarm summary and sub-summary displays.
         4) System utilities.
   2. PCS development node:
      a. Provide the PCS system development node with software and licenses required to edit the programs and configuration files as part of the system application development.
      b. Unless otherwise indicated, the development node shall be complete with run-time software for fully testing the application programs.
      c. Functions required at the development node include:
         1) Edit the PCS database.
         2) Edit graphic displays.
         3) Modify alarm files.

4) Modify PLC programs.
5) Modify programs and scripts executing at any of the workstations.
6) Set up trends and historical displays.
7) Edit user authorizations.
8) Other functions as may be required to modify the PCS system application software.

3. Historian server:
   a. The Historian is integral to the SCADA servers.
   b. The historian server collects real time data and compresses the values into historical records for trending and reporting.
   c. Unless otherwise indicated, the historian server shall archive all data provided by the PCS server.
   d. The server shall be provided with software for interfacing with standard report software packages via MS-SQL, ODBC and other standard interfaces as described in this Section.
   e. Provide software required for collector redundancy when auto-fail over PCS servers are supplied.
4. Alarm node:
   a. Alarming software and remote notification is integral to each development and runtime SCADA server.
   b. Each SCADA client is equipped with an alarm window on the operator display with local annunciation.
   c. Where a separate alarm node has been indicated, this node shall handle the interface to telephone, paging and radio alarming systems.

2.03 MANUFACTURERS

A. SCADA Software:
   1. Trihedral VTScada.

B. Endpoint Protection Software:
   1. Symantec Endpoint Protection, Complete.
   2. Crowdstrike Endpoint Security.
   3. Microsoft Defender.

C. Network Management Software:
   1. Claroty OT.
   2. Tenable OT.
   3. Nozomi Networks Guardian.

2.04 EXISTING PRODUCTS (NOT USED)

2.05 MATERIALS (NOT USED)

2.06 MANUFACTURED UNITS

A. General:
   1. Unless otherwise indicated, provide all run-time and development software licensed for:
      a. 5,000 tags.
      b. Unlimited screens.

c. No direct limits on the number of connections to a server machine.
d. Provide the number of client licenses as indicated by the number of machines shown or specified, the addition of a new client shall not require an upgrade to the server license.
e. Historian tags: Provide at least 50 percent of the number of I/O SCADA tags.

2. Provide software and licenses as required to implement the system architecture and functionality as indicated on the Drawings and as described in the System Description article of this Section.
3. License/registered all software in the Owner's name.
4. Turn all software installed on the workstation, over to the Owner with disks, keys, and manuals.
5. The system software specified as part of this Section support PCS system functions including, but not limited to:
   a. Human machine interface (HMI) process graphics development and display.
   b. Real time point database development and display.
   c. Historical database generation, collection, and display.
   d. Alarming subsystem.
   e. Trending and report subsystems.
   f. Drivers and interfaces.
6. PLC programming software is specified in Section 17720 - Control Systems: Programmable Logic Controllers.

B. Operating system software:
1. Contractor shall furnish all workstations and servers with operating system software compatible with the software provided under this Section and shall coordinate with Programmer to confirm software compatibility with PCS software furnished by Programmer:
   a. Client nodes: Microsoft Windows 11 Professional, 64-Bit.
   b. Server nodes: Microsoft Windows Server 2022.
2. Contractor shall provide all operating system software as a clean install. Where workstations have been loaded with OEM versions of software containing trial software or other advertisements, remove the OEM software and reinstall the operating system and all drivers from the original installation disks.
3. Contractor shall provide all workstation PCs with recovery media.

C. Virtualized Operating Systems:
1. When a virtual environment is used for the operating system, it is the responsibility to the Programmer to verify compatibility of the PCS software package with the Virtual Operating System software.
2. Provide host machine hardware to meet the minimum requirements of the Virtualized Operating System(s).
   a. If multiple virtual environments are used on the same host or in a cluster, a hypervisor should be used to manage resource pool and memory allocation such that each virtual operating system has the recommended minimum hardware resources.
3. Synchronize all virtual timekeeping with a single real external time source.

D. Engineering Laptops:
   1. For engineering laptops Programmer shall provide all software for the generation and modification of the graphic screens, PCS system databases, access control files and supervisory control programs.
   2. The development node shall contain all client software and licenses for use as an additional operator display.
   3. License all software in the Owner's name.
   4. Contractor shall provide Engineering Laptop hardware and operating system software.

E. Remote Alarm Notification System:
   1. Integral to each SCADA development and runtime server:
      a. Includes 2-way communication with all notifiers: SMS, Email, Voice, and 10 Smartphone Apps.
      b. Includes Announcer.
      c. Allows for remote acknowledgments, alarm requests, report requests. Includes Basic Escalation / Call Out List.
   2. SMS Hardware Gateway (SHG):
      a. The SHG shall be used for the sole purpose of remote alarm notification sent from the VTScada System to City personnel using SMS Text messages.
      b. Refer to Section 17733 for SHG hardware requirements.

F. Endpoint Protection Software:
   1. General:
      a. Provide for all devices having an operating system.
      b. Management: On-premises.
      c. Devices: Server, Laptop, Desktop, Tablet, Mobile
      d. OS Coverage: Windows, Linux, iOS, Android
   2. Protection Technologies:
      a. Attack Prevention.
      b. Breach Assessment.
      c. Application Control.
      d. Adaptive Protection.
      e. Device Control.
      f. Intrusion Prevention.
      g. Firewall.
      h. Active Directory security.
      i. Attack Analytics.
      j. Threat Intelligence.
      k. Host Integrity Checks.
   3. Provide necessary management console and agents for system monitoring and updating.

G. Network Management Software:
   1. General:
      a. Deployment: On-premises.
      b. Devices: All network connected devices.
   2. Features:
      a. Asset Inventory: Develop an inventory of all network connected devices.

b. Exposure Management: Provides listing of known vulnerabilities for each device.
c. Network Protection: Inspect traffic and define network policies.
d. Threat Detection.
e. Network status and visibility.

H. Miscellaneous software:
1. Provide the following support software for use on the PCS system computers. Install all software on the appropriate system node. Provide all software digital media. License software to the Owner:
a. Provide all nodes with virus protection software.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 INSTALLATION

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

B. VTScada Alarm Notification:
1. Programmer shall configure VTScada and SMS Gateway based on the recommendation from VTScada for the approved SMS Hardware Gateway (SHG).
2. Programmer shall coordinate with the Owner for the approved remote devices for receiving remote alarms via SMS Text messages.
3. Programmer shall coordinate with the Owner for password PIN protection for remote alarm acknowledgement, manual remote alarm/report requests, VTScada SMS Gateway, etc., as required to set-up a completely functional VTScada Alarm Notification System.

C. Programmer shall coordinate with the Owner for re-assigning an approved IP address to the SHGs.

D. Endpoint Protection Software:
1. Configure endpoint protection software to detect and alert on all threats detected but not automatically disable operation or communication.
2. Configure management of all devices from the Endpoint Protection System manager console installed on the Management server.
3. Tune software during testing based on necessary traffic for proper system operation.
4. Update software and protection definitions on a monthly basis.

E. Network Management Software:
1. Configure software to add all network connected devices as assets. Coordinate with Owner on device naming and tagging schemes.
2. Configure system to actively monitor all devices for threats and vulnerabilities. Configure software to automatically update to the latest software definitions.

3. Configure monitoring portal to be available through the Engineering workstations on the process control network for specific users as identified by the Owner, but not through remote access.

3.03 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

B. Owner Training:
   1. As specified in Section 17950 - Commissioning for Instrumentation and Controls.

C. License all software for the duration of the project. Provide licensing renewals extending for a minimum of 1 year after receipt of substantial completion.

3.04 FIELD QUALITY CONTROL

A. Test all software provided as part of this Section as part of the system tests specified in Section 17950 - Commissioning for Instrumentation and Controls.

3.05 ADJUSTING (NOT USED)

3.06 CLEANING (NOT USED)

3.07 DEMONSTRATION AND TRAINING (NOT USED)

3.08 PROTECTION (NOT USED)

3.09 SCHEDULES (NOT USED)

END OF SECTION

SECTION 17903

SCHEDULES: I/O LIST

PART 1 GENERAL

1.01 SUMMARY

A. The I/O list is not a take-off list. Additional information is as indicated on the Drawings and specified in the Contract Documents. Where any discrepancies between this list and the P&ID drawings arise, the P&ID shall govern.

B. Abbreviations used in the I/O list are indicated on the Drawings.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 I/O LIST

A. As specified in Attachment A - I/O list.

END OF SECTION

PLC I/O Listing for PLC-050-220-01

Drawing	Tag	I/O	Location	Description	Service	(E/F)
14N01	REM-050-143-11	DI	PLC-050-220-01	REMOTE	SLUDGE BLOWDOWN PUMP 1	
14N01	REM-050-143-12	DI	PLC-050-220-01	REMOTE	SLUDGE BLOWDOWN PUMP 2	
14N01	RNG-050-143-11	DI	PLC-050-220-01	RUNNING	SLUDGE BLOWDOWN PUMP 1	
14N01	RNG-050-143-12	DI	PLC-050-220-01	RUNNING	SLUDGE BLOWDOWN PUMP 2	
14N01	TSH-050-143-11	DI	PLC-050-220-01	HI TEMP	SLUDGE BLOWDOWN PUMP 1	
14N01	TSH-050-143-12	DI	PLC-050-220-01	HI TEMP	SLUDGE BLOWDOWN PUMP 2	
14N02	REM-050-143-21	DI	PLC-050-220-01	REMOTE	SLUDGE BLOWDOWN PUMP 1	
14N02	REM-050-143-22	DI	PLC-050-220-01	REMOTE	SLUDGE BLOWDOWN PUMP 2	
14N02	RNG-050-143-21	DI	PLC-050-220-01	RUNNING	SLUDGE BLOWDOWN PUMP 1	
14N02	RNG-050-143-22	DI	PLC-050-220-01	RUNNING	SLUDGE BLOWDOWN PUMP 2	
14N02	TSH-050-143-21	DI	PLC-050-220-01	HI TEMP	SLUDGE BLOWDOWN PUMP 1	
14N02	TSH-050-143-22	DI	PLC-050-220-01	HI TEMP	SLUDGE BLOWDOWN PUMP 2	
14N03	REM-050-143-31	DI	PLC-050-220-01	REMOTE	SLUDGE BLOWDOWN PUMP 1	
14N03	REM-050-143-32	DI	PLC-050-220-01	REMOTE	SLUDGE BLOWDOWN PUMP 2	
14N03	RNG-050-143-31	DI	PLC-050-220-01	RUNNING	SLUDGE BLOWDOWN PUMP 1	
14N03	RNG-050-143-32	DI	PLC-050-220-01	RUNNING	SLUDGE BLOWDOWN PUMP 2	
14N03	TSH-050-143-31	DI	PLC-050-220-01	HI TEMP	SLUDGE BLOWDOWN PUMP 1	
14N03	TSH-050-143-32	DI	PLC-050-220-01	HI TEMP	SLUDGE BLOWDOWN PUMP 2	
14N04	REM-050-143-41	DI	PLC-050-220-01	REMOTE	SLUDGE BLOWDOWN PUMP 1	
14N04	REM-050-143-42	DI	PLC-050-220-01	REMOTE	SLUDGE BLOWDOWN PUMP 2	
14N04	RNG-050-143-41	DI	PLC-050-220-01	RUNNING	SLUDGE BLOWDOWN PUMP 1	
14N04	RNG-050-143-42	DI	PLC-050-220-01	RUNNING	SLUDGE BLOWDOWN PUMP 2	
14N04	TSH-050-143-41	DI	PLC-050-220-01	HI TEMP	SLUDGE BLOWDOWN PUMP 1	
14N04	TSH-050-143-42	DI	PLC-050-220-01	HI TEMP	SLUDGE BLOWDOWN PUMP 2	
14N05	JS1-050-220-01	DI	PLC-050-220-01	PWR SUP OK	WEST CLEARWELL CONTROL PANEL	
14N05	JS2-050-220-01	DI	PLC-050-220-01	PWR SUP OK	WEST CLEARWELL CONTROL PANEL	
14N05	JS3-050-220-01	DI	PLC-050-220-01	REDUNDANCY OK	WEST CLEARWELL CONTROL PANEL	

PLC I/O Listing for PLC-050-220-01

Drawing	Tag	I/O	Location	Description	Service	(E/F)
14N05	JS4-050-220-01	DI	PLC-050-220-01	ACB OK	WEST CLEARWELL CONTROL PANEL	
14N05	TSH-050-220-01	DI	PLC-050-220-01	HIGH CABINET TEMP	WEST CLEARWELL CONTROL PANEL	
14N05	XA10-050-220-01	DI	PLC-050-220-01	ECP FAIL	WEST CLEARWELL CONTROL PANEL	
14N05	XA1-050-220-01	DI	PLC-050-220-01	SPD FAIL	WEST CLEARWELL CONTROL PANEL	
14N05	XA2-050-220-01	DI	PLC-050-220-01	SPD FAIL	WEST CLEARWELL CONTROL PANEL	
14N05	XA5-050-220-01	DI	PLC-050-220-01	ES FAIL	WEST CLEARWELL CONTROL PANEL	
14N05	XA6-050-220-01	DI	PLC-050-220-01	ES FAIL	WEST CLEARWELL CONTROL PANEL	
14N05	XA7-050-220-01	DI	PLC-050-220-01	ECP FAIL	WEST CLEARWELL CONTROL PANEL	
14N05	XA8-050-220-01	DI	PLC-050-220-01	ECP FAIL	WEST CLEARWELL CONTROL PANEL	
14N05	XA9-050-220-01	DI	PLC-050-220-01	GW FAIL	WEST CLEARWELL CONTROL PANEL	
14N05	ZS-050-220-01	DI	PLC-050-220-01	INTRUSION	WEST CLEARWELL CONTROL PANEL	
22N01	FSL-050-225-21	DI	PLC-050-220-01	LOW FLOW ALARM	THERMAL FLOW SWITCH	
PLC-050-220-0	Total DI Points = 39					
14N01	RUN-050-143-11	DO	PLC-050-220-01	RUN	SLUDGE BLOWDOWN PUMP 1	
14N01	RUN-050-143-12	DO	PLC-050-220-01	RUN	SLUDGE BLOWDOWN PUMP 2	
14N01	ZCO-050-144-11	DO	PLC-050-220-01	OPEN	CLARIFIER 1 HI PRESS. BACKFLUSH WATER SUPPLY VALVE	
14N02	RUN-050-143-21	DO	PLC-050-220-01	RUN	SLUDGE BLOWDOWN PUMP 1	
14N02	RUN-050-143-22	DO	PLC-050-220-01	RUN	SLUDGE BLOWDOWN PUMP 2	
14N02	ZCO-050-144-21	DO	PLC-050-220-01	OPEN	CLARIFIER 2 HI PRESS. BACKFLUSH WATER SUPPLY VALVE	
14N03	RUN-050-143-31	DO	PLC-050-220-01	RUN	SLUDGE BLOWDOWN PUMP 1	
14N03	RUN-050-143-32	DO	PLC-050-220-01	RUN	SLUDGE BLOWDOWN PUMP 2	
14N03	ZCO-050-144-31	DO	PLC-050-220-01	OPEN	CLARIFIER 3 HI PRESS. BACKFLUSH WATER SUPPLY VALVE	
14N04	RUN-050-143-41	DO	PLC-050-220-01	RUN	SLUDGE BLOWDOWN PUMP 1	
14N04	RUN-050-143-42	DO	PLC-050-220-01	RUN	SLUDGE BLOWDOWN PUMP 2	
14N04	ZCO-050-144-41	DO	PLC-050-220-01	OPEN	CLARIFIER 4 HI PRESS. BACKFLUSH WATER SUPPLY VALVE	
PLC-050-220-0	Total DO Points = 12					

PLC I/O Listing for PLC-050-220-01

Drawing	Tag	I/O	Location	Description	Service	(E/F)
22N01	AE-050-225-21	EtherNet/IP	PLC-050-220-01	CHLORINE	CHLORINE RESIDUAL ANALYZER	
22N01	AE-050-225-21	EtherNet/IP	PLC-050-220-01	COMMUNICATION FAILURE	CHLORINE RESIDUAL ANALYZER	
22N01	AE-050-225-21	EtherNet/IP	PLC-050-220-01	CONFIGURATION ERROR	CHLORINE RESIDUAL ANALYZER	
22N01	AE-050-225-21	EtherNet/IP	PLC-050-220-01	DEVICE FAILURE	CHLORINE RESIDUAL ANALYZER	
22N01	AE-050-225-21	EtherNet/IP	PLC-050-220-01	DISPLAY UNITS	CHLORINE RESIDUAL ANALYZER	
22N01	AE-050-225-21	EtherNet/IP	PLC-050-220-01	SENSOR NOT CONNECTED	CHLORINE RESIDUAL ANALYZER	
22N01	AE-050-225-21	EtherNet/IP	PLC-050-220-01	TRANSMITTER OK	CHLORINE RESIDUAL ANALYZER	
22N01	AE-050-225-21	EtherNet/IP	PLC-050-220-01	WARNING	CHLORINE RESIDUAL ANALYZER	
22N01	AE-050-225-22	EtherNet/IP	PLC-050-220-01	CHLORINE	CHLORINE RESIDUAL ANALYZER	
22N01	AE-050-225-22	EtherNet/IP	PLC-050-220-01	COMMUNICATION FAILURE	CHLORINE RESIDUAL ANALYZER	
22N01	AE-050-225-22	EtherNet/IP	PLC-050-220-01	CONFIGURATION ERROR	CHLORINE RESIDUAL ANALYZER	
22N01	AE-050-225-22	EtherNet/IP	PLC-050-220-01	DEVICE FAILURE	CHLORINE RESIDUAL ANALYZER	
22N01	AE-050-225-22	EtherNet/IP	PLC-050-220-01	DISPLAY UNITS	CHLORINE RESIDUAL ANALYZER	
22N01	AE-050-225-22	EtherNet/IP	PLC-050-220-01	SENSOR NOT CONNECTED	CHLORINE RESIDUAL ANALYZER	
22N01	AE-050-225-22	EtherNet/IP	PLC-050-220-01	TRANSMITTER OK	CHLORINE RESIDUAL ANALYZER	
22N01	AE-050-225-22	EtherNet/IP	PLC-050-220-01	WARNING	CHLORINE RESIDUAL ANALYZER	
22N01	AE-050-225-23	EtherNet/IP	PLC-050-220-01	COMMUNICATION FAILURE	PH	
22N01	AE-050-225-23	EtherNet/IP	PLC-050-220-01	CONFIGURATION ERROR	PH	
22N01	AE-050-225-23	EtherNet/IP	PLC-050-220-01	DEVICE FAILURE	PH	
22N01	AE-050-225-23	EtherNet/IP	PLC-050-220-01	DISPLAY UNITS	PH	
22N01	AE-050-225-23	EtherNet/IP	PLC-050-220-01	pH	PH	
22N01	AE-050-225-23	EtherNet/IP	PLC-050-220-01	SENSOR NOT CONNECTED	PH	
22N01	AE-050-225-23	EtherNet/IP	PLC-050-220-01	TEMPERATURE	PH	
22N01	AE-050-225-23	EtherNet/IP	PLC-050-220-01	TRANSMITTER OK	PH	
22N01	AE-050-225-23	EtherNet/IP	PLC-050-220-01	WARNING	PH	
22N01	AE-050-225-24	EtherNet/IP	PLC-050-220-01	COMMUNICATION FAILURE	PH	
22N01	AE-050-225-24	EtherNet/IP	PLC-050-220-01	CONFIGURATION ERROR	PH	

PLC I/O Listing for PLC-050-220-01

Drawing	Tag	I/O	Location	Description	Service	(E/F)
22N01	AE-050-225-24	EtherNet/IP	PLC-050-220-01	DEVICE FAILURE	PH	
22N01	AE-050-225-24	EtherNet/IP	PLC-050-220-01	DISPLAY UNITS	PH	
22N01	AE-050-225-24	EtherNet/IP	PLC-050-220-01	pH	PH	
22N01	AE-050-225-24	EtherNet/IP	PLC-050-220-01	SENSOR NOT CONNECTED	PH	
22N01	AE-050-225-24	EtherNet/IP	PLC-050-220-01	TEMPERATURE	PH	
22N01	AE-050-225-24	EtherNet/IP	PLC-050-220-01	TRANSMITTER OK	PH	
22N01	AE-050-225-24	EtherNet/IP	PLC-050-220-01	WARNING	PH	
22N01	AE-050-225-25	EtherNet/IP	PLC-050-220-01	BAD LAMP	TURBIDITY	
22N01	AE-050-225-25	EtherNet/IP	PLC-050-220-01	COMMUNICATION FAILURE	TURBIDITY	
22N01	AE-050-225-25	EtherNet/IP	PLC-050-220-01	CONFIGURATION ERROR	TURBIDITY	
22N01	AE-050-225-25	EtherNet/IP	PLC-050-220-01	DEVICE FAILURE	TURBIDITY	
22N01	AE-050-225-25	EtherNet/IP	PLC-050-220-01	DISPLAY UNITS	TURBIDITY	
22N01	AE-050-225-25	EtherNet/IP	PLC-050-220-01	LOW SIGNAL	TURBIDITY	
22N01	AE-050-225-25	EtherNet/IP	PLC-050-220-01	OUTPUT MODE	TURBIDITY	
22N01	AE-050-225-25	EtherNet/IP	PLC-050-220-01	SENSOR NOT CONNECTED	TURBIDITY	
22N01	AE-050-225-25	EtherNet/IP	PLC-050-220-01	TRANSMITTER OK	TURBIDITY	
22N01	AE-050-225-25	EtherNet/IP	PLC-050-220-01	TURBIDITY	TURBIDITY	
22N01	AE-050-225-25	EtherNet/IP	PLC-050-220-01	VOLTAGE	TURBIDITY	
22N01	AE-050-225-25	EtherNet/IP	PLC-050-220-01	WARNING	TURBIDITY	
22N01	AE-050-225-26	EtherNet/IP	PLC-050-220-01	BAD LAMP	TURBIDITY	
22N01	AE-050-225-26	EtherNet/IP	PLC-050-220-01	COMMUNICATION FAILURE	TURBIDITY	
22N01	AE-050-225-26	EtherNet/IP	PLC-050-220-01	CONFIGURATION ERROR	TURBIDITY	
22N01	AE-050-225-26	EtherNet/IP	PLC-050-220-01	DEVICE FAILURE	TURBIDITY	
22N01	AE-050-225-26	EtherNet/IP	PLC-050-220-01	DISPLAY UNITS	TURBIDITY	
22N01	AE-050-225-26	EtherNet/IP	PLC-050-220-01	LOW SIGNAL	TURBIDITY	
22N01	AE-050-225-26	EtherNet/IP	PLC-050-220-01	OUTPUT MODE	TURBIDITY	
22N01	AE-050-225-26	EtherNet/IP	PLC-050-220-01	SENSOR NOT CONNECTED	TURBIDITY	

PLC I/O Listing for PLC-050-220-01

Drawing	Tag	I/O	Location	Description	Service	(E/F)
22N01	AE-050-225-26	EtherNet/IP	PLC-050-220-01	TRANSMITTER OK	TURBIDITY	
22N01	AE-050-225-26	EtherNet/IP	PLC-050-220-01	TURBIDITY	TURBIDITY	
22N01	AE-050-225-26	EtherNet/IP	PLC-050-220-01	VOLTAGE	TURBIDITY	
22N01	AE-050-225-26	EtherNet/IP	PLC-050-220-01	WARNING	TURBIDITY	
PLC-050-220-0	Total EtherNet/IP Points = 58					

PLC I/O Listing for PLC-050-500-01

Drawing	Tag	I/O	Location	Description	Service	(E/F)
14N02	L-050-401-01	AI	PLC-050-500-01	LEVEL FUEL	DIESEL FUEL TANK LEVEL TRANS	
14N02	P-050-401-01	AI	PLC-050-500-01	PRESS. OIL (PSI)	STANDBY GENERATOR	
51N01	LI-050-512-11	AI	PLC-050-500-01	LEVEL	ULTRASONIC	
51N01	LI-050-512-31	AI	PLC-050-500-01	LEVEL	RADAR FMCW	
51N02	SI-050-513-11	AI	PLC-050-500-01	SPDF	FERRIC CHLORIDE METERING PUMP 1	
51N02	SI-050-513-21	AI	PLC-050-500-01	SPDF	FERRIC CHLORIDE METERING PUMP 2	
51N03	SI-050-513-31	AI	PLC-050-500-01	SPDF	FERRIC CHLORIDE METERING PUMP 3	
51N03	SI-050-513-41	AI	PLC-050-500-01	SPDF	FERRIC CHLORIDE METERING PUMP 4	
51N03	SI-050-513-51	AI	PLC-050-500-01	SPDF	FERRIC CHLORIDE METERING PUMP 5	
52N01	SI-050-522-11	AI	PLC-050-500-01	SPDF	POLYMER METERING PUMP 1	
52N01	SI-050-522-21	AI	PLC-050-500-01	SPDF	POLYMER METERING PUMP 2	
52N02	SI-050-522-31	AI	PLC-050-500-01	SPDF	POLYMER METERING PUMP 3	
52N02	SI-050-522-41	AI	PLC-050-500-01	SPDF	POLYMER METERING PUMP 4	
53N01	LI-050-532-11	AI	PLC-050-500-01	LEVEL	RADAR FMCW	
53N01	SI-050-533-11	AI	PLC-050-500-01	SPDF	SODIUM HYPOCHLORITE METERING PUMP 1	
53N01	SI-050-533-21	AI	PLC-050-500-01	SPDF	SODIUM HYPOCHLORITE METERING PUMP 2	
53N02	SI-050-533-31	AI	PLC-050-500-01	SPDF	SODIUM HYPOCHLORITE METERING PUMP 3	
53N02	SI-050-533-41	AI	PLC-050-500-01	SPDF	SODIUM HYPOCHLORITE METERING PUMP 4	
53N02	SI-050-533-51	AI	PLC-050-500-01	SPDF	SODIUM HYPOCHLORITE METERING PUMP 5	
53N03	SI-050-533-61	AI	PLC-050-500-01	SPDF	SODIUM HYPOCHLORITE METERING PUMP 6	
53N03	SI-050-533-71	AI	PLC-050-500-01	SPDF	SODIUM HYPOCHLORITE METERING PUMP 7	
53N03	SI-050-533-81	AI	PLC-050-500-01	SPDF	SODIUM HYPOCHLORITE METERING PUMP 8	
54N01	LI-050-542-11	AI	PLC-050-500-01	LEVEL	RADAR FMCW	
54N01	LI-050-542-31	AI	PLC-050-500-01	LEVEL	RADAR FMCW	
54N02	SI-050-543-11	AI	PLC-050-500-01	SPDF	PHOSPHATE METERING PUMP 1	
54N02	SI-050-543-21	AI	PLC-050-500-01	SPDF	PHOSPHATE METERING PUMP 2	
54N03	SI-050-543-31	AI	PLC-050-500-01	SPDF	PHOSPHATE METERING PUMP 3	

PLC I/O Listing for PLC-050-500-01

Drawing	Tag	I/O	Location	Description	Service	(E/F)
54N03	SI-050-543-41	AI	PLC-050-500-01	SPDF	PHOSPHATE METERING PUMP 4	
54N03	SI-050-543-51	AI	PLC-050-500-01	SPDF	PHOSPHATE METERING PUMP 5	
56N01	A-050-563-01	AI	PLC-050-500-01	NH3	AMMONIA GAS LEAK SENSOR/TRANSMITTER	
56N01	FI-050-563-11	AI	PLC-050-500-01	FLOW STATUS	AMMONIA MASS FLOW CONTROLLER 1	
56N01	FI-050-563-21	AI	PLC-050-500-01	FLOW STATUS	AMMONIA MASS FLOW CONTROLLER 2	
PLC-050-500-0	Total AI Points = 32					

PLC I/O Listing for PLC-050-500-01

Drawing	Tag	I/O	Location	Description	Service	(E/F)
14N01	SC-050-142-11	AO	PLC-050-500-01	SPEED	CLARIFIER 1 TURBINE	
51N02	SC-050-513-11	AO	PLC-050-500-01	SPDC	FERRIC CHLORIDE METERING PUMP 1	
51N02	SC-050-513-21	AO	PLC-050-500-01	SPDC	FERRIC CHLORIDE METERING PUMP 2	
51N03	SC-050-513-31	AO	PLC-050-500-01	SPDC	FERRIC CHLORIDE METERING PUMP 3	
51N03	SC-050-513-41	AO	PLC-050-500-01	SPDC	FERRIC CHLORIDE METERING PUMP 4	
51N03	SC-050-513-51	AO	PLC-050-500-01	SPDC	FERRIC CHLORIDE METERING PUMP 5	
52N01	SC-050-522-11	AO	PLC-050-500-01	SPDC	POLYMER METERING PUMP 1	
52N01	SC-050-522-21	AO	PLC-050-500-01	SPDC	POLYMER METERING PUMP 2	
52N02	SC-050-522-31	AO	PLC-050-500-01	SPDC	POLYMER METERING PUMP 3	
52N02	SC-050-522-41	AO	PLC-050-500-01	SPDC	POLYMER METERING PUMP 4	
53N01	SC-050-533-11	AO	PLC-050-500-01	SPDC	SODIUM HYPOCHLORITE METERING PUMP 1	
53N01	SC-050-533-21	AO	PLC-050-500-01	SPDC	SODIUM HYPOCHLORITE METERING PUMP 2	
53N02	SC-050-533-31	AO	PLC-050-500-01	SPDC	SODIUM HYPOCHLORITE METERING PUMP 3	
53N02	SC-050-533-41	AO	PLC-050-500-01	SPDC	SODIUM HYPOCHLORITE METERING PUMP 4	
53N02	SC-050-533-51	AO	PLC-050-500-01	SPDC	SODIUM HYPOCHLORITE METERING PUMP 5	
53N03	SC-050-533-61	AO	PLC-050-500-01	SPDC	SODIUM HYPOCHLORITE METERING PUMP 6	
53N03	SC-050-533-71	AO	PLC-050-500-01	SPDC	SODIUM HYPOCHLORITE METERING PUMP 7	
53N03	SC-050-533-81	AO	PLC-050-500-01	SPDC	SODIUM HYPOCHLORITE METERING PUMP 8	
54N02	SC-050-543-11	AO	PLC-050-500-01	SPDC	PHOSPHATE METERING PUMP 1	
54N02	SC-050-543-21	AO	PLC-050-500-01	SPDC	PHOSPHATE METERING PUMP 2	
54N03	SC-050-543-31	AO	PLC-050-500-01	SPDC	PHOSPHATE METERING PUMP 3	
54N03	SC-050-543-41	AO	PLC-050-500-01	SPDC	PHOSPHATE METERING PUMP 4	
54N03	SC-050-543-51	AO	PLC-050-500-01	SPDC	PHOSPHATE METERING PUMP 5	
56N01	FIC-050-563-11	AO	PLC-050-500-01	FLOW CONTROL	AMMONIA MASS FLOW CONTROLLER 1	
56N01	FIC-050-563-21	AO	PLC-050-500-01	FLOW CONTROL	AMMONIA MASS FLOW CONTROLLER 2	
PLC-050-500-0	Total AO Points = 25					

PLC I/O Listing for PLC-050-500-01

Drawing	Tag	I/O	Location	Description	Service	(E/F)
14N01	LSH-050-401-01	DI	PLC-050-500-01	LEVEL ALARM HIGH	CHEM ROOM DIESEL PIT	
14N01	RNG-050-141-11	DI	PLC-050-500-01	RUNNING	CLARIFIER 1 RAKE	
14N01	RNG-050-142-11	DI	PLC-050-500-01	RUNNING	CLARIFIER 1 TURBINE	
14N01	RNG-050-401-01	DI	PLC-050-500-01	RUNNING	STANDBY GENERATOR	
14N02	PAL-050-401-01	DI	PLC-050-500-01	PRESS. ALARM LOW	STANDBY GENERATOR	
14N02	RNG-050-141-21	DI	PLC-050-500-01	RUNNING	CLARIFIER 2 RAKE	
14N02	RNG-050-142-21	DI	PLC-050-500-01	RUNNING	CLARIFIER 2 TURBINE	
14N03	RNG1-050-141-31	DI	PLC-050-500-01	RUNNING	CLARIFIER 3 RAKE	
14N03	RNG1-050-142-31	DI	PLC-050-500-01	RUNNING	CLARIFIER 3 TURBINE	
14N04	RNG-050-141-41	DI	PLC-050-500-01	RUNNING	CLARIFIER 4 RAKE	
14N04	RNG-050-142-41	DI	PLC-050-500-01	RUNNING	CLARIFIER 4 TURBINE	
51N01	LAH-050-514-01	DI	PLC-050-500-01	LEAK ALARM	LEVEL SWITCH HIGH	
51N01	LSHH-050-512-32	DI	PLC-050-500-01	OVERFLOW ALARM SWITCH	CAPACITANCE PROX	
51N02	HSA-050-513-11	DI	PLC-050-500-01	REM	FERRIC CHLORIDE METERING PUMP 1	
51N02	HSA-050-513-21	DI	PLC-050-500-01	REM	FERRIC CHLORIDE METERING PUMP 2	
51N02	Y2-050-513-11	DI	PLC-050-500-01	FAIL	FERRIC CHLORIDE METERING PUMP 1	
51N02	Y2-050-513-21	DI	PLC-050-500-01	FAIL	FERRIC CHLORIDE METERING PUMP 2	
51N03	HSA-050-513-31	DI	PLC-050-500-01	REM	FERRIC CHLORIDE METERING PUMP 3	
51N03	HSA-050-513-41	DI	PLC-050-500-01	REM	FERRIC CHLORIDE METERING PUMP 4	
51N03	HSA-050-513-51	DI	PLC-050-500-01	REM	FERRIC CHLORIDE METERING PUMP 5	
51N03	Y2-050-513-31	DI	PLC-050-500-01	FAIL	FERRIC CHLORIDE METERING PUMP 3	
51N03	Y2-050-513-41	DI	PLC-050-500-01	FAIL	FERRIC CHLORIDE METERING PUMP 4	
51N03	Y2-050-513-51	DI	PLC-050-500-01	FAIL	FERRIC CHLORIDE METERING PUMP 5	
52N01	HSA-050-522-11	DI	PLC-050-500-01	REM	POLYMER METERING PUMP 1	
52N01	HSA-050-522-21	DI	PLC-050-500-01	REM	POLYMER METERING PUMP 2	
52N01	Y2-050-522-11	DI	PLC-050-500-01	FAIL	POLYMER METERING PUMP 1	
52N01	Y2-050-522-21	DI	PLC-050-500-01	FAIL	POLYMER METERING PUMP 2	

Drawing	Tag	I/O	Location	Description	Service	(E/F)
52N02	HSA-050-522-31	DI	PLC-050-500-01	REM	POLYMER METERING PUMP 3	
52N02	HSA-050-522-41	DI	PLC-050-500-01	REM	POLYMER METERING PUMP 4	
52N02	Y2-050-522-31	DI	PLC-050-500-01	FAIL	POLYMER METERING PUMP 3	
52N02	Y2-050-522-41	DI	PLC-050-500-01	FAIL	POLYMER METERING PUMP 4	
53N01	HSA-050-533-11	DI	PLC-050-500-01	REM	SODIUM HYPOCHLORITE METERING PUMP 1	
53N01	HSA-050-533-21	DI	PLC-050-500-01	REM	SODIUM HYPOCHLORITE METERING PUMP 2	
53N01	LAH-050-534-51	DI	PLC-050-500-01	LEAK ALARM	SODIUM HYPO CONTAINMENT SUMP HI LEVEL SWITCH	
53N01	Y2-050-533-11	DI	PLC-050-500-01	FAIL	SODIUM HYPOCHLORITE METERING PUMP 1	
53N01	Y2-050-533-21	DI	PLC-050-500-01	FAIL	SODIUM HYPOCHLORITE METERING PUMP 2	
53N02	HSA-050-533-31	DI	PLC-050-500-01	REM	SODIUM HYPOCHLORITE METERING PUMP 3	
53N02	HSA-050-533-41	DI	PLC-050-500-01	REM	SODIUM HYPOCHLORITE METERING PUMP 4	
53N02	HSA-050-533-51	DI	PLC-050-500-01	REM	SODIUM HYPOCHLORITE METERING PUMP 5	
53N02	Y2-050-533-31	DI	PLC-050-500-01	FAIL	SODIUM HYPOCHLORITE METERING PUMP 3	
53N02	Y2-050-533-41	DI	PLC-050-500-01	FAIL	SODIUM HYPOCHLORITE METERING PUMP 4	
53N02	Y2-050-533-51	DI	PLC-050-500-01	FAIL	SODIUM HYPOCHLORITE METERING PUMP 5	
53N03	HSA-050-533-61	DI	PLC-050-500-01	REM	SODIUM HYPOCHLORITE METERING PUMP 6	
53N03	HSA-050-533-71	DI	PLC-050-500-01	REM	SODIUM HYPOCHLORITE METERING PUMP 7	
53N03	HSA-050-533-81	DI	PLC-050-500-01	REM	SODIUM HYPOCHLORITE METERING PUMP 8	
53N03	Y2-050-533-61	DI	PLC-050-500-01	FAIL	SODIUM HYPOCHLORITE METERING PUMP 6	
53N03	Y2-050-533-71	DI	PLC-050-500-01	FAIL	SODIUM HYPOCHLORITE METERING PUMP 7	
53N03	Y2-050-533-81	DI	PLC-050-500-01	FAIL	SODIUM HYPOCHLORITE METERING PUMP 8	
54N01	LSHH-050-542-32	DI	PLC-050-500-01	OVERFLOW ALARM SWITCH	CAPACITANCE PROX	
54N02	HSA-050-543-11	DI	PLC-050-500-01	REM	PHOSPHATE METERING PUMP 1	
54N02	HSA-050-543-21	DI	PLC-050-500-01	REM	PHOSPHATE METERING PUMP 2	
54N02	Y2-050-543-11	DI	PLC-050-500-01	FAIL	PHOSPHATE METERING PUMP 1	
54N02	Y2-050-543-21	DI	PLC-050-500-01	FAIL	PHOSPHATE METERING PUMP 2	
54N03	HSA-050-543-31	DI	PLC-050-500-01	REM	PHOSPHATE METERING PUMP 3	

PLC I/O Listing for PLC-050-500-01

Drawing	Tag	I/O	Location	Description	Service	(E/F)
54N03	HSA-050-543-41	DI	PLC-050-500-01	REM	PHOSPHATE METERING PUMP 4	
54N03	HSA-050-543-51	DI	PLC-050-500-01	REM	PHOSPHATE METERING PUMP 5	
54N03	Y2-050-543-31	DI	PLC-050-500-01	FAIL	PHOSPHATE METERING PUMP 3	
54N03	Y2-050-543-41	DI	PLC-050-500-01	FAIL	PHOSPHATE METERING PUMP 4	
54N03	Y2-050-543-51	DI	PLC-050-500-01	FAIL	PHOSPHATE METERING PUMP 5	
57N03	JS1-050-500-01	DI	PLC-050-500-01	PWR SUP OK	CHEMICAL STORAGE CONTROL PANEL	
57N03	JS2-050-500-01	DI	PLC-050-500-01	PWR SUP OK	CHEMICAL STORAGE CONTROL PANEL	
57N03	JS3-050-500-01	DI	PLC-050-500-01	REDUNDANCY OK	CHEMICAL STORAGE CONTROL PANEL	
57N03	JS4-050-500-01	DI	PLC-050-500-01	ACB OK	CHEMICAL STORAGE CONTROL PANEL	
57N03	TSH-050-500-01	DI	PLC-050-500-01	HIGH CABINET TEMP	CHEMICAL STORAGE CONTROL PANEL	
57N03	XA10-050-500-01	DI	PLC-050-500-01	ECP FAIL	CHEMICAL STORAGE CONTROL PANEL	
57N03	XA1-050-500-01	DI	PLC-050-500-01	SPD FAIL	CHEMICAL STORAGE CONTROL PANEL	
57N03	XA2-050-500-01	DI	PLC-050-500-01	SPD FAIL	CHEMICAL STORAGE CONTROL PANEL	
57N03	XA5-050-500-01	DI	PLC-050-500-01	ES FAIL	CHEMICAL STORAGE CONTROL PANEL	
57N03	XA6-050-500-01	DI	PLC-050-500-01	ES FAIL	CHEMICAL STORAGE CONTROL PANEL	
57N03	XA7-050-500-01	DI	PLC-050-500-01	ECP FAIL	CHEMICAL STORAGE CONTROL PANEL	
57N03	XA8-050-500-01	DI	PLC-050-500-01	ECP FAIL	CHEMICAL STORAGE CONTROL PANEL	
57N03	XA9-050-500-01	DI	PLC-050-500-01	GW FAIL	CHEMICAL STORAGE CONTROL PANEL	
57N03	ZS-050-500-01	DI	PLC-050-500-01	INTRUSION	CHEMICAL STORAGE CONTROL PANEL	
PLC-050-500-0	Total DI Points = 73					

PLC I/O Listing for PLC-050-500-01

Drawing	Tag	I/O	Location	Description	Service	(E/F)
51N02	HST-050-513-11	DO	PLC-050-500-01	STSP	FERRIC CHLORIDE METERING PUMP 1	
51N02	HST-050-513-21	DO	PLC-050-500-01	STSP	FERRIC CHLORIDE METERING PUMP 2	
51N03	HST-050-513-31	DO	PLC-050-500-01	STSP	FERRIC CHLORIDE METERING PUMP 3	
51N03	HST-050-513-41	DO	PLC-050-500-01	STSP	FERRIC CHLORIDE METERING PUMP 4	
51N03	HST-050-513-51	DO	PLC-050-500-01	STSP	FERRIC CHLORIDE METERING PUMP 5	
52N01	HST-050-522-11	DO	PLC-050-500-01	STSP	POLYMER METERING PUMP 1	
52N01	HST-050-522-21	DO	PLC-050-500-01	STSP	POLYMER METERING PUMP 2	
52N02	HST-050-522-31	DO	PLC-050-500-01	STSP	POLYMER METERING PUMP 3	
52N02	HST-050-522-41	DO	PLC-050-500-01	STSP	POLYMER METERING PUMP 4	
53N01	HST-050-533-11	DO	PLC-050-500-01	STSP	SODIUM HYPOCHLORITE METERING PUMP 1	
53N01	HST-050-533-21	DO	PLC-050-500-01	STSP	SODIUM HYPOCHLORITE METERING PUMP 2	
53N02	HST-050-533-31	DO	PLC-050-500-01	STSP	SODIUM HYPOCHLORITE METERING PUMP 3	
53N02	HST-050-533-41	DO	PLC-050-500-01	STSP	SODIUM HYPOCHLORITE METERING PUMP 4	
53N02	HST-050-533-51	DO	PLC-050-500-01	STSP	SODIUM HYPOCHLORITE METERING PUMP 5	
53N03	HST-050-533-61	DO	PLC-050-500-01	STSP	SODIUM HYPOCHLORITE METERING PUMP 6	
53N03	HST-050-533-71	DO	PLC-050-500-01	STSP	SODIUM HYPOCHLORITE METERING PUMP 7	
53N03	HST-050-533-81	DO	PLC-050-500-01	STSP	SODIUM HYPOCHLORITE METERING PUMP 8	
54N02	HST-050-543-11	DO	PLC-050-500-01	STSP	PHOSPHATE METERING PUMP 1	
54N02	HST-050-543-21	DO	PLC-050-500-01	STSP	PHOSPHATE METERING PUMP 2	
54N03	HST-050-543-31	DO	PLC-050-500-01	STSP	PHOSPHATE METERING PUMP 3	
54N03	HST-050-543-41	DO	PLC-050-500-01	STSP	PHOSPHATE METERING PUMP 4	
54N03	HST-050-543-51	DO	PLC-050-500-01	STSP	PHOSPHATE METERING PUMP 5	
PLC-050-500-0	Total DO Points = 22					

PLC I/O Listing for PLC-050-500-1

Drawing	Tag	I/O	Location	Description	Service	(E/F)
51N01	HSB-050-512-21	DI	PLC-050-500-1	STOP FERRIC TRANSFER	FERRIC CHLORIDE TRANSFER PUMP 1	
51N01	HSC-050-512-21	DI	PLC-050-500-1	START FERRIC TRANSFER	FERRIC CHLORIDE TRANSFER PUMP 1	
51N01	HSU-050-500-02	DI	PLC-050-500-1	EQUIPMENT STOP	CHEMICAL TRANSFER SYSTEM LCP	
51N01	OL-050-512-21	DI	PLC-050-500-1	MOTOR OVERLOAD	FERRIC CHLORIDE TRANSFER PUMP 1	
51N01	OL-050-512-22	DI	PLC-050-500-1	MOTOR OVERLOAD	FERRIC CHLORIDE TRANSFER PUMP 2	
51N01	RNG-050-512-21	DI	PLC-050-500-1	RUNNING	FERRIC CHLORIDE TRANSFER PUMP 1	
51N01	RNG-050-512-22	DI	PLC-050-500-1	RUNNING	FERRIC CHLORIDE TRANSFER PUMP 2	
51N01	RST-050-500-02	DI	PLC-050-500-1	RESET/SILENCE	CHEMICAL TRANSFER SYSTEM LCP	
51N01	ZSC-050-512-15	DI	PLC-050-500-1	CLOSED	ELECTRIC DISCRETE VALVE OPEN/CLOSE	
51N01	ZSO-050-512-15	DI	PLC-050-500-1	OPENED	ELECTRIC DISCRETE VALVE OPEN/CLOSE	
54N01	HSB-050-542-21	DI	PLC-050-500-1	STOP PHOSPHATE TRANSFER	PHOSPHATE TRANSFER PUMP 1	
54N01	HSC-050-542-21	DI	PLC-050-500-1	START PHOSPHATE TRANSFER	PHOSPHATE TRANSFER PUMP 1	
54N01	OL-050-542-21	DI	PLC-050-500-1	MOTOR OVERLOAD	PHOSPHATE TRANSFER PUMP 1	
54N01	OL-050-542-22	DI	PLC-050-500-1	MOTOR OVERLOAD	PHOSPHATE TRANSFER PUMP 2	
54N01	RNG-050-542-21	DI	PLC-050-500-1	RUNNING	PHOSPHATE TRANSFER PUMP 1	
54N01	RNG-050-542-22	DI	PLC-050-500-1	RUNNING	PHOSPHATE TRANSFER PUMP 2	
54N01	ZSC-050-542-15	DI	PLC-050-500-1	CLOSED	ELECTRIC DISCRETE VALVE OPEN/CLOSE	
54N01	ZSO-050-542-15	DI	PLC-050-500-1	OPENED	ELECTRIC DISCRETE VALVE OPEN/CLOSE	
PLC-050-500-1	Total DI Points = 18					

PLC I/O Listing for PLC-050-500-1

Drawing	Tag	I/O	Location	Description	Service	(E/F)
51N01	RNG-050-512-21	DO	PLC-050-500-1	FERRIC TRANSFER RUNNING	FERRIC CHLORIDE TRANSFER PUMP 1	
51N01	RUN-050-512-21	DO	PLC-050-500-1	RUN	FERRIC CHLORIDE TRANSFER PUMP 1	
51N01	RUN-050-512-22	DO	PLC-050-500-1	RUN	FERRIC CHLORIDE TRANSFER PUMP 2	
51N01	YL-050-500-02	DO	PLC-050-500-1	COMMON ALARM	CHEMICAL TRANSFER SYSTEM LCP	
51N01	ZCO-050-512-15	DO	PLC-050-500-1	OPEN	ELECTRIC DISCRETE VALVE OPEN/CLOSE	
54N01	RNG-050-542-21	DO	PLC-050-500-1	PHOSPHATE TRANSFER RUNNING	PHOSPHATE TRANSFER PUMP 1	
54N01	RUN-050-542-21	DO	PLC-050-500-1	RUN	PHOSPHATE TRANSFER PUMP 1	
54N01	RUN-050-542-22	DO	PLC-050-500-1	RUN	PHOSPHATE TRANSFER PUMP 2	
54N01	ZCO-050-542-15	DO	PLC-050-500-1	OPEN	ELECTRIC DISCRETE VALVE OPEN/CLOSE	
PLC-050-500-1	Total DO Points = 9					

PLC I/O Listing for PLC-050-550-01

Drawing	Tag	I/O	Location	Description	Service	(E/F)
55N02	A-050-555-01	AI	PLC-050-550-01	pH	FILTER INFLUENT pH (NORTH TREATMENT BASIN)	E
55N02	A-050-555-02	AI	PLC-050-550-01	pH	FILTER INFLUENT pH (SOUTH TREATMENT BASIN)	E
PLC-050-550-0	Total AI Points = 2					
55N01	SC-050-553-11	AO	PLC-050-550-01	RATE SP	CARBONATOR 1	
55N01	SC-050-553-21	AO	PLC-050-550-01	RATE SP	CARBONATOR 2	
55N01	SC-050-553-31	AO	PLC-050-550-01	RATE SP	CARBONATOR 3	
55N02	SC-050-403-11	AO	PLC-050-550-01	SPEED SP	LIME SLAKER 1	
55N02	SC-050-403-21	AO	PLC-050-550-01	SPEED SP	LIME SLAKER 2	
55N02	SC-050-403-31	AO	PLC-050-550-01	SPEED SP	LIME SLAKER 3	
55N02	SC-050-403-41	AO	PLC-050-550-01	SPEED SP	LIME SLAKER 4	
PLC-050-550-0	Total AO Points = 7					

PLC I/O Listing for PLC-050-550-01

Drawing	Tag	I/O	Location	Description	Service	(E/F)
55N01	PAH-050-552-01	DI	PLC-050-550-01	PRESS HIGH		
55N01	PAL-050-552-01	DI	PLC-050-550-01	PRESS LOW		
55N01	TAH-050-552-01	DI	PLC-050-550-01	TEMP HIGH		
55N02	LAH-050-405-01	DI	PLC-050-550-01	OVERFLOW ALARM	LIME POT OVERFLOW 1	
55N02	LAH-050-405-02	DI	PLC-050-550-01	OVERFLOW ALARM	LIME POT OVERFLOW 2	
55N02	REM-050-553-51	DI	PLC-050-550-01	REMOTE	CO2 EJECTOR WATER PUMP 1	
55N02	REM-050-553-61	DI	PLC-050-550-01	REMOTE	CO2 EJECTOR WATER PUMP 2	
55N02	RNG-050-553-51	DI	PLC-050-550-01	RUNNING	CO2 EJECTOR WATER PUMP 1	
55N02	RNG-050-553-61	DI	PLC-050-550-01	RUNNING	CO2 EJECTOR WATER PUMP 2	
55N02	TSH-050-553-51	DI	PLC-050-550-01	HI TEMP	CO2 EJECTOR WATER PUMP 1	
55N02	TSH-050-553-61	DI	PLC-050-550-01	HI TEMP	CO2 EJECTOR WATER PUMP 2	
55N02	ZIC-050-403-11	DI	PLC-050-550-01	LOCKOUT	SLAKER 1 LOCKOUT	
55N02	ZIC-050-403-21	DI	PLC-050-550-01	LOCKOUT	SLAKER 2 LOCKOUT	
55N02	ZIC-050-403-31	DI	PLC-050-550-01	LOCKOUT	SLAKER 3 LOCKOUT	
55N02	ZIC-050-403-41	DI	PLC-050-550-01	LOCKOUT	SLAKER 4 LOCKOUT	
55N03	JS1-050-550-01	DI	PLC-050-550-01	PWR SUP OK	CARBON DIOXIDE SYSTEM CONTROL PANEL	
55N03	JS2-050-550-01	DI	PLC-050-550-01	PWR SUP OK	CARBON DIOXIDE SYSTEM CONTROL PANEL	
55N03	JS3-050-550-01	DI	PLC-050-550-01	REDUNDANCY OK	CARBON DIOXIDE SYSTEM CONTROL PANEL	
55N03	JS4-050-550-01	DI	PLC-050-550-01	ACB OK	CARBON DIOXIDE SYSTEM CONTROL PANEL	
55N03	TSH-050-550-01	DI	PLC-050-550-01	HIGH CABINET TEMP	CARBON DIOXIDE SYSTEM CONTROL PANEL	
55N03	XA10-050-550-01	DI	PLC-050-550-01	ECP FAIL	CARBON DIOXIDE SYSTEM CONTROL PANEL	
55N03	XA1-050-550-01	DI	PLC-050-550-01	SPD FAIL	CARBON DIOXIDE SYSTEM CONTROL PANEL	
55N03	XA2-050-550-01	DI	PLC-050-550-01	SPD FAIL	CARBON DIOXIDE SYSTEM CONTROL PANEL	
55N03	XA5-050-550-01	DI	PLC-050-550-01	ES FAIL	CARBON DIOXIDE SYSTEM CONTROL PANEL	
55N03	XA6-050-550-01	DI	PLC-050-550-01	ES FAIL	CARBON DIOXIDE SYSTEM CONTROL PANEL	
55N03	XA7-050-550-01	DI	PLC-050-550-01	ECP FAIL	CARBON DIOXIDE SYSTEM CONTROL PANEL	
55N03	XA8-050-550-01	DI	PLC-050-550-01	ECP FAIL	CARBON DIOXIDE SYSTEM CONTROL PANEL	

PLC I/O Listing for PLC-050-550-01

Drawing	Tag	I/O	Location	Description	Service	(E/F)
55N03	XA9-050-550-01	DI	PLC-050-550-01	GW FAIL	CARBON DIOXIDE SYSTEM CONTROL PANEL	
55N03	ZS-050-550-01	DI	PLC-050-550-01	INTRUSION	CARBON DIOXIDE SYSTEM CONTROL PANEL	
PLC-050-550-0	Total DI Points = 29					
55N02	RUN-050-553-51	DO	PLC-050-550-01	RUN	CO2 EJECTOR WATER PUMP 1	
55N02	RUN-050-553-61	DO	PLC-050-550-01	RUN	CO2 EJECTOR WATER PUMP 2	
PLC-050-550-0	Total DO Points = 2					

PLC I/O Listing for RIO-050-145-11

Drawing	Tag	I/O	Location	Description	Service	(E/F)
14N01	FI-050-145-11	AI	RIO-050-145-11	FLOW	INSERTION MAGNETIC METER	
14N02	F-050-145-21	AI	RIO-050-145-11	FLOW	INSERTION MAG METER	
RIO-050-145-1	Total AI Points = 2					
14N01	FAIL-050-142-11	DI	RIO-050-145-11	FAILED	CLARIFIER 1 TURBINE	
14N01	REM-050-141-11	DI	RIO-050-145-11	REMOTE	CLARIFIER 1 RAKE	
14N01	TSH-050-141-11	DI	RIO-050-145-11	HI TEMP RAKE	CLARIFIER 1 RAKE	
14N01	TSH-050-142-11	DI	RIO-050-145-11	HI TEMP TURBINE	CLARIFIER 1 TURBINE	
14N01	XSH-050-141-11	DI	RIO-050-145-11	TORQUE HI	CLARIFIER 1 RAKE	
14N01	XSHH-050-141-11	DI	RIO-050-145-11	TORQUE HI HI	CLARIFIER 1 RAKE	
14N02	FAIL-050-142-21	DI	RIO-050-145-11	FAILED	CLARIFIER 2 TURBINE	
14N02	REM-050-141-21	DI	RIO-050-145-11	REMOTE	CLARIFIER 2 RAKE	
14N02	TSH-050-141-21	DI	RIO-050-145-11	HI TEMP RAKE	CLARIFIER 2 RAKE	
14N02	TSH-050-142-21	DI	RIO-050-145-11	HI TEMP TURBINE	CLARIFIER 2 TURBINE	
14N02	XSH-050-141-21	DI	RIO-050-145-11	TORQUE HI HI	CLARIFIER 2 RAKE	
14N02	XSHH-050-141-21	DI	RIO-050-145-11	TORQUE HI HI	CLARIFIER 2 RAKE	
14N05	TSH-050-145-11	DI	RIO-050-145-11	HIGH CABINET TEMP	CLARIFIERS 1&2 RIO PANEL	
14N05	ZS-050-145-11	DI	RIO-050-145-11	INTRUSION	CLARIFIERS 1&2 RIO PANEL	
RIO-050-145-1	Total DI Points = 14					

PLC I/O Listing for RIO-050-145-31

Drawing	Tag	I/O	Location	Description	Service	(E/F)
14N03	F-050-145-31	AI	RIO-050-145-31	FLOW	INSERTION MAG METER	
14N04	F-050-145-41	AI	RIO-050-145-31	FLOW	INSERTION MAG METER	
RIO-050-145-3	Total AI Points = 2					
14N03	FAIL-050-142-31	DI	RIO-050-145-31	FAILED	CLARIFIER 3 TURBINE	
14N03	REM1-050-141-31	DI	RIO-050-145-31	REMOTE	CLARIFIER 3 RAKE	
14N03	TSH1-050-141-31	DI	RIO-050-145-31	HI TEMP RAKE	CLARIFIER 3 RAKE	
14N03	TSH1-050-142-31	DI	RIO-050-145-31	HI TEMP TURBINE	CLARIFIER 3 TURBINE	
14N03	XSH1-050-141-31	DI	RIO-050-145-31	TORQUE HI	CLARIFIER 3 RAKE	
14N03	XSHH1-050-141-31	DI	RIO-050-145-31	TORQUE HI HI	CLARIFIER 3 RAKE	
14N04	FAIL-050-142-41	DI	RIO-050-145-31	FAILED	CLARIFIER 4 TURBINE	
14N04	REM-050-141-41	DI	RIO-050-145-31	REMOTE	CLARIFIER 4 RAKE	
14N04	TSH-050-141-41	DI	RIO-050-145-31	HI TEMP RAKE	CLARIFIER 4 RAKE	
14N04	TSH-050-142-41	DI	RIO-050-145-31	HI TEMP TURBINE	CLARIFIER 4 TURBINE	
14N04	XSH-050-141-41	DI	RIO-050-145-31	TORQUE HI	CLARIFIER 4 RAKE	
14N04	XSHH-050-141-41	DI	RIO-050-145-31	TORQUE HI HI	CLARIFIER 4 RAKE	
14N05	TSH-050-145-31	DI	RIO-050-145-31	HIGH CABINET TEMP	CLARIFIERS 3&4 RIO PANEL	
14N05	TSH-050-185-01	DI	RIO-050-145-31	HIGH CABINET TEMP	FILTER GALLERY RIO PANEL	
14N05	ZS-050-145-31	DI	RIO-050-145-31	INTRUSION	CLARIFIERS 3&4 RIO PANEL	
14N05	ZS-050-185-01	DI	RIO-050-145-31	INTRUSION	FILTER GALLERY RIO PANEL	
RIO-050-145-3	Total DI Points = 16					

SECTION 17950

COMMISSIONING FOR INSTRUMENTATION AND CONTROLS

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PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Testing requirements that apply to process control and instrumentation systems for the entire Project.

1.02 REFERENCES

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

B. Definitions:
   1. Complete End-to-End Testing (CEET) - Signals are tested from the field device through the PLC program, the network, and all the way to the operator’s HMI graphic screens.
   2. Loop validation tests - Signals are tested from the field device to the PLC.
   3. Platform testing: Testing of the PLC and SCADA/HMI at the ICSC 's shop to demonstrate the program’s functionality based upon specified and designed control requirements.
   4. Permanent link: The fixed portion of cabling installed between an equipment outlet and its immediate distributor or between 2 distributors.

C. Standards:
   1. Electronics Industries Alliance (EIA).
   2. Telecommunications Industry Association (TIA).

1.03 SUBMITTALS

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

B. General:
   1. Reference additional detailed test submittal scheduling and prerequisite requirements as specified in the Sequencing article of Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

C. Overall test plan:
   1. Develop the PCIS system test submittals in consultation and cooperation with all applicable subcontractors.
   2. Develop network security testing based on network security systems provided and in accordance with network security descriptions.
   3. Develop and submit an overall testing plan for the PCIS. The overall test plan to be reviewed and approved by the Engineer before detailed test plans, procedures, and forms will be reviewed.
   4. Describe the test phases as they apply specifically to this Project and each process system.
   5. Provide a preliminary testing schedule to show the sequence of tests and commissioning as they apply to each process system and each PLC.

6. Provide a description of factory tests. Describe what equipment will be included, what testing equipment will be used, and the simulator that will be used.
7. Provide examples of proposed forms and checklists.

D. Test procedures:
   1. Develop and submit detailed test procedures to show that the integrated SCADA system hardware and software is fully operational and in compliance with the requirements specified in the Contract Documents.
   2. Develop and submit detailed test procedures to show that SCADA system cybersecurity solutions are fully implemented and are in compliance with industry standards and the requirements specified in the Contract Documents.
   3. Provide a statement of test objectives for each test.
   4. Prepare specific procedures for each process system.
   5. Describe sequentially the steps to be followed in verifying the correct operation of each process system, including all features described in the loop descriptions, control strategies, and shown in the P&IDs. Implied or generic test procedures are not acceptable.
   6. Specify who will perform the tests, specifically what testing equipment will be used (including serial numbers and NIST-traceable calibration), and how the testing equipment will be used.
   7. Describe the expected role of the Engineer, as well as any requirements for assistance from Owner's staff.
   8. Provide the forms and checklists to be used.

E. Test forms:
   1. Submit completed calibration forms, test forms, and checklists.
      a. Test forms shall include the detailed test procedures or shall include clear references to separate pages containing the complete test procedure applicable to each form. If references to procedures are used, the complete procedure shall be included with each test binder.
      b. Every page of each test form shall include project name, date, time, name of person conducting the test, signature of person conducting the test, and for witnessed tests, place for signature of person (Engineer and Owner) witnessing the test.
      c. Sample test forms at the end of this Section show the minimum required content:
         1) The sample test forms have not been customized for this Project.
         2) Contractor shall develop and submit test forms customized for the Project and meeting the specified test and submittal requirements.

F. FAT procedure additional minimal requirements:
   1. Prepare and submit a FAT procedure which includes:
      a. Control system testing block diagram.
      b. Estimated test duration.

G. Details on the simulator construction, components, and operation. Testing binders:
   1. Sub-system to be tested, provide and submit a test binder containing all test procedures and individual test forms for the test. References to other documents for test procedures and requirements are not acceptable.
   2. Fill out in advance headings and all other information known before the test.

3. Include applicable test plan information, as well as a list of all test prerequisites, test personnel, and equipment.
4. Include or list reference material and provide separately at the time of the test.
5. Record test results and verify that all test requirements and conditions have been met.

H. Furnish commissioning submittals listed below and specified in this Section as specified in Section 01756 - Commissioning:
1. Manufacturer's representative qualifications.
2. Owner training.

I. Test reports:
1. At the conclusion of each test, submit a complete test report, including all test results and certifications.
2. Include all completed test binders, forms, and checklists.
3. Submission, review, and acceptance of each test report is required before the start of the sub-system.

J. Furnish 4 USB Flash Drive copies of the following:
1. Application software:
a. Finalized fully annotated copy of programmed PLC logic in its native format.
b. Cross-referenced index of all PLC registers or points.

1.04 QUALITY ASSURANCE

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

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 INSTALLATION

A. Installation supervision:
1. Provide as specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.03 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

B. Testing and training phase:
1. Source testing:
a. Manufacturer services: Provide as specified in the table below.

Section Number	Section Title	Source Testing (Witnessed or Non-Witnessed)
17100	Control Strategies	Non-Witnessed
17101	Specific Control Strategies	Non-Witnessed
17710	Control Systems - Panels, Enclosures, and Panel Components	Witnessed
17733	Control Systems – Network Materials and Equipment	Witnessed
17762	Control Systems – PCS Software	Witnessed
17950	Commissioning for Instrumentation and Controls	Witnessed

b. Prerequisite requirements:
1) Engineer approval of the hardware and equipment source testing submittal, Manufacturer Certificate of Source Testing, is required before proceeding to Preliminary FAT.
c. Preliminary FAT (Pre-FAT):
1) The purpose of the Pre-FAT is to provide assurance that the HMI/SCADA system is ready for the full, witnessed FAT, in terms of both stability and functionality:
a) Debugging of software and troubleshooting of hardware shall occur during and before the pre-FAT, not during the FAT.
b) Contractor, through the ICSC, shall fully prepare and test the PCIS system hardware and network connections and fix all deficiencies found prior to and during the pre-FAT.
c) Contractor and ICSC shall coordinate with Programmer in preparation for the Pre-FAT and shall provide Programmer with access to and use of PCIS testing facility and all PCIS system hardware a minimum of 15 calendar days prior to as well as during the Pre-FAT.
d) Programmer shall prepare and test all PCIS system software and network device configurations prior to and during the Pre-FAT.
2) Conduct utilizing test procedures approved by Engineer.
3) Owner shall have the right to witness any or all of the Pre-FAT testing and shall be notified in writing 20 days before the start of the pre-FAT.
4) Submit a letter, signed by the Contractor’s project manager or company officer, certifying that integrated system hardware and software has been tested and confirmed to be fully operational and in compliance with the requirements specified in the Contract Documents and is fully ready for the full, witnessed FAT:
a) Attach the completed pre-FAT test forms, signed by the Contractor’s staff.
5) Engineer approval of the pre-FAT submittal is required before proceeding to FAT.

d. FAT hardware and communications testing:
    1) Perform tests to show that the integrated system hardware and software is fully operational and in compliance with the requirements specified in the Contract Documents.
    2) The complete PCIS system including operator stations, servers, network equipment, PCMs, PLCs, LCPs, CCS, peripherals, communications equipment, and other HMI/SCADA equipment, shall be assembled, connected, and software loaded for a fully functional FAT of the integrated system.
    3) For any fault tolerant networks such as ring topology networks, disconnect each segment of the network individually to demonstrate proper failover and alarming at the HMI.
    4) Testing simulation:
        a) Inputs and outputs shall be simulated and proper control and system operation shall be validated.
        b) Whenever supplied equipment is available, such as devices internal to the control panel, test input and output signals using the equipment. Simulation is not acceptable.
        c) FAT shall make use of simulators that contain switches, pilot lights, variable analog signal generators, and analog signal level displays, which shall be connected to the I/O points within the HMI/SCADA system:
            (1) The use of jumper wires, terminal block mounted pilot lights, and loose meters to act as or supply the functionality of a simulator shall not be allowed.
            (2) The simulator may consist of a PLC, operating under an HMI/SCADA software package, or other approved software that has its I/O points wired to PLC's I/O points.
            (3) Software operating on a PC may then act as the switches, pilot lights, variable analog signal generators, and analog signal level displays.
            (4) Network communications tested and shown that systems only have the necessary communication for proper operation.
    5) Additional source tests are specified in other sections of the Instrumentation and Control Specifications.
    6) Owner shall have the right to witness any or all of the FAT testing and shall be notified in writing 20 days before the start of the FAT.
    7) Verify communications between the hardware and the ICSC programmer's software comply with specified requirements:
        a) For systems that contain remote communications with other devices, the complete communications system must be factory tested, including actual interfacing with wireless service provider equipment and/or the actual cellular modems used for wireless communication systems.

8) Panel inspections:
   a) Engineer will inspect each control panel for completeness, workmanship, fit and finish, and compliance with the Contract Documents and the accepted shop drawings:
      (1) Inspection to include, as a minimum: Layout, mounting, wire and data cable routing, wire tags, power supply, components and wiring, I/O components layout (including terminals, wiring and relays), device layout on doors and front panels, and proper ventilation operation.
   b) Inspection forms:
      (1) Provide panel inspection forms as part of the FAT procedures submittal.
      (2) A sample FAT control panel form has been provided at the end of this Section.
9) I/O test:
   a) Engineer will verify that I/O is properly wired to field terminals and is properly mapped into the PLC and the rest of the SCADA system, including all operator interface devices:
   b) Test methodology:
      (1) Discrete inputs:
         (a) Apply appropriate input from simulator at panel terminal, observe input card indicator, observe data value at each indicated data address, and observe data received at field wiring terminals or operator interface screen.
      (2) Discrete outputs:
         (a) Issue commands from operator interface screen or PLC, verify output card indicator light, and measure response at field wiring terminals or multimeter.
      (3) Analog inputs:
         (a) Apply appropriate analog input signal at panel terminals on simulator, observe data value at each indicated data address, and observe data properly received at field wiring terminals or operator interface screen.
         (b) Check each point at 0 percent, 50 percent, and 100 percent of scale.
      (4) Analog outputs:
         (a) Enter scaled values in the output buffer file, observe the output data file value, and measure appropriate response at field wiring terminals or multimeter.
         (b) Check each point at 0 percent, 50 percent, and 100 percent of scale.
   c) Test forms to include, but not be limited to the following data:
      (1) PLC and panel number.
      (2) I/O type.
      (3) I/O tag name.
      (4) Rack/slot/number of I/O point.
      (5) Check-off for correct response for each I/O point.
      (6) Comments field.
      (7) Initials of individual performing test.

(8) Date test was performed.
(9) Witness signature lines.

10) System configuration test:
    a) Demonstrate and test the setup and configuration of operator stations, servers, development stations, and peripherals.
    b) Demonstrate utility software and functions, such as virus protection, backup, optical drive burning, network monitoring, etc.
    c) Demonstrate the proper operation of peripheral hardware.
    d) Demonstrate general HMI/SCADA functions.
    e) Demonstrate proper operation of log-on and other security access functions.
    f) Demonstrate the proper operation of all historical data storage, trend, display, backup, and report functions.
    g) Test automatic fail over of redundant equipment.
    h) Demonstrate the proper operation of the alarm display and acknowledgement functions.
    i) For any fault tolerant networks, such as ring topology networks, disconnect each segment of the network individually to demonstrate proper failover and alarming.
    j) Test forms:
        (1) For each test, list the specification page and paragraph of the function demonstrated, and provide a description of the function.
        (2) List the specific tests and steps to be conducted.
        (3) For each function, list all of the different sub-functions or ways the function can be used, and provide a test check-off for each:
            (a) Include signature and date lines.
11) Engineer approval of the FAT Communication Testing activities is required before proceeding to FAT Platform Testing.

e. FAT Platform Testing - Control logic test:
    1) Verify the PLC, HMI and SCADA, provides monitoring and control functionality based upon specified and designed control requirements.
    2) Testing requirements:
        a) Demonstrate each function described in the Control Strategies.
        b) Demonstrate in detail how each function operates under a variety of operating scenarios:
            (1) Test to verify the application of each general control strategy function to each specific control strategy or loop description.
        c) Demonstrate the proper operation of the programming and configuration for each control strategy or loop description:
            (1) Test each strategy or loop description on a sentence by sentence and function by function basis.
            (2) Loops with similar or identical logic must each be tested individually.
            (3) Test the boundaries of each numeric operator input by entering values outside of the allowable range.

d) Demonstrate the proper operation of all digital communication links and networks.
(1) Verify each digital communication I/O point.
e) Failure testing: Demonstrate how the system responds to and recovers from abnormal conditions including, but not limited to, equipment failure, operator error, communications subsystem error, communications failures, simulated/forced software lockups, power failure (both utility power and power to HMI and/or SCADA hardware), process equipment failure, and high system loading conditions.

3) Test forms:
a) Submit completed test forms for each loop including but not limited to the fully revised and approved control strategy.
b) Identify the cause and effect as each I/O point is toggled through the simulator:
(1) Identify and track proper and/or improper operation of the loop.
c) Note any deficiencies or operational changes on the forms for correction and documentation:
(1) Include signature and date lines.

4) Engineer approval of the FAT submittal is required prior to shipment of system components.

2. Owner Training:
a. Perform Owner training as specified in Section 01756 - Commissioning.

Table 1

Course Title	Minimum Course Length (hours per session)	Personnel (Estimated Number of Students)	Minimum Number of Sessions
System Overview	4	10	1
Operator Training - Basic	4	10	1
Operator Training - Advanced	8	5	1
HMI Software	2	10	1
Historian System Training	2	10	1
PLC Hardware	4	5	1
PLC Software	4	5	1
Network Equipment	4	5	1

3. Training course requirements:
a. System overview training:
1) Furnish training courses that give the Owner's supervisory level personnel and overview of all elements of the PCIS system that focus on the overall functional aspect of elements of the control system and provide an understanding of the interaction of the various components.

2) Furnish a training course that gives the Owner's supervisory level personnel and overview of the new Contractor-provided elements of the PCIS system. Focus on the overall functional aspects of each new elements of the control system, particularly the mechanical system vendor-provided control packages.

b. Operator training:
   1) Furnish training courses that instruct system operators in the efficient operation of all aspects of the PCIS that include not only the general operation of the control system but also the operation of specific system features.
   2) Furnish training courses that instruct system operators in the efficient operation of Contractor-provided aspects of the PCIS that include not only the general operation of each control system but also the operation of specific system features.
   3) Operator's training shall include the following for each vendor package and programmable device:
      a) Control system overview: Architecture, equipment functions, software components, etc.
      b) Display navigation, overview, and types of displays.
      c) Process and equipment monitoring and control: Basic principles and operation.
      d) Logging ON and OFF the system and description of the security and access system.
      e) Alarm subsystem.
      f) Trending: Provide a thorough session on how to use all trending functions.
      g) Reports: How to access, print, and review content.
      h) Control strategies: Present an average 15-minute review of each control strategy, including a hands-on demonstration of screens and operator functions for each.
      i) Instruction on the use of all operational functionality alarm logging, trending, displays, database, reports, and control software developed for the Project and incorporated in the installed PCIS system.

c. HMI software training:
   1) Furnish training courses that will enable the Owner's staff to develop and maintain all aspects of the operator interface system applications.
   2) Include topics:
      a) Operating systems and utilities such as virus protection software.
      b) Point (tag) database development and modification.
      c) Graphic screen creation and editing.
      d) Scripting.
      e) I/O servers, drivers, etc.
      f) PLC interface functions and software.
      g) Displays, scripts conventions, and documentation.
      h) Trending.
      i) Alarms and events.
      j) System security, access levels, and areas of responsibility.

k) General system maintenance, including backups, history data archive, version control, file naming and cataloging conventions, and system file housekeeping.

3) Address not only the procedures associated with the control system's standard software packages, but in addition include material explaining the specific conventions used in developing the Project's system applications (graphics, PLC/RTU interface, scripts, control strategies, trends, etc.). In addition, provide instruction in the use of techniques for developing and maintaining current, comprehensive documentation for all installed system applications.

d. Historian system training:
   1) Furnish the following training:
      a) Introduction to relational databases.
      b) Introductory training on the specific relational database program used for the historian server.
      c) How to set up points for historian logging.
      d) How to develop, edit, and print custom reports, in detail.
      e) Introduction to use of the query language.
      f) System maintenance.
      g) Interface to networks outside of the control system.

e. PLC software training:
   1) The Contractor, through the I&C subcontractor, shall provide the following PLC software training:
      a) Project-specific PLC software training that covers the programming conventions, new standardized software modules, specific control strategy programs, and documentation created for the Work performed under this Contract. This training includes the specific knowledge needed to modify, expand, duplicate, troubleshoot, and repair the PLC programs provided under this Contract, provided by a qualified individual who is thoroughly familiar with the delivered system, and is one of the senior programmers who programmed the PLCs for this Project.

f. Network equipment training:
   1) Furnish basic training on all network hardware, switch and router configuration and software, and network monitoring software.
   2) Include a detailed description and explanation of the installed network architecture, media, and functions.
   3) Furnish an overview of the function and operation of each piece of network equipment.
   4) Furnish training on network maintenance troubleshooting and repair.
   5) Furnish training on how to install spare or off-line backup equipment.
   6) Basic network overview:
      a) Discuss a basic network overview for each site.
      b) Discuss the architecture (loop, star, etc.), media redundancy, and items that are not readily apparent to staff.
      c) Discuss how to monitor the network health through the HMI network screen.
      d) Discuss both enterprise level networks, the PCS communications network, and the field network.
   7) Ethernet switches and Firewalls:
      a) Discuss the various types of switches (Layer 2, Layer 3, etc.).

b) Discuss switch health monitoring through the HMI.
c) Discuss the VLAN configuration (what ports should be used for what network, etc.).
d) Discuss testing procedures.
e) Device Management Consoles.
f) Access Control Lists.

8) Field networks:
a) General:
(1) Discuss general principles behind likely device failures and actions to take to resolve such failures for each type of field network.
b) Fiber optic and copper Ethernet/IP networks:
(1) Discuss the network topology, redundancy protocol, LAN switch configuration and network troubleshooting.

9) Remote Access Device (RAD): Discuss remote access hardware, VPN configuration, and software features, including but not limited to: adding and removing users, establishing secure remote connections (hardware remote access keys, mobile keys, and serialized software keys) antennas and antenna cables, sim cards, and wireless service providers.

10) Hardware SMS Gateway (HSG): discuss how the HSG is connected via USB to the rack mounted workstation in the SCADA network rack, how the VTScada workstation can be accessed remotely from another workstation in the WTP, how VTSCADA alarms are configured, antennas and antenna cables, sim cards, and wireless service providers.

g. Follow-up training:
1) Provide a series of on-site follow-up training classes beginning after process start-up of the SCADA/PCIS system. The intent for these classes is to provide the Owner's personnel the opportunity for a review and "refresher" of the training topics and material after they have had some experience using the system.
2) Mutually schedule and develop the content of these classes with the Owner no later than 1 month before the beginning of the first session:
a) Schedule at the Owner's discretion on non-consecutive days spaced out over the process start-up and warranty period.

4. Installation testing:
a. Calibration:
1) Performed by Contractor and ICSC.
2) Calibrate and adjust all instruments, devices, valves, and systems, in conformance with the component manufacturer's instructions and as specified in these Contract Documents.
3) Replace either individually or within a system, defective elements that cannot achieve proper calibration or accuracy.
a) Calibration for discrete devices:
(1) Calibrate and adjust devices for reliable operation and to avoid nuisance tripping.
b) Calibration for ultrasonic and radar level devices:
(1) Provide Echo Transmission and signal quality on level transmitters including guided and unguided units.

(a) Submit printout of the actual transmission and parameters.
(2) Adjust mounting, as required, to obtain accurate readings.
(3) Post mounting: Provide any additional calibration required by manufacturer.

c) Calibrating analog transmitters:
(1) Components having adjustable features are to be set accurately for the specific conditions and applications of this installation.
(2) Test and verify that components and/or systems are within the specified limits of accuracy.
(3) Calibration points:
(a) Calibrate each analog instrument at 0 percent, 25 percent, 50 percent, 75 percent, and 100 percent of span, using test instruments with accuracies traceable to NIST.
(4) Field verify calibration of instruments including units that have been factory-calibrated to determine whether any of the calibrations are in need of adjustment.

d) Analyzer calibration:
(1) Calibrate and test each analyzer system as a workable system after installation. Follow the testing procedures directed by the manufacturers' technical representatives.
(2) Submit completed instrument calibration sheets for every field instrument and analyzer.
(3) Calibration tags:
(a) Attach a calibration and testing tag to each instrument, piece of equipment, or system.
(b) Sign the tag when calibration is complete.

e) Calibration for industrial networking test equipment:
f) Submit calibration documentation.

b. Loop check:
1) Performed by the Contractor.
2) Cabling installed, terminated, and labeled.
3) Perform continuity check of wiring to each field device through intermediate devices to field terminals in the cabinet.
4) Complete loop check form for each device.
5) Submit loop check test results before proceeding to the next step.

c. Loop validation tests:
1) Performed by the Contractor, ICSC, and manufacturer's representative, working together, and witnessed by the Owner or Owner's representative.
2) Perform tests on the signal from each field device through intermediate devices to the I/O module on the PLC.
a) The PLC may or may not be connected to the network.
3) Engineer approval of the loop validation test submittal is required before proceeding to CEET.

d. Copper Ethernet cable acceptance testing:
1) All testing procedures and field-test instruments shall comply with applicable requirements of:

a) TIA-1152 - Requirements for Field Test Instruments and Measurements for Balanced Twisted-Pair Cabling.
b) TIA-568.0-E - Generic Telecommunications Cabling for Customer Premises.
c) TIA-568.1-E - Commercial Building Telecommunications Infrastructure Standard.
d) TIA-568.2-D - Balanced Twisted-Pair Telecommunications Cabling and Components Standard.
e) Copper Ethernet cable installation testing as specified in Section 16950 - Field Electrical Acceptance Tests.

2) Testing shall be performed by trained technicians who have successfully completed an appropriate training program and have obtained a certificate as proof thereof shall execute the tests. These certificates may have been issued by any of the following organizations or an equivalent organization:
   a) Manufacturer of the connectors or cable.
   b) Manufacturer of the test equipment used for the field certification.
   c) Training organizations (e.g., BICSI).
3) Submit the following information before testing begins:
   a) Manufacturer's catalog sheets, specifications, and the most recent calibration report for the test equipment.
   b) Certificate of testing technician's training.
   c) A schedule of all balanced twisted-pair copper links to be tested, including:
      (1) Cable identification as it appears on the cable records.
      (2) Cable identification as it appears on the individual test reports.
      (3) Cable identification as specified in Section 16075 - Identification for Electrical Systems.
   d) Sample test reports.
   e) All installed cabling Permanent Links shall be field-tested and pass the test requirements and analysis as described below:
      (1) Any Permanent Link that fails these requirements shall be diagnosed and corrected.
      (2) Any corrective action that must take place shall be documented and followed with a new test to prove that the corrected Permanent Link meets performance requirements.
      (3) The final and passing result of the tests for all Permanent Links shall be provided in the test results documentation in accordance with the testing requirements.
   f) Acceptance of the test results shall be given in writing after the project is fully completed and tested in accordance with Contract Documents and to the satisfaction of the Engineer.
4) Cable field-test instruments:
   a) The field-test instrument shall be within the calibration period recommended by the manufacturer, typically 12 months.
   b) Certification tester requirements:
      (1) Level III in accordance with TIA-1152.
      (2) Independent verification of accuracy.

(3) Must be capable of storing more than 10,000 results for all required measurements.
(4) Manufacturer: The following or equal:
(a) Fluke CableAnalyzer Industrial Ethernet Kit, DSX2-5-IE-K1.

c) Permanent Link adapters:
(1) Use manufacturer's adapter for connecting to tested equipment.
(a) Patch cables shall not be used for testing.
(2) RJ45 plug must meet the requirements for NEXT, FEXT and Return Loss in accordance with TIA-568.2-D Annex C.

d) Measurement capabilities:
(1) Wire Map.
(2) Length.
(3) Propagation Delay.
(4) Delay Skew.
(5) DC Loop Resistance.
(6) DC Resistance Unbalance.
(7) Insertion Loss.
(8) NEXT (Near-End Crosstalk).
(9) PS NEXT (Power Sum Near-End Crosstalk).
(10) ACR-N (Attenuation to Crosstalk Ratio Near-End).
(11) PS ACR-N (Power Sum Attenuation to Crosstalk Ratio Near-End).
(12) ACR-F (Attenuation to Crosstalk Ratio Far-End).
(13) PS ACR-F (Power Sum Attenuation to Crosstalk Ratio Far-End).
(14) Return Loss.
(15) TCL (Transverse Conversion Loss).
(16) ELTCTL (Equal Level Transverse Conversion Transfer Loss).
(17) Time Domain Reflectometer.
(18) Time Domain Xtalk Analyzer.

5) Testing requirements:
a) Field-test instruments shall have the latest software and firmware installed.
b) Permanent Link test results including the individual frequency measurements from the tester shall be recorded in the test instrument upon completion of each test for subsequent uploading to a PC in which the administrative documentation (reports) may be generated.
c) Testing shall be performed on each cabling segment from connector to connector:
(1) Sampling is not acceptable.
d) The installer shall build a reference link:
(1) All components shall be anchored so it is not possible to disturb them.
(2) The technician is to conduct a Permanent Link test each day, for each type of category cable used, to ensure no degradation of the tester or its Permanent Link adapters.

e) Unless noted otherwise tests shall use the following frequency resolution:
   (1) 1 - 31.25 MHz: 150 kHz.
   (2) 31.25 - 100 MHz: 250 kHz.
   (3) 100 - 250 MHz: 500 kHz.

f) Wire Map measurement:
   (1) Wire map test is intended to verify pin-to-pin termination at each end and check for installation connectivity errors. For each of the 8 conductors in the cabling, the wire map indicates:
      (a) Continuity to the remote end.
      (b) Shorts between any two or more conductors.
      (c) Reversed pairs.
      (d) Split pairs.
      (e) Transposed pairs.
      (f) Distance to open on shield.
      (g) Any other miss-wiring.
      (h) The correct connectivity of telecommunications outlets/connectors is defined in TIA-568.2-D:
         - 2 color schemes are permitted.
         - User shall define which scheme is to be used.
         - Field tester shall document which color scheme was used.

g) Length measurement:
   (1) Record the length of each cable. Use the physical length of the link calculated using the pair with the shortest electrical delay for reporting and to determine pass/fail.
   (2) Pass or fail criteria is based on the maximum length allowed for the Permanent Link as specified in TIA-568.D-2 plus the nominal velocity of propagation (NVP) uncertainty of 10 percent. For a Permanent Link, the length measurement can be 325 feet before a fail is reported.

h) Propagation Delay measurement:
   (1) Is the time it takes for a signal to reach the end of the link.
   (2) The measurement shall be made at 10 MHz in accordance with TIA-1152.
   (3) The propagation delay of each balanced twisted pair shall be recorded.
   (4) Is not to exceed 498 ns in accordance with TIA-568.2-D Section 6.4.21.

i) Delay Skew measurement:
   (1) Is the difference in propagation delay at 10 MHz between the shortest delay and the delays of the other wire pairs.
   (2) The delay skew of each balanced twisted pair shall be recorded.
   (3) Is not to exceed 44 ns in accordance with TIA-568.2-D Section 6.4.22.

j) DC Resistance:
   (1) Often reported as Resistance, is the loop resistance of both conductors in the pair.

(2) Is not specified in TIA-1152 but shall be recorded for all 4 pairs.

k) DC Resistance Unbalance:
   (1) Often reported as Resistance Unbalance, is the difference in resistance of the 2 wires within the pair.
   (2) Is not specified in TIA-1152 for a Permanent Link but shall be recorded for all 4 pairs.

l) Insertion Loss:
   (1) Is the loss of signal strength over the cabling (in dB).
   (2) Worst case shall be reported for all 4 pairs in one direction only.
   (3) Reported margins found to be within the accuracy of the field tester shall be marked with an asterisk.
   (4) Is not to exceed the Category 6 Permanent Link limits in accordance with TIA-568.2-D Section 6.4.10.

m) NEXT (Near-End Crosstalk):
   (1) Is the difference in amplitude (in dB) between a transmitted signal and the crosstalk received on other wire pairs at the same end of the cabling.
   (2) Shall be measured in both directions (12 pair to pair possible combinations).
   (3) Both worst case and worst margins shall be reported.
   (4) Is not to exceed the Category 6 Permanent Link limits in accordance with TIA-568.2-D Section 6.4.11.
   (5) Reported margins found to be within the accuracy of the field tester shall be marked with an asterisk (*).
   (6) The Time Domain Xtalk data shall be stored for any marginal or failing NEXT results.

n) PS NEXT (Power Sum Near-End Crosstalk):
   (1) Is the difference (in dB) between the test signal and the crosstalk from the other pairs received at the same end of the cabling.
   (2) Shall be measured in both directions (8 pair possible combinations).
   (3) Both worst case and worst margins shall be reported.
   (4) Is not to exceed the Category 6 Permanent Link limits in accordance with TIA-568.2-D Section 6.4.12.
   (5) Reported margins found to be within the accuracy of the field tester shall be marked with an asterisk (*).
   (6) Time Domain Xtalk data shall be stored for any marginal or failing PS NEXT results.

o) ACR-N (Attenuation Crosstalk Ratio Near-End):
   (1) Is a calculation of NEXT minus Insertion Loss of the disturbed pair in dB.
   (2) Shall be calculated in both directions.
   (3) Is not specified in TIA-1152 but shall be recorded for all 12 possible combinations.

p) PS ACR-N (Power Sum Attenuation Crosstalk Ratio Near-End):
   (1) Is a calculation of PS NEXT minus Insertion Loss of the disturbed pair in dB.
   (2) Shall be calculated in both directions.

(3) Is not specified in TIA-1152 but shall be recorded for all 8 possible combinations.

q) ACR-F (Attenuation Crosstalk Ratio Far-End):
   (1) Is a calculation of FEXT minus Insertion Loss of the disturbed pair in dB.
   (2) Shall be measured in both directions (24 pair to pair possible combinations).
   (3) Both worst case and worst margins shall be reported.
   (4) Is not to exceed the Category 6 Permanent Link limits in accordance with TIA-568.2-D Section 6.4.14.
   (5) Reported margins found to be within the accuracy of the field tester shall be marked with an asterisk (*).

r) PS ACR-F (Power Sum Attenuation Crosstalk Ratio Far-End):
   (1) Is a calculation of PS FEXT minus Insertion Loss of the disturbed pair in dB.
   (2) Shall be measured in both directions (8 pair possible combinations).
   (3) Both worst case and worst margins shall be reported.
   (4) Is not to exceed the Category 6 Permanent Link limits in accordance with TIA-568.2-D Section 6.4.16.
   (5) Reported margins found to be within the accuracy of the field tester shall be marked with an asterisk (*).

s) Return Loss:
   (1) Is the difference (in dB) between the power of a transmitted signal and the power of the signals reflected back.
   (2) Shall be measured in both directions (8 pair possible combinations).
   (3) Both worst case and worst margins shall be reported.
   (4) Shall be ignored at all frequencies where the Insertion Loss is less than 3 dB for that pair.
   (5) Is not to exceed the Category 6 Permanent Link limits in accordance with TIA-568.2-D Section 6.4.9.
   (6) Reported margins found to be within the accuracy of the field tester shall be marked with an asterisk (*).
   (7) Time Domain Reflectometer data shall be stored for any marginal or failing Return Loss results.

t) TCL (Transverse Conversion Loss):
   (1) Is the ratio (in dB) between a differential mode signal inject at the near-end and the common-mode signal measured at the near-end on the same wire pair.
   (2) Shall be measured in both directions.
   (3) Is not specified in TIA-1152 for a Permanent Link but shall be recorded for all 8 possible combinations.

u) ELTCTL (Equal Level Transverse Conversion Transfer Loss):
   (1) Is the ratio (in dB) between a differential mode signal inject at the near-end and the common-mode signal measured at the far end on the same wire pair minus the Insertion Loss of that pair.
   (2) Shall be measured in both directions.
   (3) Is not specified in TIA-1152 for a Permanent Link but shall be recorded for all 8 possible combinations.

6) Test results documentation:
   a) The detailed test results documentation data is to be provided in an electronic database for each tested balance twisted pair and shall contain the following information:
      (1) The overall Pass/Fail evaluation of the link-under-test.
      (2) The date and time the test results were saved in the memory of the tester.
      (3) The identification of the customer site as specified by the end-user.
      (4) The name of the test limit selected to execute the stored test results.
      (5) The name of the personnel performing the test.
      (6) The version of the test software and the version of the test limit database held within the test instrument.
      (7) The manufacturer, model and serial number of the field-test instrument.
      (8) The adapters used.
      (9) The factory calibration date.
      (10) Wire Map.
      (11) Propagation Delay values, for all 4 pairs.
      (12) Delay Skew values, for all 4 pairs.
      (13) DC Resistance values, for all 4 pairs.
      (14) DC Resistance Unbalance, values for all 4 pairs.
      (15) Insertion Loss, worst case values for all 4 pairs.
      (16) NEXT, worst case margin and worst case values, both directions.
      (17) PS NEXT, worst case margin and worst case values, both directions.
      (18) ACR-F, worst case margin and worst case values, both directions.
      (19) PS ACR-F, worst case margin and worst case values, both directions.
      (20) Return Loss, worst case margin and worst case values, both directions.
      (21) TCL, worst case values both directions.
      (22) ELTCTL, worst case values, both directions.
      (23) Time Domain Crosstalk data if the link is marginal or fails.
      (24) Time Domain Reflectometer data if the link is marginal or fails.
   b) Maintain a set of “red-line” throughout during construction:
      (1) Drawings shall be available for review at any time as requested by Owner or Engineer.
      (2) Provide record copy drawings at the end of the project shall be in CAD format and include notations reflecting the as built conditions of any additions to or variation from the drawings provided such as, but not limited to cable paths and termination point.
      (3) The as built drawings shall include, but are not limited to block diagrams, frame and cable labeling, cable termination points, equipment room layouts and frame installation details.

(4) The as-builts shall include all field changes made up to construction completion:
(a) Field directed changes to pull schedule.
(b) Horizontal cable routing changes.

7) Associated detail drawings. Engineer approval of the copper Ethernet cable acceptance-testing submittal is required before proceeding to CEET.

e. Complete End-to-End Testing (CEET):
1) Performed by Contractor, ICSC, manufacturer's representative and Programmer working together, with assistance from the Owner or the inspection staff, as needed:
a) The participants need to be dedicated full-time to CEET.
b) ICSC will provide staff to verify input signals at, and create output signals from, an HMI or Engineering Workstation.
c) Contractor and ICSC will be responsible for creating field signals and verifying proper operation of final control elements.
2) Prerequisites:
a) CEET cannot begin until the successful completion of the preceding tests:
(1) Calibration.
(2) Loop check.
(3) Loop validation tests.
(4) Copper Ethernet cable acceptance testing.
(5) Industrial network testing.
3) Testing description:
a) This testing is to ensure all I/O signals operate to the intent of the design from the field device to the HMI and all other auxiliary controls and indicators in the PCS.
b) Connect PLC to the network to test signals from the field device through the PLC program, the network, and to the operator's HMI graphic screens. The outputs will be energized for a duration long enough to verify proper operation of the final control element.
c) SCADA screens:
(1) Test and record operator commands and signal readouts to each operator device where there is more than one operator interface point.
(2) For each signal, perform separate tests for SCADA computer screens, local operator interface (LOI) screens, and local control panels.
(3) Retest any loop following any necessary corrections.
4) Check control loops under simulated operating conditions by causing a range of input signals at the primary control elements and observing appropriate responses of the respective control and monitoring elements, final control elements, and the graphic displays associated with the HMI/SCADA system:
a) Use actual process inputs wherever available.
b) Issue commands from the HMI/SCADA system and verify proper responses of field devices:
(1) Test SCADA system inputs from field device to SCADA system operator workstations:

(a) Track responses through trend charts in the HMI/SCADA system.

(2) Test SCADA system outputs from SCADA operator workstations to field devices and equipment.

c) Observe and record responses at intermediate devices.

5) Discrete device testing:

a) Exercise each field device providing a discrete input to the HMI/SCADA system in the field and observe the proper operation shall be observed at the operator workstation:

(1) Test limit switches, set limits mechanically, and observe proper operation at the operator workstation.

(2) Exercise starters, relay contacts, switch contacts, and observe proper operation.

(3) Calibrate and test instruments supplying discrete inputs and observe proper operation.

b) Test each device accepting a discrete output signal from the HMI/SCADA. Perform the appropriate operator action at the SCADA operator stations (including LOIs, if present) and confirm the proper operation of the field device:

(1) Stroke valves through outputs from the HMI/SCADA system and confirm proper directional operation. Confirm travel limits and any feedback signals to the HMI/SCADA system.

(2) Exercise motors starters from the HMI/SCADA system and verify proper operation through direct field observation.

(3) Exercise solenoids and other field devices from the HMI/SCADA system and verify proper operation through direct field observation.

6) Analog device testing:

a) Apply continuously variable up and down analog inputs to verify the proper operation and setting of discrete devices (signal trips, etc.).

b) Apply provisional settings on controllers and alarm setpoints.

7) Analog input:

a) Exercise each field device monitoring the analog signal, through the HMI/SCADA system:

(1) Apply simulated sensor inputs corresponding to 0 percent, 25 percent, 50 percent, 75 percent, and 100 percent of span for networks that incorporate analog elements and monitor the resulting outputs to verify compliance to accuracy tolerance requirements.

8) Analog output:

a) Exercise each field device requiring an analog command signal, through the HMI/SCADA system:

(1) Vary the output from the PLC HMI/SCADA system and measure the end device position, speed, etc., to confirm the proper operation of the device for the supplied analog signal.

(2) Manually set the output from the HMI/SCADA screen at 0 percent, 25 percent, 50 percent, 75 percent, and 100 percent and measure the response at the final device and at any intermediate devices.

9) Submit completed test forms:
    a) Discrete instrument input devices:
        (1) Switch setting, contact action, and dead band.
        (2) Valve position switches:
            (a) Response in the PLC as the valve is stroked from the PLC.
            (b) Field observed actual valve position, and valve indicator position as the valve is stroked from the PLC.
        (3) Operator interface switches (control stations and other pilot devices) and associated response.
        (4) Starter and drive auxiliary device contact response.
        (5) Response of all other discrete inputs to the PLC.
        (6) Test equipment used and associated serial numbers.
    b) Discrete output devices:
        (1) Observed response of field device to the discrete output from the PLC.
        (2) Observe the proper operation of Open, Close, Start, Stop, On, Off, etc.
        (3) Test equipment used and associated serial numbers.
    c) Analog input devices:
        (1) Calibration range.
        (2) Calibration data: Input, output, and error at each test value.
        (3) Analog input associated PLC register address.
        (4) Value in PLC register at each test point.
        (5) Value displayed at each operator interface station (local operator interface displays and SCADA workstations).
        (6) Test equipment used and associated serial numbers.
    d) Analog output devices:
        (1) Calibration range.
        (2) Test value at each test point.
        (3) Analog output associated PLC register address.
        (4) Control variable value at field device at each test point.
        (5) Physical device response at each test point:
            (a) Response to be actual valve position, or motor speed, etc.
        (6) Test equipment used and associated serial numbers.
10) Failure testing:
    a) Demonstrate how the system reacts and recovers from abnormal conditions including, but not limited to:
        (1) Equipment failure.
        (2) Communications sub-system error.
        (3) Power failure.
        (4) Process equipment failure.
        (5) High system loading conditions.
11) Engineer approval of the CEET submittals is required before proceeding to Functional Testing.

5. Functional Testing:
    a. General:
        1) Testing to demonstrate proper operation of systems with process equipment operating over full operating ranges under conditions as closely resembling actual operating conditions as possible.

2) Performed by Contractor, ICSC, manufacturer's representative and Programmer working together, with assistance from the Owner or the inspection staff, as needed.
3) Additional tests are specified in other Instrumentation and Control Sections.
4) Follow approved detailed test procedures and check lists for Functional Test activities.

b. Control logic operational validation:
1) The purpose of control logic validation is to field test the operation of the complete control system, including all parts of the HMI/SCADA system, all control panels (including vendor control panels), all control circuits, all control stations, all monitored/controlled equipment, and final control elements.
2) Demonstrate control functionality shown on the P&IDs, control schematics, and other drawings, and specified in the loop descriptions, control strategies, Electrical Specifications, and Mechanical Equipment Specifications.
3) Test in detail on a function-by-function and sentence-by-sentence basis.
4) Thoroughly test hardware and software functions:
5) Including all hardwired and software control circuit interlocks and alarms.
6) Test final control elements, controlled equipment, control panels, and ancillary equipment under startup, shut down, and steady-state operating conditions to verify all logic and control is achieved.
7) Control logic validation tests to include, but not limited to, a repeat of all control logic tests from the FAT, modified and expanded to include all field instruments, control panels, circuits, and equipment.

c. Loop tuning:
1) Optimally tune all electronic control stations and software control logic incorporating proportional, integral, or derivative control. Apply control signal disturbances at various process variable levels and adjusting the gain, reset, or rate settings as required to achieve proper response.
2) Verify the transient stability of final control elements operating over the full range of operating conditions, by applying control signal disturbances, monitoring the amplitude and decay rate of control parameter oscillations and making necessary controller adjustments as required to eliminate excessive oscillatory amplitudes and decay rates. As a minimum, achieve 1/4-wave amplitude decay ratio damping (subsidence ratio of 4) under the full range of operating conditions.
3) If excessive oscillations or system instability occur, as determined by the Engineer, continue tuning and parameter adjustments, or develop and implement any additional control algorithms needed to achieve satisfactory control loop operation.
4) Functional validation sheets:
a) Document each Functional test on an approved test form.

b) Document loop tuning with a report for each loop, including two-pen chart recordings showing the responses to step disturbance at a minimum of 3 setpoints or process rates approved by the Engineer. Show tuning parameters on the charts, along with time, date, and sign-off by Contractor and Engineer.
c) Include on the form, functions which can be demonstrated on a loop-by-loop basis:
   (1) Loop number and P&ID number.
   (2) Control strategy, or reference to specification tested.
   (3) Test procedures: Where applicable, use the FAT function-by-function, sentence-by-sentence loop test checklist forms modified to meet the requirements of the Functional test. Otherwise, create new forms.
d) For functions that cannot be demonstrated on a loop-by-loop basis (such as overall plant power failure), include on the test form a listing of the specific steps and tests to be conducted. Include with each test description the following information:
   (1) Specification page and paragraph of function demonstrated.
   (2) Description of function and/or text from specification.
   (3) Test procedures: use the FAT loop test checklist forms modified to meet the specific testing conditions of the Functional test.

5) Network Testing:
   a) Verify connectivity to each network connected device.
   b) Verify allowed connectivity between devices.
   c) Test non-allowed traffic blocking for common protocols such as ping, remote desktop, and file transfer.
   d) Review configuration and monitoring console for network management software.
   e) Review configuration and monitoring console for Microsoft Admin Center.
   f) Review configuration and monitoring console for Firewall management.
   g) Review configuration and monitoring console for Endpoint Protection software.
   h) Demonstrate remote VPN access.
   i) Demonstrate Authentication via active directory and specific device credentials.
   j) Review Active Directory Configuration.
   k) Test VTScada Card Reader Access.
6) Functional certification:
   a) Provide Manufacturer’s Certificate of Installation and Functionality Compliance as specified in Section 01756 - Commissioning:
      (1) Including all test forms with test data entered, submitted to the Engineer with a clear and unequivocal statement that all Functional test requirements have been satisfied.

6. Clean Water Facility Testing:
    a. Programmer shall be onsite to support Clean Water Test activities and provide functional changes as required:
        1) ICSC shall be available as needed.

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

4) Failures:
    a) Classify failures as either major or minor:
        (1) Minor failure:
            (a) A small and non-critical component failure or software problem that can be corrected by the Owner's operators.
            (b) Log this occurrence but this is not a reason for stopping the test and is not grounds for nonacceptance.
            (c) Should the same or similar component failure occur repeatedly, this may be considered as grounds for non-acceptance.
            (d) Failure of one printer or operator station is considered a minor failure providing all functions can be provided by backup equipment, i.e., alternate printers and operator station, and repairs can be made, and equipment returned to service within 3 working days.
        (2) Major failure:
            (a) Considered to have occurred when a component, subsystem, software control, or program fault causes a halt in or improper operation of the system and/or when a technician's work is required to make a repair or to re-initiate operation of the system.
            (b) Cause termination of the PCIS Optimization and Fine-Tuning.
            (c) Start a new acceptance test when the causes of a major failure have been corrected.
            (d) A failure is also considered major when failure of any control system that results in an overflow, underflow, overdose, or underdose condition occurs.
5) Technician report:
    a) Each time a technician is required to respond to a system malfunction, they must complete a report, which includes details concerning the nature of the complaint or malfunction and the resulting repair action required and taken.
    b) If a malfunction occurs which clears itself or which the operator on duty is able to correct, no report is required or logged as specified above.
    c) If a technician has performed work but no report is written, then a major failure is considered to have occurred.
    d) Each report shall be submitted within 24 hours to the Engineer and the Owner, or its representative.

3.04 SCHEDULES

A. Example test forms:
    1. Example test forms are attached at the end of this Section. They may be used as a starting point for the development of Project-specific test forms for this Project.

2. The example test forms are not intended to be complete or comprehensive. Edit and supplement the forms to meet the requirements for testing and test forms specified in this Section and other Contract Documents.

END OF SECTION

ATTACHMENT A - FACTORY ACCEPTANCE TEST - CONTROL PANELS

	FACTORY ACCEPTANCE TEST - CONTROL PANELS	

1. GENERAL INSPECTION

A. Structural Inspection

- ☐ Verify Lifting Lugs Installed
- ☐ Verity enclosure has lock and lock is functional
- ☐ Confirm that seismic bracing components are provided per manufacturer's installation instructions

B. Exterior Inspection

- ☐ Cabinet exterior is clean, scratch, and dent free
- ☐ Inspect externally for corrosion and damage
- ☐ Verify enclosure door opens and closes easily
- ☐ Verify enclosure has a 3-point latch
- ☐ Verify enclosure has a flange mounted disconnect (where voltages greater than 120 VAC enter the cabinet)
- ☐ Verify enclosure has the appropriate NEMA rating (1, 1G, 12, 3R, 4, 4X, etc.)
- ☐ Verify enclosure is the appropriate size (not grossly larger than design, and will still fit in the plant)

Nameplates

- ☐ Cabinet has identification nameplate
- ☐ All door labels are straight, spelled correctly, and match the tagging defined in the Contract
- ☐ Cabinet has a nameplate that includes the following:
  - ☐ Power source(s)
  - ☐ Integrator's Logo
  - ☐ Circuit ID(s)
  - ☐ Short Circuit KAIC ratings
- ☐ If labels are screwed to door, silicone was utilized to cover screw holes (Labels screwed to the door of a NEMA 4/4X panel technically violates the NEMA rating.)

Door Devices

- ☐ All devices penetrating the outside of panel have gaskets, silicone or both
- ☐ All door devices are installed (HMIs, Pilot Devices, etc.)
- ☐ Door mounted equipment is mounted straight and square
- ☐ All exterior or door mounted equipment present and accounted for, installed and securely fastened
- ☐ NEMA classification has not been violated due to penetrations
- ☐ Door mounted equipment has the same NEMA rating as the panel
- ☐ All door mounted equipment installed at the correct height
- ☐ All door mounted equipment installed in the correct positions and order (layout of door mounted equipment is grouped properly and in a logical manner)
- ☐ Doors with multiple penetrations have adequate bracing (if needed)
- ☐ Visually check condition of indicators , controllers and annunciators
- ☐ Check that pilot lights illuminate correctly
- ☐ Check the Push-To-Test function
- ☐ Ensure correct pilot light color

Peripheral Devices

- ☐ Horn / Beacon is installed (where required)
- ☐ Silence and Reset pushbutton

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1. GENERAL INSPECTION (continued)

C. Interior Inspection

- ☐ Cabinet is cleaned of marks and dirt.
- ☐ Inspect internally for corrosion and damage.
- ☐ Back panel is clean of marks and dirt.
- ☐ Interior of panel vacuumed and shall be free of all debris.
- ☐ Check that the panel roof is clean and clear of foreign materials.
- ☐ Bottom of panel has been cut out (where bottom entry is required), with angle iron welded around the bottom perimeter. Re-painting has been performed.
- ☐ If internal light door limit switch is provided, ensure the light automatically turns "on" when the doors are open.
- ☐ Check that a document pocket has been provided.
- ☐ Intrusion alarms (where required).

Interior Labeling

- ☐ All panel mounted equipment has identification labeling, by using either a Brothers or Phenolic type tags.
- ☐ Verify that door mounted components are mounted square and symmetrical.
- ☐ Verify that nameplates are straight, legible, and spelled correctly.
- ☐ All terminal blocks are identified/labeled with permanent labels including tight end blocks and caps.
- ☐ All wiring shrink labeled and or phased correctly to the specifications.
- ☐ All wire labels shrunk completely rotated and aligned alike for easy identification.
- ☐ All fuses and circuit breakers are labeled with ID and current rating.
- ☐ System Integrator’s label or labels installed on door.
- ☐ Panel manufacturer model/serial number tag is present.
- ☐ All required safety/warning tags installed and straight.
- ☐ Correct UL (typically UL 508) or cUL tag installed and registered and all other associated tags installed and straight (the UL tag might not be installed in the panel at the factory test. If the panel is modified due to changes during the factory test or a punch list generated from the factory test, the UL labeling would need to be re-applied. Some UL shops do not apply the UL label until the panel is released to be shipped.).

Wireways

- ☐ Plastic wire way covers installed properly.
- ☐ Plastic wireways have no sharp edges.
- ☐ No wire Ties inside the wireways.
- ☐ No sharp edges on wire ties.
- ☐ Separation: White duct is used for DC voltages; Gray duct is used for AC voltages.
- ☐ Ensure wiring duct is not over-full, includes provision for 20% more wiring and the cover may easily be installed. Panduit recommends 50% duct fill, but 40% is a better practice.

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1. GENERAL INSPECTION (continued)

C. Interior Inspection (continued)

Wiring

- ☐ Visually check terminals and condition of internal wirings
- ☐ Verify that the control panel has been assembled and wired as designed
- ☐ Verify that all components are operational and perform the functions intended
- ☐ Verify that all components are sized appropriately for the application
- ☐ Verify that equipment control circuits function as intended
- ☐ Back of door wiring is labeled and neatly formed
- ☐ Back panel to door wiring has sufficient bending radius with spiral wrap
- ☐ Wire connection has been verified wired to correct points within the panel
- ☐ Individual wires have been given a pull test to verify a good terminal connection
- ☐ Wire and cable minimum bending radius have not been violated
- ☐ All equipment installed straight and square to back panel
- ☐ Wire colors are correct:
  - ☐ Black and White > AC hot and neutral, respectively
  - ☐ Red > AC control signals
  - ☐ Blue > DC power and control (Blue w/White stripe for DC ground)
  - ☐ Yellow > Foreign voltages (those still present when panel power is disconnected)
  - ☐ Green > AC equipment ground
  - ☐ Black > TSP (+)
  - ☐ White> TSP(-)
- ☐ Analog wiring shields are continuous (connected by a dedicated terminal block for such shields)
- ☐ Analog shield wires are grounded within the panel, where not otherwise grounded at the transmitter itself
- ☐ Discrete inputs are separately fused or protected by a circuit breaker on a “per loop” basis
- ☐ Intrinsic Safety Wiring
  - ☐ Ensure wiring associated with intrinsic safety circuits or intrinsic safety barriers is kept away from all other wiring by UL minimum distances or by a physical (grounded metal) barrier preventing non-intrinsically safe wiring from coming in contact with intrinsically safe circuits or wiring
- ☐ Verify all spare terminals are installed according to the percentage listed in the specifications

Grounding

- ☐ Equipped with “Blackburn” or other grounding type lug
- ☐ Lug is securely fastened to the panel structure
- ☐ Verify Grounding bar is installed
- ☐ Verify Isolated ground bar is installed

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2. POWER TEST

A. AC Power

- ☐ AC Power is routed correctly within the panel and is isolated from DC and network wiring.
- ☐ All fuses are installed and sized properly.
- ☐ All breakers are installed and sized properly.
- ☐ 24 VDC Power Supplies are functional.
- ☐ 24 VDC Power fail contacts are functional.
- ☐ 24 VDC power supplies are redundant and have diode modules enabling the hot swap-over between supplies.
  - ☐ 24 VDC supplies are equipped with dry contact failure alarms, wired as PLC inputs to signal failure of any DC power supply. Such alarm inputs to the PLC have been tested as being functional.
- ☐ Dedicated receptacle is wired to receive a dedicated AC supply.
- ☐ Verify continuity for all DC commons, ground and AC neutrals.
- ☐ Verify that the CP temporary input power is connected correctly and is the correct voltage.
- ☐ Close the CP main circuit breaker(s).
- ☐ Verify that voltages at subsequent circuit breakers are correct.
- ☐ Close circuit breakers.
- ☐ Verify that power feeding interruptible and uninterruptible power supplies is correct.
- ☐ Turn on power supplies if they are not already on.
- ☐ Verify that voltages at distribution terminals are correct.
- ☐ Energize any remaining hardware such as the PLC.

B. Uninterruptible Power Supply (UPS)

- ☐ Mounted appropriately within the cabinet, on a dedicated shelf, or rear of a swing-out sub panel.
- ☐ Is equipped with maintenance bypass switch (or at least plug/receptacle means for bypassing the unit).
- ☐ Test all UPS alarms (on inverter, failure, battery failure etc.)
- ☐ Turn off the AC power supply and verify that the UPS will be switched on to supply the designated vital loads in the control panel.

3. CONTROLS & AUXILIARY DEVICES TEST

- ☐ Verify all interposing and auxiliary relays are functioning.
- ☐ Verify panel lights are functioning.

Ventilation and Heating

- ☐ If ventilation fans are fitted, check the fans operate correctly any associated air filters are clean and not blocked.
- ☐ Verify components are installed in the correct orientation for proper air flow.

4. HARDWIRED INTERLOCK AND SAFETY TEST

- ☐ Verify that hardwired interlocks through the control panel as shown on schematic drawings are functioning. For example, outlet high pressure switch interlock to a pump.
- ☐ Verify that all hardwired safety devices through the control panel is functioning. For example, the pull cord emergency stops of conveyors.

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5. PLC TEST

A. Components

☐ PLC interior High Temperature alarm is installed, wired to the PLC, and is shown to be functional.

☐ Relays have transient suppression across their coils. This is particularly important for DC coil relays, where diodes in reverse polarity are often used.

☐ TVSS is installed across the main incoming 120 VAC.

PLC and PLC Rack

☐ Verify all cards are securely seated.

☐ Ensure clearance around PLC rack has been met, such that convective heat transfer is not impeded by devices erroneously mounted in the “no encroachment” area. Confirm with manufacturer clearance recommendations.

B. PLC I/O Test

☐ Furnish **I/O test forms** and test all the listed input and output points as follows:

☐ Discrete Inputs: Simulate a field contact closure by “shorting” across the appropriate terminal blocks. Observe the transition between a logical “0” and “1” in the PLC software.

☐ Discrete Outputs: Force the output bit to toggle between logical “0” and logical “1” using the PLC software. Measure contact resistance at the wired terminal blocks using a digital meter selected for the “ohms” setting.

☐ Analog Inputs: Connect a signal generator to the appropriate terminal blocks. Tailor the connection depending on whether a 2-wire or 4-wire simulation is required. Modulate the 4-20mA signal. Observe the associated PLC internal memory register to transition between 0-65535 or if scaled in engineering units, between 0 and the maximum scaled engineering unit. The latter method is preferred.

☐ Analog Outputs: Force the output register to a value between 0-65535 or 0-100%, if the scaling block can be manipulated. Observe the measured 4-20mA value increment and decrement using a digital ammeter.

C. Redundant Controllers (where required) Test

☐ Remove Communication cable from primary PLC to verify switching to backup PLC

☐ Remove Communication cable from backup PLC to verify switching back to primary PLC

☐ Remove Power cable from primary PLC to verify switching to backup PLC

☐ Remove Power cable from backup PLC to verify switching back to primary PLC

D. PLC Control Logic Verification

☐ The PLC control strategy is verified by following the Control Logic Verification Form based on the specifications. Each control strategy will be verified by simulating the process and checking the state or value of PLC outputs. The results of equipment status and alarms and process instrument values and trends shall also be verified on the Plant SCADA graphic screens stored in a temporary SCADA computer. Since all PLC input and output wiring has been verified and some field devices are not available during Factory Acceptance Testing, certain inputs will be simulated either by means of additional hardware and/or software as described below.

☐

☐

☐ DI states are either simulated by hardwired switches or forced inputs using a programming terminal.

☐ For example, when starters and drives are not provided as part of the contract, jumpers may be installed from the output call relays to the running confirmation inputs to simulate the running state of the motors.

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5. PLC TEST (continued)

D. PLC Control Logic Verification (continued)

Typical Fault Logic

- ☐ If the fault input is high and the disable (if applicable) for the fault is not high and the common disable (if applicable) is not high begin timing. If any of these conditions changes, stop timing and reset the timer. If the timer reaches its preset, activate the alarm output. If the fault alarm is a shutdown alarm stop the associated motor and latch the alarm so that it remains present even if the condition clears.
- ☐ The fault condition must return to normal and the alarm must be reset for a latched alarm to clear.

Typical Fail to Start Logic

- ☐ If the motor is called to run (call output high) and no running feedback is received (running input is low) and the fail to start and common alarm disables (if applicable) are not high start timing. If any of these conditions changes, stop timing and reset the timer. If the timer reaches its preset, activate the alarm output, stop calling the motor and latch the alarm.

6. HMI OR OIT TEST

HMI / OIT Functionality

- ☐ Communication with PLC
- ☐ Screen Layouts
- ☐ Screen Navigation
- ☐ Set Point Entry
- ☐ Animation
- ☐ Color Correctness (Green=Run, Red=Off, Amber=Alarm, or the agreed upon convention)
- ☐ Alarms
- ☐ Acknowledge and Reset
- ☐ Security / Access Levels / Passwords

7. NETWORK COMMUNICATION TEST

A. Network Components

- ☐ Fiber optic cabling terminates in a patch panel
- ☐ Media converters are installed and functional
- ☐ Terminating resistors have been installed for trunk/tap topologies or where required
- ☐ Wire and cable bending limitations have not been violated

B. Networking Functions

- ☐ Verify data transfer via the network to different PLCs as shown on the Network Block Diagrams
- ☐ Verify network traffic rate and error margin is acceptable

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8. FAT DOCUMENTATION AND RECORD

Panel Documentation

- ☐ As-built panel drawings showing actual panel construction and devices arrangement and c/w Bill of Material.
- ☐ Panel schematic and interconnection drawings.
- ☐ P&ID drawings and schematic drawings for the process area controlled by the panel that is to be tested.
- ☐ I/O list test forms of the process area to be tested.
- ☐ FAT procedure of the process area to be tested.
- ☐ Test record forms of the process area to be tested. Forms shall include area for signature of responsible test personnel.
- ☐ Hard copy of the PLC application program of the process area to be tested.
- ☐ Hard copy of the HMI/OIT graphic screens of the process area to be tested.

9. FAT TOOLS AND SOFTWARE

- ☐ Simulation software if required
- ☐ Digital volt meter Fluke 87
- ☐ Process meter Fluke 787
- ☐ Laptop computer with PLC application program
- ☐ Temporary SCADA computer with HMI software and applicable graphic screens
- ☐ Jumper wires

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ATTACHMENT B - INSTALLATION AND CERTIFICATION CHECKLIST DOCUMENTATION

	INSTALLATION AND CERTIFICATION CHECKLIST DOCUMENTATION	

INSTRUMENT LOOP NO. _____

SERVICE DESCRIPTION _____

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

☐ INSTRUMENT SPECIFICATION SHEETS (FOR ALL INSTRUMENTS IN THE LOOP)

☐ INSTRUMENT INSTALLATION DETAILS (FOR ALL INSTRUMENTS IN THE LOOP)

☐ INSTRUMENT LOOP WIRING DIAGRAMS

☐ INSTRUMENT INSTALLATION CERTIFICATION CHECKLIST

☐ SIZING CALCULATIONS

☐ INSTRUMENT INSTALLATION SCHEDULE (APPLICABLE PART)

☐ NAMEPLATE SCHEDULE (APPLICABLE PART)

☐ VENDOR LITERATURE CALIBRATION INFORMATION

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

REMARKS: _____

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

SIGNATURE _____ SIGNATURE _____

DATE _____ DATE _____

ATTACHMENT C - SWITCHES INSTALLATION AND CALIBRATION CHECKLIST

	SWITCHES INSTALLATION AND CALIBRATION CHECKLIST	

INSTRUMENT LOOP NO. _____

SERVICE DESCRIPTION _____

CHECK BELOW, WHEN COMPLETED:

☐ BENCH CALIBRATED PER SPECIFICATION SHEET NO. _____

☐ VERIFIED PER P&ID NO. _____

☐ CORRESPONDS TO SPECIFICATION SHEET NO. _____

☐ WIRING CORRECT PER INSTRUMENT LOOP DRAWING NO. _____

☐ INSTALLATION CORRECT PER DETAIL NO. _____

☐ ACCESSORIES ARE PRESENT AND PROPERLY INSTALLED

☐ INSTRUMENT IS ACCESSIBLE FOR MAINTENANCE OR REMOVAL

☐ ENGRAVED LAMINATED NAMEPLATE (NO SPELLING ERRORS) PERMANENTLY INSTALLED

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

FIELD CALIBRATION CHECK

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

NOTE: PERM IS ABBREVIATION FOR PERMISSIVE

	SWITCHES INSTALLATION AND CALIBRATION CHECKLIST	

REMARKS: _____

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

SIGNATURE _____ SIGNATURE _____

DATE _____ DATE _____

ATTACHMENT D - TRANSMITTER/CONTROLLER/INDICATOR INSTALLATION AND CALIBRATION CHECKLIST

	TRANSMITTER/CONTROLLER/INDICATOR INSTALLATION AND CALIBRATION CHECKLIST	

☐ ☐

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

INSTRUMENT TYPE ☐ TRANSMITTER ☐ CONTROLLER ☐ INDICATOR

☐ OTHER DESCRIPTION _____

INSTRUMENT TAG NO. _____ SERIAL NO. _____

SERVICE DESCRIPTION _____

BENCH CALIBRATION CHECK

INPUT RANGE = _____ OUTPUT RANGE = _____

HEAD CORRECTION = _____ ☐ LINEAR

CALIBRATED SPAN = _____ ☐ SQUARE ROOT

% CALIB SPAN	DESIRED VALUE	ACTUAL VALUE	EXPECTED VALUE	ACTUAL VALUE
0				
50				
100				

CHECK BELOW, WHEN COMPLETED:

☐ BENCH CALIBRATED PER SPECIFICATION SHEET NO. _____

☐ VERIFIED PER P&ID NO. _____

☐ CORRESPONDS TO SPECIFICATION SHEET NO. _____

☐ WIRING CORRECT PER INSTRUMENT LOOP DRAWING NO. _____

☐ INSTALLATION CORRECT PER DETAIL NO. _____

☐ ACCESSORIES ARE PRESENT AND PROPERLY INSTALLED

☐ INSTRUMENT IS ACCESSIBLE FOR MAINTENANCE OR REMOVAL

☐ ENGRAVED LAMINATED NAMEPLATE (NO SPELLING ERRORS) PERMANENTLY INSTALLED

FIELD CALIBRATION CHECK

INPUT RANGE = _____ OUTPUT RANGE = _____

% CALIB SPAN	DESIRED VALUE	ACTUAL VALUE	EXPECTED VALUE	ACTUAL VALUE
0				
50				
100				

	TRANSMITTER/CONTROLLER/INDICATOR INSTALLATION AND CALIBRATION CHECKLIST	

☐ DIRECT ☐ REVERSE

☐ ACTION VERIFIED AT 50% SPAN

☐ ACTION VERIFIED AT _____ SPAN

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

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

REMARKS _____

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

SIGNATURE _____ SIGNATURE _____

DATE _____ DATE _____

ATTACHMENT E - ANALYZERS INSTALLATION AND CALIBRATION CHECKLIST

	ANALYZERS **INSTALLATION AND CALIBRATION CHECKLIST**	

☐ No ☐ Yes

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

TYPE OF INSTRUMENT _____

INSTRUMENT TAG NO. _____ SERIAL NO. _____

SERVICE DESCRIPTION _____

CHECK BELOW, IF TRUE

☐ BENCH CALIBRATED PER SPECIFICATION SHEET NO. _____

☐ VERIFIED PER P&ID NO. _____

☐ CORRESPONDS TO SPECIFICATION SHEET NO. _____

☐ WIRING CORRECT PER INSTRUMENT LOOP DRAWING NO. _____

☐ INSTALLATION CORRECT PER DETAIL NO. _____

☐ ACCESSORIES ARE PRESENT AND PROPERLY INSTALLED

☐ INSTRUMENT IS ACCESSIBLE FOR MAINTENANCE OR REMOVAL

☐ ENGRAVED LAMINATED NAMEPLATE (NO SPELLING ERRORS) PERMANENTLY INSTALLED

REMARKS _____

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

SIGNATURE _____ SIGNATURE _____

DATE _____ DATE _____

ATTACHMENT F - CONTROL VALVES
INSTALLATION AND CALIBRATION CHECKLIST

	CONTROL VALVES INSTALLATION AND CALIBRATION CHECKLIST	

☐ No ☐ Yes

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

☐ VALVE TAG NO. _____ SERIAL NO. _____

☐ TRANSDUCER TAG NO. _____ SERIAL NO. _____

☐ SOLENOID TAG NO. _____ SERIAL NO. _____

☐ VOLUME BOOSTER TAG NO. _____ SERIAL NO. _____

☐ POSITIONER _____ SERIAL NO. _____

SERVICE DESCRIPTION _____

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

CHECK BELOW, IF TRUE:

☐ BENCH CALIBRATED PER ABOVE _____

☐ VERIFIED PER P&ID NO. _____

☐ CORRESPONDS TO SPECIFICATION SHEET NO. _____

- ☐ VALVE SPECIFICATION NO. _____
- ☐ TRANSDUCER SPECIFICATION NO. _____
- ☐ SOLENOID SPECIFICATION NO. _____

☐ WIRING CORRECT PER INSTRUMENT LOOP DRAWING NO. _____

☐ INSTALLATION CORRECT PER INSTRUMENT INSTALLATION DETAILS _____

- ☐ VALVE DETAIL NO. _____
- ☐ TRANSDUCER DETAIL NO. _____
- ☐ SOLENOID DETAIL NO. _____

	CONTROL VALVES INSTALLATION AND CALIBRATION CHECKLIST	

☐ ACCESSORIES ARE PRESENT AND PROPERLY INSTALLED

☐ INSTRUMENT IS ACCESSIBLE FOR MAINTENANCE OR REMOVAL

☐ ENGRAVED LAMINATED NAMEPLATE (NO SPELLING ERRORS) PERMANENTLY INSTALLED

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

REMARKS _____

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

SIGNATURE _____ SIGNATURE _____

DATE _____ DATE _____