



Post-Filter GAC Adsorption Facilities

Issued for Construction

Hazen Contract No. 30402-067

SRF Project No. D-EC-0003 & D-2052

PWS Serial No. 24-01307

Fayetteville, North Carolina

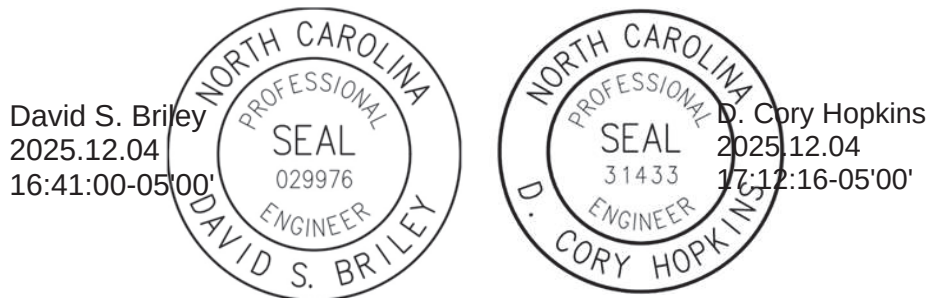
November 2025

Hazen



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**SECTION 01 11 00
SUMMARY OF WORK**

PART 1 – GENERAL

1.01 SUMMARY

A. Section Includes:

1. Summary
2. Location and Description of Work
3. Construction Contracts, This Project
4. Construction Contracts, Other Projects
5. Work by Others
6. Work by Owner
7. Owner Furnished Equipment and Materials
8. Owner Assigned Procurement Contracts
9. Owner Pre-selected Equipment and Materials
10. Sequence and Progress of Work
11. Contractor's Use of Site
12. Easements and Rights-of-Way
13. Notices to Owners and Authorities of Properties Adjacent to the Work
14. Salvage of Equipment and Materials
15. Partial Utilization by Owner

1.02 LOCATION AND DESCRIPTION OF WORK

A. The Work is located at the following Sites:

1. P.O. Hoffer WTF - 508 Hoffer Drive, Fayetteville, NC 28301
2. Glenville Lake WTF - 628 Filter Plant Drive, Fayetteville, NC 28301

B. The Work to be performed under this Contract includes, but is not limited to, constructing the Work described below and all appurtenances related to the Work. The Work shall be as follows:

1. P.O. Hoffer WTF

- a. Construct a GAC Facility to include twelve (12) post-filter GAC contactors, a filter gallery, an electrical room, an intermediate pump station with four (4) vertical turbine can pumps, and a backwash pump station with three (3) vertical turbine can pumps.
- b. Install yard piping and make connections to existing structures to provide a fully functional post-filter GAC system.
- c. Complete building, electrical, instrumentation and controls systems upgrades associated with this work.
- d. Startup and commission all new facilities and associated equipment.

2. Glenville Lake WTF

- a. Construct a GAC Facility to include ten (10) dual-cell post-filter GAC contactors and a filter gallery.
- b. Construct an electrical building.
- c. Construct an intermediate pump station with three (3) vertical turbine can pumps and a backwash pump station with two (2) vertical turbine can pumps.
- d. Construct a chemical injection/mixing vault and splitter weir box.
- e. Install yard piping and make connections to existing structures to provide a fully functional post-filter GAC system.
- f. Complete building, electrical, instrumentation and controls system upgrades associated with this work.
- g. Startup and commission all new facilities and associated equipment.

1.03 CONSTRUCTION CONTRACTS, THIS PROJECT

A. The Contracts under which the Project will be constructed are:

1. Work specified in Divisions 01 through 46 (inclusive) of the Specifications.
2. Work shown on all sheets of the Contract Drawings.

1.04 CONSTRUCTION CONTRACTS, OTHER PROJECTS

- A. Reliability Improvements Project (P.O. Hoffer WTF and Glenville Lake WTF)

1. Project Manager: Brian Harrington, Crowder Construction Company

1.05 WORK BY OTHERS (NOT USED)

1.06 WORK BY OWNER

- A. Owner will perform the following in connection with the Work: Operate all existing valves, gates, pumps, equipment, and appurtenances that will affect Owner's operation, unless otherwise specified or indicated.

1.07 OWNER-FURNISHED EQUIPMENT AND MATERIALS (NOT USED)

1.08 OWNER ASSIGNED PROCUREMENT DOCUMENTS (NOT USED)

1.09 OWNER PRE-SELECTED EQUIPMENT AND MATERIALS

- A. Items of equipment and material to be provided by Contractor that have been pre-selected and with Bid Form price listed:
1. Granular activated carbon media by Calgon
 2. Turbidity, pH/temperature, and free chlorine analyzers by SWAN
 3. PLCs by Allen-Bradley
 4. Motor starters and VFDs by Allen-Bradley
 5. Electric valve actuators by Emerson
 6. Radar level sensors and transmitters by Krohne
 7. Differential pressure sensors and transmitters by Rosemount
- B. Contractor shall provide equipment and material in accordance with the Contract Documents.

1.10 SEQUENCE AND PROGRESS OF WORK

- A. Requirements for sequencing and coordinating with Owner's operations, including maintenance of plant operations during construction, and requirements for tie-ins and shutdowns, are in Section 01 14 00 – Coordination with Owner's Operations.

1.11 CONTRACTOR'S USE OF SITE

- A. Contractors' use of the Site shall be confined to the areas shown. Contractors shall share use of the Site with other contractors and others specified in this Section.
- B. Contractor shall move stored products that interfere with operations of Owner, other contractors, or others performing work for Owner.

1.12 EASEMENTS AND RIGHTS-OF-WAY

- A. Easements and rights-of-way will be provided by Owner in accordance with the General Conditions. Confine construction operations to within Owner's property, public rights-of-way, easements obtained by Owner, and the limits shown. Use care in placing construction tools, equipment, excavated materials, and products to be incorporated into the Work to avoid damaging property and interfering with traffic. Do not enter private property outside the construction limits without permission from the owner of the property.

1.13 NOTICES TO OWNERS AND AUTHORITIES OF PROPERTIES ADJACENT TO THE WORK

- A. Notify owners of adjacent property and utilities when execution of the Work may affect their property, facilities, or use of property.
- B. When it is necessary to temporarily obstruct access to property, or when utility service connection will be interrupted, provide notices sufficiently in advance to enable affected persons to provide for their needs. Conform notices to Laws and Regulations and, whether delivered orally or in writing, include appropriate information concerning the interruption and instructions on how to limit inconvenience caused.
- C. Notify utility owners and other concerned entities at least 48 hours prior to cutting or closing streets or other traffic areas or excavating near Underground Facilities or exposed utilities.

1.14 SALVAGE OF EQUIPMENT AND MATERIALS

- A. Existing equipment and materials removed and not shown or specified to be reused in the Work will be Contractor's property.

- B. Existing equipment and material removed by Contractor shall not be reused in the Work, except where specified or indicated.
- C. Carefully remove in manner to prevent damage all equipment and materials specified or indicated to be salvaged and reused or to remain property of Owner. Store and protect salvaged items specified or indicated to be used in the Work. Replace in kind or with new items equipment, materials, and components damaged in removal, storage, or handling through carelessness or improper procedures.
- D. Contractor may furnish and install new items, with Engineer's approval, instead of those specified or indicated to be salvaged and reused, in which case such removed items will become Contractor's property.

1.15 PARTIAL UTILIZATION BY OWNER

- A. Owner reserves the right to enter and use portions of the Work prior to Certificate of Substantial Completion is issued by Engineer.
- B. Owner shall be responsible to prevent premature connections by private and public parties, persons or groups of persons, before Engineer issues Certificate of Substantial Completion for the portion of Work being partially utilized by Owner.
- C. Contractor shall cooperate with Owner, Owner's agents, and Engineer to accelerate completion of Work designed for partial utilization by Owner in accordance with Contractor's progress schedule.

PART 2 – PRODUCTS (NOT USED)

PART 3 – EXECUTION (NOT USED)

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SECTION 01 14 00
COORDINATION WITH OWNER'S OPERATIONS

PART 1 – GENERAL

1.01 SUMMARY

A. Section Includes:

1. Requirements for coordinating with Owner's operations during the Work and included requirements for tie-ins and shutdowns necessary to complete the Work without impact on Owner's operations except as allowed in this Section.
2. Contractor shall provide labor, materials, tools, equipment and incidentals shown, specified and required to coordinate with Owner's operations during the Work.

B. General Requirements:

1. Except for shutdowns specified in this Section, perform the Work such that Owner's facility remains in continuous satisfactory operation during the Project. Schedule and conduct the Work such that the Work does not: impede Owner's production or processes, create potential hazards to operating equipment and personnel, reduce the quality of the facility's products or effluent, or cause odors or other nuisances.
2. Work not specifically covered in this Section or in referenced Sections may, in general, be completed at any time during regular working hours in accordance with the General Conditions and Supplementary Conditions, subject to the requirements in this Section.
3. Contractor has the option of providing additional temporary facilities that can eliminate or mitigate a constraint without additional cost to Owner, provided such additional temporary facilities: do not present hazards to the public, personnel, structures, and equipment; that such additional temporary facilities do not adversely affect Owner's ability to comply with Laws and Regulations, permits, and operating requirements; that such temporary facilities do not generate or foster the generation of odors and other nuisances; and that requirements of the Contract Documents are fulfilled.
4. Coordinate shutdowns with Owner and Engineer. When possible, combine multiple tie-ins into a single shutdown to minimize impacts on Owner's operations and processes.
5. Do not shut off or disconnect existing operating systems, unless accepted by Engineer in writing. Operation of existing equipment will be by Owner unless

otherwise specified or indicated. Where necessary for the Work, Contractor shall seal or bulkhead Owner-operated gates and valves to prevent leakage that may affect the Work, Owner's operations, or both. Provide temporary watertight plugs, bulkheads, and line stops as required. After completing the Work, remove seals, plugs, bulkhead, and line stops to satisfaction of Engineer.

C. Continuous Treatment Provision:

1. Federal regulations prohibit bypassing of untreated or partially treated wastewater or sewage during construction Work.
2. Contractor shall provide labor, equipment, materials, and incidentals to provide continuous treatment to the level prior to construction Work.
3. Contractor shall be responsible for providing temporary pumping facilities, systems, piping, valve, appurtenances, equipment, materials, and temporary utilities necessary to complete the Work without treatment bypassing.

D. Related Sections:

1. Section 01 11 00 – Summary of Work
2. Section 01 25 00 – Substitution Procedures
3. Section 01 73 00 – Demolition and Execution of Work

1.02 REFERENCES

- A. Definitions: A "shutdown" is when a portion of the normal operation of Owner's facility, whether equipment, systems, piping, or conduit, has to be temporarily suspended or taken out of service to perform the Work.

1.03 ADMINISTRATIVE REQUIREMENTS

A. Coordination:

1. Review installation procedures under other Specification sections and coordinate Work that must be performed with or before the Work specified in this Section.
2. Notify other contractors in advance of Work requiring coordination with Owner's operations, to provide other contractors sufficient time for work included in their contracts that must be installed with or before Work specified in this Section.
3. When possible, combine multiple tie-ins into a single shutdown to minimize impacts on Owner's operations and processes.

- B. Pre-Shutdown Meetings: Contractor shall schedule and conduct meeting with Owner and Engineer prior to scheduling shutdown
- C. Sequencing:
 - 1. Perform the Work in the specified sequence. Certain phases or stages of the Work may require working 24-hour days or work during hours outside of regular working hours. Work may be accelerated from a later stage to an earlier stage if Owner's operations are not adversely affected by proposed sequence change, with Engineer's acceptance. Stages specified in this Section are sequential in performance of the Work.
- D. Scheduling:
 - 1. Work that may interrupt normal operations shall be accomplished at times convenient to Owner.
 - 2. Furnish at the Site, in close proximity to the shutdown and tie-in work areas, tools, equipment, spare parts and materials, both temporary and permanent, necessary to successfully complete the shutdown. Complete to the extent possible, prefabrication of piping and other assemblies prior to the associated shutdown Demonstrate to Engineer's satisfaction that Contractor has complied with these requirements before commencing the shutdown.
 - 3. If Contractor's operations cause an unscheduled interruption of Owner's operations, immediately re-establish satisfactory operation for Owner.
 - 4. Unscheduled shutdowns or interruptions of continued safe and satisfactory operation of Owner's facilities that result in fines or penalties by authorities having jurisdiction shall be paid solely by Contractor if, in Engineer's opinion, Contractor did not conform to the requirements of the Contract Documents, or was negligent in the Work, or did not exercise proper precautions in conducting the Work.
 - 5. Work requiring service interruptions for tie-ins shall be performed during scheduled shutdowns.
 - 6. Temporary, short-term shutdowns of smaller piping, conduits, equipment, and systems may be required. Coordinate requirements for such shutdowns with Engineer and Owner.

1.04 SUBMITTALS

- A. Action/Informational Submittals:

1. Substitute Sequence Submittal: When deviation from specified sequence is proposed, provide submittal explaining in detail the proposed sequence change and its effects, including evidence that Owner's operations will not be adversely affected by proposed change. List benefits of proposed sequence change, including benefits to Progress Schedule. Submit in accordance with Section 01 25 00 – Substitution Procedures.
2. Shutdown Planning Submittal:
 - a. For each shutdown, submit an inventory of labor and materials required to perform the shutdown and tie-in tasks, an estimate of time required to accomplish the complete shutdown including time for Owner to take down and start up existing equipment, systems, or conduits, and written description of steps required to complete the Work associated with the shutdown.
 - b. Furnish submittal to Engineer at least thirty (30) days prior to proposed shutdown start date. Do not start shutdown until obtaining Engineer's acceptance of shutdown planning submittal.
3. Shutdown Notification: After acceptance of shutdown planning submittal and prior to starting the shutdown, provide written notification to Owner and Engineer of date and time each shutdown is to start. Provide notification at least 72 hours in advance of each shutdown.

1.05 SITE CONDITIONS

- A. General Constraints: Specified in the Contract Documents are the sequence and shutdown durations, where applicable, for Owner's equipment, systems, and conduits that are to be taken out of service temporarily for the Work. New equipment, materials, and systems may be used by Owner after the specified field quality controls and testing are successfully completed and the materials or equipment are Substantially Complete.
- B. The following constraints apply to coordination with Owner's operations:
 1. Operational Access: Owner's personnel shall have access to equipment and areas that remain in operation.
 2. Schedule and perform equipment and system start-ups for Monday through Thursday. Equipment and systems shall not be placed into operation on Friday, Saturday, and Sunday without prior approval of Owner.
 3. Dead End Valves or Pipe: Provide blind flanges, watertight bulkheads, or valves at temporary and permanent terminuses of pipes and conduits. Blind flanges and bulkheads shall be suitable for the service and braced and blocked, as required, or otherwise restrained as directed by Engineer. Temporary valves shall be suitable for their associated service. Where valve is provided at permanent terminus of pipe or

conduit, also provide on downstream side of valve a blind flange with drain/flushing connection.

4. Owner will assist Contractor in dewatering process tanks, basins, conduits, and other work areas to be dewatered for shutdowns. Maintain clean and dry work area by pumping and properly disposing of fluid that accumulates in work areas.
5. Draining and Cleaning of Conduits, Tanks, and Basins: Unless otherwise specified, Owner will dewater process tanks and basins at beginning of each shutdown. Owner will flush and wash down tanks and basins with plant non-potable water. Draining and cleaning conducted by Contractor shall be as specified below:
 - a. Contractor shall remove liquids and solids and dispose of them at appropriate location at the Site as directed by Engineer. If there is no place onsite to dispose of contents, contractor is fully responsible for offsite disposal of all contents, including any associated disposal permits. Contents of pipes, tanks, basins, and conduits undergoing modifications shall be transferred to existing process tanks or conduits at the Site with capacity sufficient to accept such discharges, using hoses, piping, pumps, or other means provided by Contractor. Discharge of fluids across floors is not allowed.
 - b. If drainage point is not available on the piping or conduit to be drained, provide a wet tap using tapping saddle and valve or other method approved by Engineer. Uncontrolled spillage of pipe's or conduit's contents is not allowed.
 - c. Spillage shall be brought to Engineer's attention immediately, both verbally and in writing, and reported in accordance with Laws and Regulations. Contractor shall wash down spillage to floor drains or sumps and flush the system to prevent clogging and odors. If spillage is not suitable for discharge to the drainage system, such as chemical spills, as determined by Engineer, Contractor shall remove spillage by other method, such as vactor truck, acceptable to Engineer.
6. Electrical, Control, Communication, and Monitoring Systems:
 - a. Owner's existing SCADA system and fiber optic network shall remain functional, subject to the constraints herein.
 - b. Fiber optic communications and network connectivity to all facilities shall remain operational at all times unless approved in writing by the Engineer.
 - c. Unless Contractor elects to use existing fiber and/or temporary fiber, at his/her discretion, at least one communication path through the new dual redundant fiber optic ring to all communication points shall be in place at all times until substantial completion.

- d. Each process area shall be permitted to have a single, non-concurrent, scheduled outage for the purpose of making PLC panel hardware modifications, loading the associated PLC logic, and its field testing/demonstration. Field testing and demonstration shall immediately follow modifications in an effort to keep scheduled shutdowns as short as possible. A 14-day day period of no SCADA outage shall proceed each scheduled shutdown.

1.06 SUGGESTED SEQUENCE OF WORK

- A. Perform the Work in the proposed sequence or as otherwise approved by Engineer. Certain activities may require working 24-hour days or work during hours outside of regular working hours. Work may be accelerated if Owner's operations are not adversely affected by proposed sequence change, and with Engineer's acceptance. The construction activities specified in this Section are sequence dependent and are not meant to be inclusive of all project requirements but are intended to show the associated construction activities and constraints of events as well as the effort to take the facilities out of service and to isolate the affected process pipelines and other utilities. If there are any conflicting project requirements, the more stringent requirements shall be applicable.

- B. Glenville Lake

- 1. Notable Long-Term Shutdown: Due to the severe operational impacts of many improvements in this contract, the entire Glenville Lake Facility will perform a long-term shutdown. The Contractor shall complete specific parts of the scope of work during this long-term shutdown as noted in Part B.1 herein.
 - a. The long-term shutdown will occur between the months of October – February at the owner's discretion and will be dependent on plant demands during the time it is requested. The shutdown will be for a period of 30 calendar days.
 - b. All modifications to the 30" FLW shall be completed during the long-term shutdown. At the end of the shutdown, the Owner shall have the ability to convey water through the 30" FLW from the filtered water flumes to the 5 MG clearwell.
 - c. All modification to the 30" FW on the downstream side of the 5 MG clearwell shall be complete.
 - d. All improvements impacting the filtered water flume shall be completed during the long-term shutdown. Improvement include, but are not limited to, 30" FLW pipe connection, 24" GE pipe connection, installation of new chemical feed points, and structural improvements inside the flume.
 - e. The Contractor may elect to perform additional tie-ins during the long-term shutdown provided; however, priority shall be given to completing all work

specified in Part B.1 herein prior to the Glenville Lake Facility being placed back into service at the end of the 30-day period.

2. Existing Oil and Grease Storage Building

- a. Contractor shall relocate the existing oil and grease building to the new location where indicated on the Contract Drawings prior to commencing work at the Intermediate Pump Station or adjacent yard piping.

3. 24" BWD Tie-In

- a. Contractor shall perform tie-in during a short term shutdown not to exceed 8 hours.
- b. Advanced notice of 45 days will be required to allow plant staff to coordinate plant blowdown and backwash operations accordingly.

4. Loading Dock

- a. Contractor shall maintain access to the plant loading dock on the east side of the existing ammonia building at all times

5. Ammonia Building

- a. Contractor shall maintain access to the ammonia facility fill stations as required for chemical deliveries.
- b. Owner schedules ammonia deliveries quarterly.

C. P.O. Hoffer

1. 24" GWS Tie-In

- a. Tie-In of the 24" GWS to the existing clearwell shall occur between the months of November and February unless otherwise approved by Engineer.
- b. Tie-In of the 24" GWS shall not occur when the Glenville Lake Facility is performing the long-term shutdown.
- c. Tie-In of the 24" GWS to the clearwell shall occur during a short-term shutdown not to exceed 8 hours.

2. 54" FLW and GE Tie-In

- a. Contractor shall install temporary measures in the Filter Effluent Flume as described herein and indicated on the Contract Drawings in order to isolate the areas of the Filter Effluent Flume necessary to perform the tie in of new 54"

pipng to the Filter Effluent Flume. Temporary measures shall be installed during a short-term shutdown not to exceed 8 hours.

- 1) Coordinate with plant staff to provide complete isolation to the Filter Effluent Flume areas for the duration of the shutdown.
- 2) Install a watertight bulkhead to the east of the Filter 13-16 effluent discharge inside the Filter Effluent Flume. Bulkhead shall be the full width of flume and extend to a minimum of EL 98.00.
- 3) Install a watertight steel plate at the far west end of the Filter Serpentine Flume. Plate shall be full height and prevent any water from entering the serpentine flume.
- 4) Remove the existing steel plate located at the far west end of the Filter Effluent Flume.
- 5) Once all modifications are complete, the flume may be returned to service. Modifications will effectively reverse the normal direction of flow in the Filter Effluent Flume so that flow is from East to West, and will allow the 54" tie-in modifications to be performed in the dry.
- 6) At the completion of all piping tie-ins and associated improvements, the contractor shall return the filter effluent flumes to their original operating conditions by removing the temporary plates and bulkheads, and reinstalling the steel plate at the west end of the Filter Effluent Flume. This shall be performed during a short-term shutdown not to exceed 8 hours.

3. 30" GWW

- a. Contractor shall coordinate with the Owner to schedule a short-term shutdown of all processes that discharge to the plant solids collection flume. Short-term shutdown is not to exceed 8 hours.
 - 1) During the shutdown, contractor shall install a watertight bulkhead on the west (interior) side of the existing wall opening thimble located on the east most exterior wall of the flume. The bulkhead shall be a minimum of 4 feet high. The bulkhead will allow the contractor to perform modifications to the GWW collection box at the east side of the facility.
 - 2) Bulkhead shall be removed during an additional short-term shutdown once all work is completed on the GWW collection box and the new 30" GWW is tied into the box.

4. Road Access shall be maintained for the Owner at all times. Temporary measures such as steel plates shall be provided as necessary to allow access above any excavations located at roadways.

1.07 SHUTDOWNS AND PROJECT CONSTRAINTS

A. General:

1. Work that may interrupt normal operations shall be accomplished at times convenient to Owner.
2. Furnish at the Site, in close proximity to the shutdown and tie-in work areas, tools, equipment, spare parts and materials, both temporary and permanent, necessary to successfully complete the shutdown. Complete to the extent possible, prefabrication of piping and other assemblies prior to the associated shutdown. Demonstrate to Engineer's satisfaction that Contractor has complied with these requirements before commencing the shutdown.
3. If Contractor's operations cause an unscheduled interruption of Owner's operations, immediately re-establish satisfactory operation for Owner.
4. Unscheduled shutdowns or interruptions of continued safe and satisfactory operation of Owner's facilities that result in fines or penalties by authorities having jurisdiction shall be paid solely by Contractor if, in Engineer's opinion, Contractor did not conform to the requirements of the Contract Documents, or was negligent in the Work, or did not exercise proper precautions in conducting the Work.
5. Shutdowns shall be in accordance with this Section. Work requiring service interruptions for tie-ins shall be performed during scheduled shutdowns. This specification may not include all tie-ins required for the Work; Contractor shall perform tie-ins required to complete the Work as shown on the Contract Drawings.
6. Temporary, short-term shutdowns of smaller piping, conduits, equipment, and systems may not be included in this section. Coordinate requirements for such shutdowns with Engineer and Owner.

B. Treatment Process Shutdown and Site Access Constraints:

1. Owner shall have the existing unit processes and equipment operational at all times during the Project, unless specified herein or otherwise approved by the Owner and Engineer.

C. Shutdowns of Electrical Systems: Comply with Laws and Regulations, including the National Electric Code. Contractor shall lock out and tag circuit breakers and switches

operated by Owner and shall verify that affected cables and wires are de-energized to ground potential before shutdown Work is started. Upon completion of shutdown Work, remove the locks and tags and notify Engineer that facilities are available for use.

D. Shutdowns of Communications, SCADA, and Networking:

1. All shutdowns required to complete the Work described herein shall be submitted to the engineer for review and approved 30 days prior to execution.

PART 2 – EXECUTION

2.01 DETAILED SHUTDOWN REQUIREMENTS:

A. Prior to Typical Shutdown:

1. Obtain Engineer's acceptance of proposed shutdown planning submittal and shutdown notification submittal.
2. Submittal and approval of all shop drawings required.
3. Coordinate with plant operations on timing of shutdown and provide required notice to Owner.
4. Bring necessary piping, couplings, valves, equipment, and appurtenances to the work areas.
5. Assist Owner in preparing to take equipment, tanks, basins, and conduits temporarily out of service.
6. Coordinate other tie-ins to be performed simultaneously.
7. Install and ensure functionality of temporary systems as applicable.

B. During Typical Shutdown:

1. Owner will dewater existing associated tanks, basins, etc. to the extent possible. Contractor will be responsible for the remainder of dewatering efforts.
2. Remove existing equipment, piping, and accessories as required.
3. Verify operation of new equipment, materials, and systems.
4. Following approval from Engineer, return equipment and system to operation with Owner.

C. Following Typical Shutdown:

1. Verify functionality of equipment and system.
2. Verify operation of new equipment and systems and verify that joints in piping are watertight or gastight as applicable.
3. Repair joints that are not watertight or gastight as applicable.
4. Remove temporary systems as applicable.

END OF SECTION

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SECTION 01 20 00
MEASUREMENT AND PAYMENT

PART 1 – GENERAL

1.01 SUMMARY

A. Section Includes:

1. Items listed in this Section refer to and are the same pay items listed in the Bid Form and constitute all pay items for completing the Work.
2. Compensation for all services, items, materials, and equipment shall be include in prices stipulated for lump sum and unit price pay items listed in this Section and included in the Contract.
3. No direct or separate payment will be made for providing miscellaneous temporary or accessory works, bonds, insurance, or other requirements of the General Conditions, Supplementary Conditions, General Requirements, and other requirements of the Contract Documents.
4. Each lump sum and unit bid price shall include an amount considered by Contractor to be adequate to cover Contractor's overhead and profit for each separately identified item.

B. Related Sections:

1. Payments to Contractor: Refer to General Conditions, Supplementary Conditions, and Agreement.
2. Changes to Contract Price: Refer to General Conditions, Supplementary Conditions, and Section 01 26 00 – Contract Modification Procedures.
3. Schedule of Values: Refer to General Conditions, Supplementary Conditions, and Section 01 29 73 – Schedule of Values.

1.02 ENGINEER'S ESTIMATE OF QUANTITIES

- A. ENGINEER'S and OWNER's estimated quantities for unit price pay items, as listed in the Bid Form, are approximate only and are included solely for the purpose of comparison of Bids. Owner does not expressly or by implication agree that the nature of the materials encountered below the surface of the ground or the actual quantities of material encountered or required will correspond therewith and reserves the right to increase or decrease any quantity or to eliminate any quantity as Owner may deem necessary. Contractor will not be entitled to any adjustment in a unit bid price as a result

of any change in an estimated quantity and agrees to accept the aforesaid unit bid prices as complete and total compensation for any additions caused by changes or alterations in the Work ordered by Owner.

1.03 ADMINISTRATIVE REQUIREMENTS

- A. Contractor shall include all additional Work items, services, goods, resources, and manpower necessary for installation of the Work to provide a completely functional system in accordance with the Contract Documents.

PART 2 – PRODUCTS (NOT USED)

PART 3 – EXECUTION (NOT USED)

END OF SECTION

SECTION 01 25 00
SUBSTITUTION PROCEDURES

PART 1 – GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Procedural requirements for product substitutions.
 - 2. Procedural requirements for substitute construction methods or procedures, when construction methods or procedures are specified.
- B. Requests for substitutions of equipment and material shall conform to the requirements of the General Conditions and Supplemental Conditions.
- C. Procedure for substitution requests and review including evaluation, reimbursement, acceptance, and determination shall be in accordance with General Conditions and Supplemental Conditions.

1.02 REFERENCES

- A. Definitions: The following words or terms are not defined but, when used in this Section, have the following meaning:
 - 1. “Acceptable Manufacturers” considered for substitution include Suppliers of equipment and material of proven reliability, and as manufactured by reputable manufacturers having experience in the production of specified equipment and material. Equipment furnished shall be designed, constructed, and installed in accordance with the industry accepted practices and shall operate satisfactorily when installed in accordance with the Contract Documents.
 - 2. “Products” includes materials, equipment, machinery, components, fixtures, systems, and other goods incorporated in the Work. Products do not include machinery and equipment used for preparing, fabricating, conveying, erecting, or installing the Work. Products include Owner-furnished goods incorporated in the Work where use of such goods is specifically required in the Contract Documents.

1.03 ADMINISTRATIVE REQUIREMENTS

- A. Contractor’s Responsibilities: In submitting request for substitution, Contractor represents that:

1. Contractor has investigated proposed substitution and determined that it is equivalent to item, product, method, or procedure specified, as applicable.
 2. Contractor will provide the same or better guarantees or warranties for proposed substitution as for the specified product, manufacturer, method, or procedure, as applicable.
 3. Contractor waives all Claims for additional costs or extension of time related to proposed substitution that subsequently may become apparent.
 4. Contractor shall submit a minimum of five (5) successful installations of the manufacturer's equipment of the same model, size, and type as specified in the Contract Documents.
 5. All costs associated with incorporation of a substitution shall be borne by the Contractor, including but not limited to, the cost of redesign and construction provisions.
- B. Engineer's Review: A proposed substitution will not be accepted for review if:
1. Approval would require changes in design concept or a substantial revision of the Contract Documents.
 2. Approval would delay completion of the Work or the work of other contractors.
 3. Substitution request is indicated or implied on a Shop Drawing or other submittal, or on a request for interpretation or clarification, and is not accompanied by Contractor's formal request for substitution.
 4. If the substitution is not clearly substantiated by performance criteria as providing an equivalent or superior performing installation.
 5. All costs associated with Engineer's review of a substitution shall be recorded by Engineer, submitted to Owner, and charged to Contractor.
- C. If Engineer does not approve the proposed substitute, Contractor shall provide the specified product, manufacturer, method, or procedure, as applicable.
- D. Approval of a substitution request will not relieve Contractor from requirement for submitting Shop Drawings as set forth in the Contract Documents.
- E. Product Substitutions Procedure:
1. Requests for approval of substitute products or items will be considered for a period of 30 days after the Effective Date of the Agreement. After end of specified

period, requests will be considered only in case of unavailability of a specified product or other conditions beyond Contractor's control.

2. Submit copies of request for substitution.
3. Submit separate request for each substitution.
4. In addition to requirements of the General Conditions and information required on substitution request forms, include with request the following:
 - a. Product identification, including manufacturer's name and address.
 - b. Manufacturer's literature with product description, performance and test data, and reference standards with which product complies.
 - c. Samples, if appropriate.
 - d. Name and address of similar projects on which product was used, and date of installation.
 - e. Certified tests, where applicable, by an independent laboratory attesting the proposed substitution is equal.
 - f. Cost information for the proposed substitution and the specified products.
 - g. Lead time information for the proposed substitution and specified products.
 - h. All other submittal requirements indicated in the individual Specification Sections associated with the specified equipment and material.

F. Construction Methods Substitutions Procedures:

1. Where construction methods or procedures are specified, for a period of 30 days after the Effective Date of the Agreement, Engineer will consider Contractor's written requests for substitute construction methods or procedures specified.
2. Submit copies of request for substitution.
3. Submit separate request for each substitution.
4. In addition to requirements of the General Conditions and information required on substitution request forms, include with request the following:
 - a. Detailed description of proposed method or procedure.
 - b. Itemized comparison of the proposed substitution with the specified method or procedure.

- c. Drawings illustrating method or procedure.
- d. Other data required by Engineer to establish that proposed substitution is equivalent to specified method or procedure.

PART 2 – PRODUCTS (NOT USED)

PART 3 – EXECUTION (NOT USED)

END OF SECTION

SECTION 01 26 00
CONTRACT MODIFICATION PROCEDURES

PART 1 – GENERAL

1.01 THE REQUIREMENT

A. Section Includes:

1. General Conditions and Supplementary Conditions provision expansion, including the following:
 - a. Requests for interpretation.
 - b. Clarification notices
 - c. Field Orders
 - d. Work Change Directives
 - e. Proposal requests
 - f. Change Proposals
 - g. Change Orders

1.02 ADMINISTRATIVE REQUIREMENTS

- A. Submit Contract modification documents to Engineer's contact person and address in the Contract Documents.
- B. Retain at Contractor's office and at the Site complete copy of each Contract modification document and related documents, and Engineer's response.

1.03 REQUEST FOR INTERPRETATION

A. General:

1. Submit electronic requests for interpretation to Engineer. Contractor and Owner may submit requests for interpretation.
2. Submit request for interpretation to obtain clarification or interpretation of the Contract Documents. Report conflicts, errors, ambiguities, and discrepancies in the Contract Documents using requests for interpretation.

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3. Do not submit request for interpretation when other form of communication is appropriate, such as submittals, requests for substitutions or "or equals", notices, ordinary correspondence, or other form of communication. Improperly prepared or inappropriate requests for interpretation will be returned without response or action.

B. Procedure:

1. Submit one original (electronic) of each request for interpretation. Submit each request for interpretation with separate letter of transmittal if hard copies are submitted.
 2. Engineer will provide timely review of requests for interpretation. Allow sufficient time for review and response.
 3. Engineer will maintain log of requests for interpretation. Copy of log will be provided upon request.
 4. Engineer will provide written response to each request for interpretation. One copy of Engineer's response will be distributed to:
 - a. Contractor
 - b. Owner
 - c. Engineer
 - d. Resident Project Representative (RPR)
- C. If Engineer requests additional information to make an interpretation, provide information requested within ten (10) days, unless Engineer allows additional time, via correspondence referring to request for interpretation number.
- D. If Contractor or Owner believes that a change in the Contract Price or Contract Times or other change to the Contract is required, notify Engineer in writing before proceeding with the Work associated with the request for interpretation.
- E. Submit each request for interpretation on a form acceptable to Engineer.
1. Number each request for interpretation as follows: Numbering system shall be the Contract number and designation followed by a hyphen and three-digit sequential number.
 2. In space provided on form, describe the interpretation requested. Provide additional sheets as necessary. Include text and sketches as required in sufficient detail for engineer's response.

3. When applicable, request for interpretation shall include Contractor's recommended resolution.

1.04 CLARIFICATION NOTICES

A. General:

1. Clarification notices, when required, will be initiated and issued by Engineer.
2. Clarification notices do not change the Contract Price or Contract Times, and do not alter the Contract Documents.
3. Clarification notices will be issued as correspondence or using clarification notice form, with additional information as required.

B. Procedure:

1. Electronic copies of Clarification Notices will be maintained, stored, and distributed by electronic construction document management system.
2. If Contractor or Owner believes that a change in the Contract Price or the Contract Times or other change to the Contract is required, notify Engineer in writing before proceeding with the Work associated with clarification notice.
3. If clarification notice is unclear, submit request for interpretation.

1.05 FIELD ORDERS

A. General:

1. Field Orders, when required, will be initiated and issued by Engineer.
2. Field Orders authorize minor variations in the Work but do not change the Contract Price or Contract Times.
3. Field Orders will be in the form of Engineers Joint Contract Documents Committee (EJCDC) document C-942, "Field Order" or other Engineer's accepted form.
4. Engineer will maintain a log of Field Orders issued.

B. Procedure.

1. Electronic copies of Field Orders will be maintained, stored, and distributed by electronic construction document management system.

2. If Contractor or Owner believes that a change in the Contract Price or the Contract Times or other change to the Contract is required, immediately notify Engineer in writing before proceeding with the Work associated with the Field Order.
3. If the Field Order is unclear, submit request for interpretation.

1.06 WORK CHANGE DIRECTIVE

A. General:

1. Work Change Directives, when required, order additions, deletions, or revisions to the Work.
2. Work Change Directives do not change the Contract Price or Contract Times but are evidence that the parties to the Contract expect that the change ordered or documented by the Work Change Directive will be incorporated in subsequently issued Change Order following negotiations by the parties as to its effect, if any, on the Contract Price or Contract Times.
3. Work Change Directives will be in the form of EJCDC document C-940, "Work Change Directive" or other Engineer's accepted form.

B. Procedure:

1. Three originals of Work Change Directive signed by Owner and Engineer will be furnished to Contractor, who shall promptly sign each original Work Change Directive and, within five days of receipt, return all originals to Engineer.
2. Original, signed Work Change Directives will be distributed as follows:
 - a. Contractor: One original
 - b. Owner: One original
 - c. Engineer: One original
3. One hard copy of each Work Change Directive will be distributed to: Resident Project Representative (RPR).
4. When required by Engineer, document for the Work performed under each separate Work Change Directive, for each day, the number and type of workers employed and hours worked; equipment used including manufacturer, model, and year of equipment, and number of hours; materials used, receipts for and descriptions of materials and equipment incorporated into the Work, invoices and labor and equipment breakdowns for Subcontractors and Suppliers, and other

information required by Owner or Engineer, in a format acceptable to Engineer. Submit this documentation to Engineer as a Change Proposal.

1.07 PROPOSAL REQUESTS

A. General:

1. Proposal requests may be initiated by Engineer or Owner.
2. Proposal requests are for requesting the effect on the Contract Price and the Contract Times and other information relative to contemplated changes in the Work. Proposal requests do not authorize changes or variations in the Work, and do not change the Contract Price or Contract Times or terms of the Contract.
3. Proposal requests will be furnished using the proposal request form included with this Section.

B. Procedure.

1. One copy of each signed proposal request will be furnished to Contractor with one copy each to:
 - a. Owner
 - b. Engineer
 - c. Resident Project Representative (RPR)
2. Submit request for interpretation to clarify conflicts, errors, ambiguities, and discrepancies in proposal request.
3. Upon receipt of proposal request, Contractor shall prepare and submit a Change Proposal, in accordance with this Section, for the proposed Work described in the proposal request.

1.08 CHANGE PROPOSALS

A. General.

1. Submit written Change Proposal to Engineer in response to each proposal request, and when Contractor believes a change in the Contract Price or Contract Times or other change to the terms of the Contract is required.

B. Procedure.

1. Submit to Engineer one original and one copy of each Change Proposal with accompanying documentation, and simultaneously submit two copies to Owner. Submit each Change Proposal with separate letter of transmittal.
 2. Engineer will review Change Proposal and either request additional information from Contractor or provide to Owner recommendation regarding approval of the Change Proposal.
 3. When Engineer requests additional information to render a decision, submit required information within five days of receipt of Engineer's request, unless Engineer allows more time. Submit the required information via correspondence that refers to Change Proposal number.
 4. Upon completing review, one copy of Engineer's written response, if any, will be distributed to:
 - a. Contractor
 - b. Owner
 - c. Engineer
 - d. Resident Project Representative (RPR)
 5. If Change Proposal is recommended for approval by Engineer and approved by Owner, a Change Order will be issued.
 6. If parties do not agree on terms for the change, Owner or Contractor may file a Claim against the other, in accordance with the General Conditions and the Supplementary Conditions.
- C. Each Change Proposal shall be submitted on a Change Proposal form acceptable to Engineer.
1. Number each Change Proposal as follows: Numbering system shall be the Contract number and designation followed by a hyphen and three-digit sequential number. Example: First Change Proposal for the general contract for project named "Contract 23" would be, "Proposal No. 23-001".
 2. In space provided on form:
 - a. Describe scope of each proposed change. Include text and sketches on additional sheets as required to provide detail sufficient for Engineer's review and response. If a change item is submitted in response to proposal request, write in as scope, "In accordance with Change Proposal Request No."

followed by the proposal request number. Provide written clarifications, if any, to scope of change.

- b. Provide justification for each proposed change. If change is in response to proposal request, write in as justification, "In accordance with Change Proposal Request No." followed by the proposal request number.
 - c. List the total change in the Contract Price and Contract Times for each proposed change.
3. Unless otherwise directed by Engineer, attach to the Change Proposal detailed breakdowns of pricing (Cost of the Work and Contractor's fee) including:
- a. List of Work tasks to accomplish the change.
 - b. For each task, labor cost breakdown including labor classification, total hours per labor classification, and hourly cost rate for each labor classification.
 - c. Construction equipment and machinery to be used, including manufacturer, model, and year of manufacture, and number of hours for each.
 - d. Detailed breakdown of materials and equipment to be incorporated into the Work, including quantities, unit costs, and total cost, with Supplier's written quotations.
 - e. Breakdowns of the Cost of the Work and fee for Subcontractors, including labor, construction equipment and machinery, and materials and equipment incorporated into the Work, other costs, and Subcontractor fees.
 - f. Breakdown of other costs eligible, in accordance with the General Conditions and the Supplementary Conditions.
 - g. Other information required by Engineer.
 - h. Contractor's fees applied to eligible Contractor costs and eligible Subcontractor costs.

1.09 CHANGE ORDERS

A. General:

- 1. Change Orders will be recommended by Engineer and signed by Owner, and Contractor, to authorize additions, deletions, or revisions to the Work, or changes to the Contract Price or Contract Times.
- 2. Change Orders will be in the form of EJCDC document C-941, "Change Order" or other Engineer's accepted form.

B. Procedure.

1. Five originals of each Change Order will be furnished to Contractor, who shall sign each original Change Order and return all originals to Engineer within five days of receipt.
2. Engineer will sign each original Change Order and forward them to Owner.
3. Owner will sign each original Change Order and forward to the funding agency.
4. After approval and signature of all parties, three executed original copies will be returned to Engineer. Engineer will distribute as follows:
 - a. Contractor: One original
 - b. Owner: One original
 - c. Engineer: One original
5. One copy of each Change Order will be distributed to:
 - a. Resident Project Representative (RPR)

PART 2 – PRODUCTS (NOT USED)

PART 3 – EXECUTION

3.01 SCHEDULE

- A. 2018 EJCDC Form C-942, Field Order
- B. 2018 EJCDC Form C-940, Work Change Directive
- C. 2018 EJCDC Form C-941, Change Order

END OF SECTION

Field Order No. _____

Date of Issuance:

Effective Date:

Owner:

Owner's Contract No.:

Contractor:

Contractor's Project No.:

Engineer:

Engineer's Project No.:

Project:

Contract Name:

Contractor is hereby directed to promptly execute this Field Order, issued in accordance with General Conditions Paragraph 9.04, for minor changes in the Work without changes in Contract Price or Contract Times. If Contractor considers that a change in Contract Price or Contract Times is required, submit a Change Proposal before proceeding with this Work.

Reference:

Specification(s)

Drawing(s) / Detail(s)

Description:

Attachments:

ISSUED:

RECEIVED:

By:

Engineer (Authorized Signature)

By:

Contractor (Authorized Signature)

Title:

Title:

Date:

Date:

Copy to: Owner

Work Change Directive No. _____

Date of Issuance:	Effective Date:
Owner:	Owner's Contract No.:
Contractor:	Contractor's Project No.:
Engineer:	Engineer's Project No.:
Project:	Contract Name:

Contractor is directed to proceed promptly with the following change(s):

Description:

Attachments: [List documents supporting change]

Purpose for Work Change Directive:

Directive to proceed promptly with the Work described herein, prior to agreeing to changes on Contract Price and Contract Time, is issued due to: [check one or both of the following]

- ☐ Non-agreement on pricing of proposed change.
- ☐ Necessity to proceed for schedule or other Project reasons.

Estimated Change in Contract Price and Contract Times (non-binding, preliminary):

Contract Price \$ _____ [increase] [decrease].

Contract Time ____ days [increase] [decrease].

Basis of estimated change in Contract Price:

- ☐ Lump Sum ☐ Unit Price
- ☐ Cost of the Work ☐ Other

RECOMMENDED:

By: _____
Engineer (Authorized Signature)

Title: _____

Date: _____

AUTHORIZED BY:

By: _____
Owner (Authorized Signature)

Title: _____

Date: _____

RECEIVED:

By: _____
Contractor (Authorized Signature)

Title: _____

Date: _____

Approved by Funding Agency (if applicable)

By: _____

Date: _____

Title: _____

Change Order No. _____

Date of Issuance:	Effective Date:
Owner:	Owner's Contract No.:
Contractor:	Contractor's Project No.:
Engineer:	Engineer's Project No.:
Project:	Contract Name:

The Contract is modified as follows upon execution of this Change Order:

Description:

Attachments: [List documents supporting change]

CHANGE IN CONTRACT PRICE Original Contract Price: \$	CHANGE IN CONTRACT TIMES [note changes in Milestones if applicable] Original Contract Times: Substantial Completion: Ready for Final Payment: days or dates
[Increase] [Decrease] from previously approved Change Orders No. to No. : \$	[Increase] [Decrease] from previously approved Change Orders No. to No. : Substantial Completion: Ready for Final Payment: days
Contract Price prior to this Change Order: \$	Contract Times prior to this Change Order: Substantial Completion: Ready for Final Payment: days or dates
[Increase] [Decrease] of this Change Order: \$	[Increase] [Decrease] of this Change Order: Substantial Completion: Ready for Final Payment: days or dates
Contract Price incorporating this Change Order: \$	Contract Times with all approved Change Orders: Substantial Completion: Ready for Final Payment: days or dates

RECOMMENDED:

By: _____
Engineer (if required)

Title: _____
Date: _____

ACCEPTED:

By: _____
Owner (Authorized Signature)

Title: _____
Date: _____

ACCEPTED:

By: _____
Contractor (Authorized Signature)

Title: _____
Date: _____

Approved Funding Agency (if required)

By: _____
Title: _____

Date: _____

SECTION 01 29 73
SCHEDULE OF VALUES

PART 1 – GENERAL

1.01 SUMMARY

A. Section Includes:

1. General requirements for preliminary and final Schedule of Values.
2. Schedule of Values and the Progress Schedule updates specified in Section 01 32 00 – Construction Progress Schedule, shall be basis for preparing each Application for Payment. Schedule of Values may be used as a basis for negotiating price of changes, if any, in the Work.

1.02 ADMINISTRATIVE REQUIREMENTS

A. General Requirements:

1. Schedule of Values shall include breakdown of costs for materials and equipment, installation, and other costs used in preparing the Bid by Contractor and each Subcontractor. List purchase and delivery costs for materials and equipment for which Contractor may apply for payment as stored materials.
2. Include separate amounts for each Specification Section in the Contract Documents by structure, building, and work area.
3. Identify each line item with number corresponding to the associated Specification Section number. List sub-items of major products or systems, as appropriate or when requested by Engineer.
4. Include in Schedule of Values unit price payment items with their associated quantity. Provide in the Schedule of Values detailed breakdown of unit prices when required by Engineer.
5. Include in Schedule of Values itemized list of Work for each major part of the Contract, for each payment item specified in Section 01 20 00 – Measurement and Payment.
6. Sum of individual values shown on the Schedule of Values shall equal the total of associated payment item. Sum of payment item totals in the Schedule of Values shall equal the Contract Price.

B. Specific Requirements:

1. Include in each line item a directly proportional amount of Contractor's overhead and profit. Do not include overhead and profit as separate item(s).
 2. Include separate line item for each allowance, and for each unit price item.
 3. Include line item for bonds and insurance in amount not exceeding two percent of the Contract Price. This may be applied for in the first Application for Payment.
 4. Include items for the General Conditions, permits (when applicable), construction Progress Schedule, and other items required by Engineer. Include such items in Applications for Payment on schedule accepted by Engineer.
 5. Line items for Site maintenance such as dust control, snow removal, compliance with storm water pollution prevention plans and permits, spill prevention control and countermeasures plans, and for construction photographic documentation; temporary utilities and temporary facilities, field offices, temporary controls, field engineering, and similar Work shall be included in the Schedule of Values and proportioned in Applications for Payment throughout duration of the Work.
 6. Include separate line items under each appropriate payment item for mobilization and demobilization. Document for Engineer the activities included in mobilization and demobilization line items.
 - a. Mobilization will be limited to two percent of the Contract Price, and will be paid in two payments, each of 50 percent of total amount for mobilization.
 - b. Demobilization shall be at least one percent of the Contract Price and shall be included with the Application for Payment following Substantial Completion, or other schedule accepted by Engineer.
 7. Costs for submittals, operations and maintenance manuals, field testing, and training of operations and maintenance personnel shall be as follows, unless otherwise accepted by Engineer:
 - a. Up to three percent of total cost of each item (including overhead and profit), including materials and equipment, and installation, may be apportioned to testing and included in the Application for Payment following Engineer's acceptance of the associated written Site testing report(s).
- C. Preliminary Schedule of Values: Submit preliminary Schedule of Values to Engineer for initial review. Contractor shall incorporate Engineer's comments into the Schedule of Values and resubmit to Engineer. Engineer may require corrections and re-submittals until Schedule of Values is acceptable.
- D. Time Frame for Submittals:

1. Submit preliminary Schedule of Values within ten days of date that the Contract Times commence running in accordance with the Notice to Proceed.
2. Submittal of the Schedule of Values shall be in accordance with the General Conditions. Engineer will not accept Applications for Payment without an acceptable Schedule of Values.
3. When required by Engineer, promptly submit updated Schedule of Values to include cost breakdowns for changes in the Contract Price.

1.03 SUBMITTALS

A. Submit the following:

1. Electronic copy of preliminary Schedule of Values.
2. Electronic copy of final Schedule of Values.

PART 2 – PRODUCTS (NOT USED)

PART 3 – EXECUTION (NOT USED)

END OF SECTION

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SECTION 01 29 76
PROGRESS PAYMENT PROCEDURES

PART 1 – GENERAL

1.01 SUMMARY

- A. Administrative and procedural requirements for progress payment to the Contractor by the Owner.
- B. Related Sections:
 - 1. Section 01 77 19 – Closeout Requirements.

1.02 ADMINISTRATIVE REQUIREMENTS

- A. General: Contractor's request for payment shall be in accordance with the Agreement, General Conditions and Supplementary Conditions, and the Specifications.
- B. Procedure:
 - 1. Review with Resident Project Representative (RPR) quantities and the Work proposed for inclusion in each progress payment. Application for Payment shall cover only the Work and quantities recommended by the RPR.
 - 2. Submit electronically to Engineer each complete Application for Payment and other documents to accompany the Application for Payment.
 - 3. Engineer will act on request for payment in accordance with the General Conditions and Supplementary Conditions.
- C. Requirements:
 - 1. Completed Application for Payment form, including summary/signature page, progress estimate sheets, and stored materials summary. Progress estimate sheets shall have the same level of detail as the Schedule of Values.
 - 2. For materials and equipment not incorporated in the Work but suitably stored, submit documentation in accordance with the General Conditions and Supplementary Conditions. Legibly indicate on invoice or bill of sale the specific materials or equipment included in the payment request and corresponding bid/payment item number for each.
 - 3. Contractor's Affidavit is required for payment application and requests beginning with the second application for payment.

4. For payment requests that include payment for Work under an allowance, submit documentation acceptable to Owner of the authorization of allowance Work.
 5. For payment requests (other than request for final payment) that include reduction or payment of retainage in an amount greater than that required in the Contract Documents, submit on form acceptable to Owner consent of surety to partial release or reduction of retainage.
- D. Requirements for request for final payment are in the General Conditions, as modified by the Supplementary Conditions, and Section 01 77 19 – Closeout Requirements.

PART 2 – PRODUCTS (NOT USED)

PART 3 – EXECUTION (NOT USED)

END OF SECTION

SECTION 01 31 19
PROJECT MEETINGS

PART 1 – GENERAL

1.01 SUMMARY

A. Section Includes:

1. Pre-Construction Meeting:
 - a. Purpose of conference is to designate responsible personnel, establish working relationships, discuss preliminary schedules submitted by Contractor, and review administrative and procedural requirements for the Project. Matters requiring coordination will be discussed and procedures for handling such matters will be established.
 - b. Date, Time and Location: Conference will be held after execution of the Contract and before Work starts at the Site. Engineer will establish the date, time, and location of conference and notify the interested and involved parties.
2. Progress Meetings:
 - a. Progress meetings will be held throughout the Project. Contractor shall attend each progress meeting prepared to discuss in detail all items on the agenda.
 - b. Engineer will preside at progress meetings and will prepare and distribute minutes of progress meetings to all meeting participants and others as requested.
 - c. Date, Time and Location:
 - 1) Regular Meetings: Every month on a day and time agreeable to Owner, Engineer, and Contractor.
 - 2) Engineer's Field Office at the Site or other location mutually agreed upon by Owner, Contractor, and Engineer.
 - d. Additional meetings may be conducted as progress of Work requires at a mutually agreed date, time and location.

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1.02 ADMINISTRATIVE REQUIREMENTS

A. Pre-Construction Meeting:

1. Contractor shall provide pre-construction meeting submittals with sufficient number of copies for each attendee:
2. Required Attendees:
 - a. Contractor
 - 1) Project manager.
 - 2) Site superintendent.
 - 3) Safety representative.
 - 4) Major Subcontractors.
 - b. Owner.
 - c. Engineer.
 - d. Resident Project Representative (RPR).
 - e. Representatives of governmental or other regulatory agencies.
3. Contractor shall prepare and submit a health and safety plan, including confined space entry plan, as specified in this Section prior to the pre-construction meeting.
4. Agenda, minimum:
 - a. Procedural requirements:
 - 1) Designation of responsible personnel
 - 2) Use of Site and Owner's requirements, including general regards for community relations
 - 3) Delivery of materials and equipment to the Site
 - 4) Safety and first aid procedures
 - 5) Confined space entry plan

- 6) Security procedures
- 7) Housekeeping procedures
- b. Administrative requirements:
 - 1) Distribution of Contract Documents.
 - 2) Shop Drawing submittal procedures.
 - 3) Maintaining record documents at the Site.
 - 4) Contract modification procedures
 - 5) Processing of Payment Application
- c. Site mobilization requirements:
 - 1) Working hours, overtime, and holidays.
 - 2) Field offices, trailers, and staging areas.
 - 3) Temporary facilities and utilities, including usage and coordination.
 - 4) Temporary controls, such as sediment and erosion control, noise, dust, storm water, and other measures.
 - 5) Access to Site, access roads, and parking for construction vehicles.
 - 6) Protection of traffic and existing property, including site barriers and temporary fencing.
 - 7) Security
 - 8) Storage of materials and equipment.
 - 9) Reference points and benchmarks, surveys and layouts.
 - 10) Site maintenance during the project, including cleaning and removal of trash and debris.
 - 11) Site restoration.
- d. Schedules
 - 1) Preliminary construction schedule
 - 2) Critical work sequencing

- 3) Preliminary Shop Drawing submittal schedule
- 4) Preliminary Schedule of Values

B. Progress Meetings:

1. Progress meetings frequency shall be conducted as specified in this Section, unless modified and agreed upon by Owner, Contractor, and Engineer. Additional meetings may be conducted as progress of Work requires.
2. Contractor shall provide submittals specified in this Section prior to each progress meeting.
3. Attendance:
 - a. Contractor, including project manager, site superintendent, safety representative, and representatives of Subcontractors and Suppliers as required.
 - b. Engineer, including project manager (or designated representative), Resident Project Representative, others as required by Engineer.
 - c. Owner.
 - d. Subcontractors, only with Engineer's approval or request, as required in the agenda.
 - e. Funding agency representative.
4. Agenda, minimum:
 - a. Review, comment, and amendment (if required) of minutes of previous progress meeting.
 - b. Review of progress since the previous progress meeting.
 - c. Planned progress through next 30 – 60 days.
 - d. Review of Progress Schedule
 - 1) Contract Times, including Milestones (if any)
 - 2) Critical path.
 - 3) Schedules for fabrication and delivery of materials and equipment.
 - 4) Corrective measures, if required.

- e. Submittals:
 - 1) Review of status of critical submittals.
 - 2) Review revisions to schedule of submittals.
- f. Contract Modifications:
 - 1) Requests for interpretation
 - 2) Clarification notices
 - 3) Field Orders
 - 4) Proposal requests
 - 5) Change Proposals
 - 6) Work Change Directives.
 - 7) Change Orders.
 - 8) Claims.
- g. Applications for progress payments.
- h. Problems, conflicts, and observations.
- i. Quality standards, testing, and inspections.
- j. Coordination between parties.
- k. Site management issues, including access, security, maintenance and protection of traffic, maintenance, cleaning, and other Site issues.
- l. Safety.
- m. Permits.
- n. Record documents status.
- o. Punch list status, as applicable.
- p. Other business.

1.03 SUBMITTALS

A. Pre-Construction Meeting Submittals:

1. Prior to the conference, submit the following preliminary schedules in accordance with the General Conditions:

- 1) Progress schedule
- 2) Schedule of submittals
- 3) Schedule of values

2. Contractor's safety and first aid procedures.
3. Confined space entry plan.
4. List of emergency contact information.

B. Progress Meeting Submittals:

1. List of Work accomplished since the previous progress meeting.
2. Up-to-date Progress Schedule.
3. Up-to-date Schedule of Submittals.
4. Detailed "look-ahead" schedule of Work planned through the next progress meeting, with specific starting and ending dates for each activity, including shutdowns, deliveries of important materials and equipment, Milestones (if any), and important activities affecting the Owner, Project, and Site.
5. When applicable, list of upcoming, planned time off (with dates) for personnel with significant roles on the Project, and the designated contact person in their absence.

1.04 EMERGENCY CONTACT INFORMATION

- A. Contractor shall provide list of emergency contact information for 24-hour use throughout the Project. Emergency contact information shall be updated and kept current throughout the Project. If personnel or contact information change, provide updated emergency contact information list at the next progress meeting.
- B. Contractor's list of emergency contact information shall include:
 1. Contractor's project manager's office, field office, cellular, and home telephone numbers.
 2. Contractor's Site superintendent's office, field office, cellular, and home telephone numbers.

3. Contractor's foreman's field office, cellular (if available), and home telephone numbers.
4. Major Subcontractors' and Suppliers' office, cellular, and home telephone numbers of project manager and foreman (when applicable).

C. Additional Emergency Contact Information:

1. Owner's Project Manager: office, cellular, and home telephone numbers.
2. Owner's central 24-hour emergency telephone number.
3. Engineer's project engineer's office, cellular, and home telephone numbers.
4. Resident Project Representative's office, field office, cellular, and home telephone numbers.
5. Emergency telephone numbers, including: "Emergency: Dial 911", and seven-digit telephone numbers for the hospital, ambulance, police, and fire department nearest to the Site. Provide names of each of these institutions.
6. Other involved entities as applicable.

PART 2 – PRODUCTS (NOT USED)

PART 3 – EXECUTION (NOT USED)

END OF SECTION

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SECTION 01 32 00
CONSTRUCTION PROGRESS SCHEDULE

PART 1 – GENERAL

1.01 SUMMARY

- A. Section includes: Detailed requirements and/or procedures for, including but not limited to, the Preliminary Project Schedule, Project Schedule Updates, Project Schedule development, Time Impact Analysis, and Recovery Schedules
- B. The Contractor shall develop, revise, and provide all information and input required for the Project Schedule for the performance of the Work in accordance with the requirements of the Contract Documents in general and, in particular, this section. The Progress Schedule shall incorporate the requirements of General Conditions, Supplementary Conditions, and all items specified in this section.
- C. Except as otherwise provided herein or elsewhere in the Contract Documents, the planning, scheduling, coordination, and execution of the Work is the sole responsibility of the Contractor.

1.02 REFERENCES

- A. Definitions:
 - 1. Activity: An element of the construction work that has the following specific characteristics: consumes time, consumes resources, has a definable start and finish, is assignable, and is measurable.
 - 2. Constraint: An imposed date on the Progress Schedule or an imposed tie between Activities. The Contract Times are Constraints.
 - 3. CPM Progress Schedule: Computerized Progress Schedule in Critical Path Method (CPM) format which accounts for the entire Work, defines the interrelationships between elements of the Work, reflects the uncompleted Work, and indicates the sequence with which the Work has been completed, indicates the sequence in which uncompleted Work will be completed, and indicates the duration of each Activity.
 - 4. Critical Path: The continuous chain of Activities with the longest duration for completion within the Contract Times.
 - 5. Early Start: The earliest possible date an Activity can start according to the assigned relationships among Activities.

6. Early Finish: The earliest possible date an Activity can finish according to the assigned relationships among the Activities.
7. Late Finish: The latest possible date an Activity can finish without extending the Contract Times.
8. Late Start: The latest possible date an Activity can start without extending the Contract Times.
9. Total Float: The total number of days that an Activity (or chain of Activities) can be delayed without affecting the Contract Times. Total float for each Activity shall be calculated as the difference between Early Finish and Late Finish.
10. Network Diagram: A time-scaled logic diagram depicting the durations and relationships of the Activities.
11. Work Areas, Area, or System: A logical breakdown of the Project elements or a group of Activities which, when collectively assembled, are readily identifiable on the Project (for example, yard piping, a structure or building, a treatment process, or other logical grouping).

1.03 ADMINISTRATIVE REQUIREMENTS

A. Initial Progress Schedule:

1. Type and Organization of Progress Schedules:
 - a. Prepare one Progress Schedule covering the entire Project using Primavera Planner (P6 or newer), or Microsoft Project scheduling software.
 - b. Schedule submittals shall include the electronic native file format (i.e., scheduling software file), and a PDF file of the schedule's logic diagram.
 - c. Time Scale: Indicate first date of each work week.
 - d. Activity Designations: Indicate concise description of the Work represented by the activity and related Specification Section number. The Work related to each activity shall be limited to one work trade and one construction area.
2. Submitted PDF files shall be in a Gantt Chart Format and shall show the following:

- a. Activity identification number.
 - b. Activity description.
 - c. Activity duration (in workdays).
 - d. Activity percent complete
 - e. Start, Early Start, Late Start, Finish, Early Finish, and Late Finish Dates
 - f. Total Float for each Activity.
 - g. Critical Path denoted.
3. Organization:
- a. Group shop drawings, samples and other submittals into a separate sub-schedule that is part of the Progress Schedule.
 - b. Group deliveries of materials and equipment into a separate sub-schedule that is part of the Progress Schedule.
 - c. Group construction into Work Area sub-schedules (that are part of the Progress Schedule) by Activity.
 - d. Clearly indicate the Critical Path on the Progress Schedule.
 - e. Organize each Work Area sub-schedule by Specification Section number.
4. Preliminary Progress Schedule:
- a. Contractor shall submit to Engineer the Preliminary Progress Schedule within ten (10) days after the Contract Times commence running.
5. Initial Acceptance of Progress Schedule:
- a. At least 10 days before submission of the first Application for Payment, Contractor shall schedule a conference at the Site for review of the Preliminary Progress Schedule.
 - 1) Attendees shall include Contractor, Engineer, Owner, and others as required.

- 2) Contractor shall have an additional 10 days to make corrections and adjustments and to complete and resubmit the Progress Schedule.
 - 3) Owner reserves the right to not make progress payment to Contractor until acceptable Progress Schedule, and other reports and schedule-related documents required are submitted to Engineer.
- b. Initially-accepted Progress Schedule shall be identified as the Baseline Progress Schedule. The Baseline Progress Schedule shall not be revised without Owner and Engineer approval.

B. Project Schedule Updates:

1. Project Schedule Updates shall be prepared on a monthly basis throughout the entire Contract Time and until Project Final Completion. The Engineer will not recommend progress payments by the Owner until a complete Project Schedule Update (including Schedule Narrative Report) is received, reviewed, and accepted by the Engineer.
2. The update to the Progress Schedule shall be based on retained logic. Progress override logic is not allowed.
3. Required scheduling software, and schedule organization, format, and content for updated Progress Schedules are identical to that required in this Section for initial Progress Schedules.
4. For all Project Schedule Updates, the percent complete reported for individual Activities shall be based on Work accepted and paid for the by Owner in monthly pay applications. Failure to comply with this requirement shall be result in rejection of the submitted update. Rejection of the Project Schedule Update will in turn result in the Engineer not recommending progress payments by the Owner.
5. Monthly Progress Schedule Updates shall be accompanied by a Schedule Narrative Report. The report shall:
 - a. Describe Work completed within the preceding month.
 - b. Describe Work planned for the following month (including a look-ahead schedule).
 - c. Identify proposed changes or revisions to the Baseline Progress Schedule.

- d. Identify all Work performed out of sequence.
- e. Identify problem areas.
- f. Identify current or anticipated conditions which may delay the Work.

1.04 PROJECT SCHEDULE DEVELOPMENT

- A. The schedule shall cover the entire Contract Time, and the Work shall be scheduled to complete the Project within the Contract Time.
- B. The Schedule's Late Finish Date shall equal the Contract Completion Date.
- C. All activities except for the NTP and Final Completion shall have a predecessor and a successor. No open-ended activities will be permitted. Note that NTP shall have a successor or successors and Final Completion shall have a predecessor or predecessors.
- D. Proposed durations assigned to each activity shall be the Contractor's best estimate of time required to complete the activity, considering the scope and resources planned for the activity.
- E. The durations of activities shall be expressed in whole working days, with a maximum duration of 20 workdays each, unless otherwise approved or directed by the Engineer or the Owner. The duration of non-construction activities including mobilization, shop drawings and sample submittals, fabrication of materials and equipment, and delivery of materials and equipment may exceed this limitation.
- F. The Schedule shall incorporate in detail all elements of the Work contained within the Contract Documents. Specific elements of the Work to incorporate into the schedule include but are not limited to the following:
 - 1. Notice to Proceed.
 - 2. Mobilization and demobilization.
 - 3. Submittals including O&M Manuals. Note that durations for Engineer review time shall be 30 working days unless specified elsewhere in these Contract Documents.
 - 4. Fabrication and procurement activities.
 - 5. Temporary construction activities and relocations
 - 6. Permitting

7. Erosion control
8. Site clearing
9. Site restoration
10. All requirements for coordination with Owner operations
11. Concrete curing and form removal
12. All testing activities
13. Inspections as required by local authorities.
14. Interim Milestones as defined by this Contact or as deemed critical as the project progresses.
15. All requirements related to facility startup and commissioning.
16. Substantial Completion (including the period for performing the punchlist)
17. Final Completion

1.05 TIME IMPACT ANALYSIS

A. General:

1. Prepare and submit a time impact analysis when one or more of the following occurs:
 - a. Change Order proposal is prepared.
 - b. Work Change Directive is issued that will affect the Progress Schedule.
 - c. When delays are experienced.
2. Time impact analysis shall illustrate the influence of each Change Order, Work Change Directive, or delay.
3. Each time impact analysis shall include a sketch (fragnet) demonstrating how Contractor proposes to incorporate the changes in the Project or, as applicable, delays into the Progress Schedule. Fragnet shall include all logic, and additions required as result of said Change Order, Work Change Directive, or delay.

4. Fragnet shall show all CPM logic revisions for the Work associated with the Change Order, Work Change Directive, or delay and its relationship to other Activities.
5. Timing of Time Impact Analysis:
 - a. Submit each time impact analysis within 7 days after the following, as applicable:
 - 1) Start of the delay.
 - 2) After the submittal of Change Order proposal to Engineer
 - 3) After Contractor's Receipt of Work Change Directive.
 - b. Failure to Submit Time Impact Analysis: When General Contractor does not submit time impact analysis for a specific change or delay under the General Contract, within the specified period of time for such submittal, such non-submittal shall be construed that no extension of the Contract Times is required

B. Evaluation by Engineer and Acceptance:

1. Engineer's evaluation of each time impact analysis comprised of complete information will be completed in timely manner after Engineer's receipt. Changes in the Contract Times will be made only by Change Order.
2. When mutual agreement is reached between the parties, on effect of the change or delay in the Project, incorporate into the next Progress Schedule and update the associated fragnets illustrating the influence of changes and delays.

1.06 RECOVERY SCHEDULES

A. General:

1. When updated Progress Schedule indicates that the ability to comply with the Contract Times falls 30 or more days behind schedule, and there is no excusable delay, Change Order, or Work Change Directive to support an extension of the Contract Times, Contractor shall prepare and submit a Progress Schedule demonstrating Contractor's plan to accelerate the Project to achieve compliance with the Contract Times (i.e., "recovery schedule") for Engineer's acceptance.
2. Submit recovery schedule within 14 days after submittal of updated Progress Schedule where need for recovery schedule is indicated.

B. Implementation of Recovery Schedule:

1. At no additional cost to Owner, Contractor shall do one or more of the following:
 - a. Furnish additional labor and construction equipment.
 - b. Employ additional work shifts.
 - c. Expedite procurement of materials and equipment to be incorporated into the Work.
 - d. Other measures necessary to complete the Work within the Contract Times.
 2. Upon acceptance of recovery schedule by Engineer, incorporate recovery schedule into the next Progress Schedule update.
- C. Lack of Action: Contractor's refusal, failure or neglect to submit a recovery schedule, shall constitute reasonable evidence that Contractor is not prosecuting the Work or separable part thereof with the diligence that will ensure completion within the Contract Times. Such lack of action shall constitute sufficient basis for Owner to exercise remedies available to Owner under the Contract Documents

1.07 USE OF FLOAT

- A. Total Float and Contract Float belong to the Project and may be used by Owner, Engineer, or Contractor to accommodate modifications, regardless of origination, in the Work or to mitigate the effect of events that may delay performance or completion of the Work.
- B. Changes or delays that influence scheduled Work Activities with Float and that do not extend the critical path will not be justification for an extension in Contract Times.

1.08 SUBMITTALS

- A. Action/Informational Submittals:
 1. Initial Progress Schedules:
 - a. Preliminary Progress Schedule
 - b. Acceptable Progress Schedule (Baseline)
 2. Progress Schedule Updates:

- a. Progress Schedule updates shall comply with requirements of this Section and shall include updated Progress Schedule and Schedule Narrative Report.
 - b. Submit updated Progress Schedule at each progress meeting. If a Progress Schedule remains unchanged from one progress meeting to the next, submit a written statement to that effect.
3. Time Impact Analyses: Submit in accordance with this Section.
4. Recovery Schedule: Submit in accordance with this Section.
5. Qualifications: Progress Schedule preparer, and other personnel that will assist Progress Schedule preparer in preparing and maintaining the Progress Schedule.

PART 2 – PRODUCTS (NOT USED)

PART 3 – EXECUTION (NOT USED)

END OF SECTION

SECTION 01 33 00
SUBMITTAL PROCEDURES

PART 1 – GENERAL

1.01 SUMMARY

A. Section includes:

1. Contractor shall provide submittals in accordance with the General Conditions as modified by the Supplementary Conditions, and this Section.
2. Contractor is responsible to confirm and correct dimensions at the Site, for information pertaining to the fabrication processes and to techniques of construction, and for coordinating the work of all trades. Contractor's signature of submittal's stamp and letter of transmittal shall be Contractor's representation that Contractor has met their obligations under the Contract Documents relative to that submittal.

B. Related Sections:

1. Section 01 25 00 – Substitution Procedures.
2. Section 01 78 23 – Operation and Maintenance Data.
3. Section 01 78 39 – Project Record Documents.
4. Section 01 78 43 – Spare Parts and Extra Material.
5. Section 01 79 00 – Instruction of Owner's Personnel.

1.02 ADMINISTRATIVE REQUIREMENTS

A. Types of Submittals: When type of submittal is not specified and is not specified in this Section, Engineer will determine type of submittal.

1. Action/Informational Submittals:

- a. Shop Drawings.
- b. Product data.
- c. Delegated design submittals in accordance with the General Conditions and as modified by the Supplemental Conditions.

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- d. Samples.
 - e. Testing plans, procedures, and testing limitations.
 - f. Design data not sealed and signed by a design professional retained by Contractor, Subcontractor, or Supplier.
 - g. Pre-construction test and evaluation reports, such as reports on pilot testing, subsurface investigations, potential Hazardous Environmental Conditions, and similar reports.
 - h. Supplier instructions, including installation data, and instructions for handling, starting-up, and troubleshooting.
 - i. Sustainable design submittals (other than sustainable design closeout documentation).
 - j. Lesson plans for training and instruction of Owner's personnel.
2. Closeout Submittals:
- a. Maintenance contracts.
 - b. Operations and maintenance data.
 - c. Bonds, such as maintenance bonds and bonds for a specific product or system.
 - d. Warranty documentation.
 - e. Record documentation.
 - f. Sustainable design closeout documentation.
 - g. Software.
3. Maintenance Material Submittals:
- a. Maintenance materials schedule and checklist.
 - b. Spare parts.
 - c. Extra stock materials.
 - d. Tools.
4. Quality Assurance Submittals:

- a. Performance affidavits.
- b. Certificates.
- c. Source quality control submittals (other than testing plans, procedures, and testing limitations), including results of shop testing.
- d. Field or Site quality control submittals (other than testing plans, procedures, and testing limitations), including results of operating and acceptability tests at the Site.
- e. Supplier reports.
- f. Special procedure submittals, including health and safety plans and other procedural submittals.
- g. Qualifications statements.

B. Submittal Requirements:

- 1. Contractor shall submit electronic copy of submittals for Engineer's review via Procore Document Management, unless otherwise specified in individual Specification Sections. Acceptable electronic formats are Adobe PDF, Microsoft Word, Autodesk DWF and AutoCAD.
- 2. Submittal shall be accompanied by letter of transmittal containing date, project title, Contractor's name, number and title of submittal, list of relevant Specification Sections, notification of deviations from Contract Documents, and other material required for Engineer's review.
- 3. Submittals with internet hyperlinks and other references to online content shall not be considered, reviewed, and included as part of the submittal review procedure. Hyperlinks and other electronic references shall not be used to comply with specified requirements of the Contract Documents, unless specifically stated in the individual technical Specification Section.
- 4. Electronic Submittal File Format Requirements:
 - a. Files shall be electronically searchable for submitted equipment and material.
 - b. Provide bookmarks within files in excess of 20 pages for submitted equipment and material including, but not limited to, the following:
 - 1) Each chapter and subsection listed in the files table of contents
 - 2) Each figure, table, and appendix.

- 3) Each drawing.

C. Scheduling:

1. Provide submittals well in advance of the Work following Engineer's approval or acceptance of the associated submittal. Work covered by a submittal will not be included in progress payments until approval or acceptance of related submittals has been obtained in accordance with the Contract Documents.
2. Submittals shall be provided by Contractor with at least thirty (30) working days for review and processing.

1.03 SCHEDULE OF SUBMITTALS

A. Schedule of Submittals, as specified in this Section:

1. Timing:
 - a. Provide submittal within time frames specified in the Contract Documents.
 - b. Provide updated Schedule of Submittals with each submittal of the updated Progress Schedule.
2. Content: In accordance with the General Conditions as modified by the Supplementary Conditions, and this Section. Requirements for content of preliminary Schedule of Submittals and subsequent submittals of the Schedule of Submittals are identical.
 - a. Identify submittals required in the Contract Documents. Updates of Schedule of Submittals shall show scheduled dates and actual dates for completed tasks. Indicate submittals that are on the Project's critical path.
 - b. Indicate the following for each submittal:
 - 1) Date when submittals are requested and received from Supplier.
 - 2) Date when certification is received from Supplier and when submitted to Engineer.
 - 3) Date when submittals are submitted to Engineer and returned with disposition from Engineer.
 - 4) Date when submittals are revised by Supplier and submitted to Engineer.
 - 5) Date when submittals are returned with "Furnish as Submitted" (FAS) or "Furnish as Corrected" (FAC) disposition from Engineer.

- 6) Date when approved submittals are returned to Supplier.
 - 7) Date of Supplier scheduled delivery of equipment and material.
 - 8) Date of actual delivery of equipment and material.
 - 9) Whether submittal will be for a substitution or “equal”. Procedures for substitutions and “or equals” are specified in the General Conditions and the Section 01 25 00 – Substitution Procedures.
 - 10) For submittals for materials or equipment, date by which material or equipment must be at the Site to avoid delaying the Work and to avoid delaying the work of other contractors.
3. Prepare Schedule of Submittals using same software, and in same format, specified for Progress Schedules.
 4. Coordinate Schedule of Submittals with the Progress Schedule.
 5. Schedule of Submittals that is not compatible with the Progress Schedule, or that does not indicate submittals on the Project’s critical path, or that places extraordinary demands on Engineer for time and resources, is unacceptable. Do not include submittals not required by the Contract Documents.
 6. In preparing Schedule of Submittals:
 - a. Considering the nature and complexity of each submittal, allow sufficient time for review and revision.
 - b. Reasonable time shall be allowed for: Engineer’s review and processing of submittals, for submittals to be revised and resubmitted, and for returning submittals to Contractor.
 - c. Identify and accordingly schedule submittals that are expected to have long anticipated review times.

1.04 ACTION/INFORMATIONAL SUBMITTALS

- A. Provide the following Submittals in accordance with the individual Specification Sections, including, but not limited to, the following:
 1. Product Data:
 - a. Catalog cut-sheets
 - b. Descriptive bulletins/brochures/specifications

- c. Material of construction data, including details on all components including applicable ASTM designations.
 - d. Lifting, erection, installation, and adjustment instructions, and recommendations.
 - e. Finish/treatment data, including interior and exterior shop coating systems.
 - f. Equipment/material weight/loading data, including total uncrated weight of the equipment plus the approximate weight of shipped materials. Support locations and loads that will be transmitted to bases and foundations following installation. Size, placement, and embedment requirements of anchor bolts.
 - g. Complete information regarding location, type, size, and length of all field welds in accordance with "Standard Welding Symbols" AWS A2.0 of the American Welding Society. Special conditions shall be fully explained by notes and details.
 - h. Motor data including horsepower; enclosure type; voltage; insulation class; temperature rise and results of dielectric tests; service-rating; rotative speed; motor speed-torque relationship; efficiency and power factor at $\frac{1}{2}$, $\frac{3}{4}$, and full load; slip at full load; running, full load, and locked rotor current values; safe running time-current curves; motor protective devices; and interconnection diagrams.
 - i. Engineering design data, calculations, and system analyses
 - j. Digital system documentation
 - k. Operating sequence descriptions
 - l. Software/programming documentation
 - m. Manufacturer's instructions
2. Shop Drawings:
- a. Equipment and material layout drawings, including panel layout drawings.
 - b. System schematics and diagrams including, but not limited to, piping systems; HVAC and ventilation systems; process equipment systems; electrical operating systems; wiring diagrams; controls, alarm and communication systems.

- c. Layout and installation drawings (interior and exterior) for all pipes, valves, fittings, sewers, drains, heating and ventilation ducts, all electrical, heating, ventilating and other conduits, plumbing lines, electrical cable trays, lighting fixture layouts, and circuiting, instrumentation, interconnection wiring diagrams, communications, power supply, alarm circuits, etc.
 - d. Layout and installation drawings shall show connections to structures, equipment, sleeves, valves, fittings, etc.
 - e. Drawings shall show the location and type of all supports, hangers, foundations, etc., and the required clearances to operate valves, equipment, etc.
 - f. Drawings for pipes, ducts, conduits, etc., shall show all new and existing 3 inch and larger electrical conduits and pressure piping, electrical cable trays, heating and ventilation ducts or pipes, structure, manholes or any other feature within four (4) feet (measured as the clear dimension) from the new pipe duct, conduit, etc., for which the profile is drawn.
 - g. Equipment and material schedules. All pipe layouts and schedules shall have manufacture's pipe schedule, bill of materials, tag numbers, etc.
3. Delegated design submittals, which include documents prepared, sealed, and signed by a design professional retained by Contractor, Subcontractor, or Supplier for materials and equipment to be incorporated into the completed Work. Delegated design submittals do not include submittals related to temporary construction unless specified otherwise in the related Specification Section. Delegated design submittals include: design drawings, design data including calculations, specifications, certifications, and other submittals prepared by such design professional.
- a. **Refer to Section 40 05 07 – Pipe Supports regarding delegated design submittals for piping support systems.**

B. Samples:

- 1. General Requirements:
 - a. Conform submittal of Samples to the General Conditions as modified by the Supplementary Conditions, this Section, and the Specification Section in which the Sample is specified.
 - b. Furnish at the same time Samples and submittals that are related to the same unit of Work or Specification Section. Engineer will not review submittals without associated Samples and will not review Samples without associated submittals.

- c. Samples shall clearly illustrate functional characteristics of product, all related parts and attachments, and full range of color, texture, pattern, and material.
- 2. Submittal Requirements:
 - a. Securely label or tag Samples with submittal identification number. Label or tag shall not cover, conceal, or alter appearance or features of Sample. Label or tag shall not be separated from the Sample.
 - b. Submit number of Samples required in Specifications. If number of Samples is not specified in the associated Specification Section, provide at least one identical Samples of each item required for Engineer's approval. If Contractor requires Sample(s) for Contractor's use, notify Engineer in writing and provide additional Sample(s). Contractor is responsible for furnishing, shipping, and transporting additional Samples.
 - c. Deliver one Sample to Engineer's field office at the Site. Deliver balance of Samples to location directed by Engineer.

1.05 CLOSEOUT SUBMITTALS

- A. Provide the following Closeout Submittals in accordance with the individual Specification Sections, including, but not limited to, the following:
 - 1. Maintenance contracts
 - 2. Bonds for specific products or systems
 - 3. Warranty documentation
 - 4. Sustainable design closeout documentation.
 - 5. Software programming and documentation.
- B. On documents such as maintenance contracts and bonds, include on each document furnished original signature of entity issuing the document.
- C. Operations and Maintenance Data: Submit in accordance with Section 01 78 23 – Operations and Maintenance Data.
- D. Record Documentation: Submit in accordance with Section 01 78 39 – Project Record Documents.
- E. Disposition: Dispositions and meanings are the same as specified for Informational Submittals.

1.06 MAINTENANCE MATERIAL SUBMITTALS

- A. For spare parts, extra stock materials, and tools, submit quantity of items specified in associated Specification Section. Furnish in accordance with Section 01 78 43 – Spare Parts and Extra Materials.
- B. Disposition: Dispositions and meanings are the same as specified for Informational Submittals.

1.07 CONTRACTOR'S RESPONSIBILITIES

- A. Contractor shall review, coordinate, and verify submittals with Subcontractors, Manufacturers, and Suppliers, including field measurements at Site, in accordance with the General Conditions and as modified by Supplemental Conditions prior to submitting material for Engineer's review.
- B. Contractor shall clearly and concisely indicate and mark equipment and material being submitted to meet the intent of the Contract Documents. Equipment and material not being submitted shall be deleted, stricken through, or otherwise designated not being submitted. Equipment and material data sheets shall be included once with cross references throughout the submittal. Multiple equipment and material data sheets for the same item within a submittal may receive a rejected disposition until corrected.
 - 1. Individual Specification Sections require a Compliance, Deviations, and Exceptions (CD&E) letter to be included with the submittal. Submittals provided without the CD&E letter shall receive a rejected disposition without review.
 - 2. CD&E letter requirements:
 - a. Include a copy of entire Specification section with each paragraph and subparagraph noted with "C", "D", or "E" to indicate if equipment and material being provided is in compliance (C), deviates (D), or exceptions (E) are taken with the Contract Documents.
 - 1) Compliance (C): Full compliance with the specified requirement.
 - 2) Deviation (D): Deviation from the specified requirement.
 - 3) Exception (E): Exception with the specified requirement.
 - b. Include all comments, deviations and exceptions taken to the Contract Documents by the Contractor and Equipment Manufacturer/Supplier.
 - c. Any requirements with the letter "D" or "E" beside them shall be provided with a full typewritten explanation of the deviation/exception. Handwritten explanation of the deviations/exceptions is not acceptable.

- d. Address deviations and exceptions taken to each Contract Drawing related to the Specification section.
- C. Contractor shall provide Contractor's stamp of approval certifying submittal material has been reviewed and conform to the Contract Documents prior to submitting material for Engineer's review.
- D. Contractor shall provide written notice of deviations or variations that submittal may have with the Contract Documents.
- E. Contractor shall provide bound, dated, labeled, tabulated, and consecutively numbered submittals as specified in the individual Specification Section. Label shall contain the following:
 - 1. Specification Section.
 - 2. Referenced Drawing number.
 - 3. Subcontractor or Supplier name.
 - 4. Type of equipment and/or materials.
- F. Contractor shall perform the following after receiving Engineer's review disposition:
 - 1. Order, fabricate, or ship equipment and materials included in the submittal (pending Engineer's review of source quality control submittals) with the following disposition:
 - a. "Furnish as Submitted" (FAS).
 - b. "Furnish as Corrected" (FAC).
 - c. "Furnish as Corrected – Confirm" (FACC), only portions of Work that do not require resubmittal for Engineer's review.
 - 2. Resubmittal requirements:
 - a. Partial resubmittal of "Furnish as Corrected – Confirm" (FACC) returned dispositions, until Engineer's disposition is either "Furnish as Submitted" (FAS) or "Furnish as Corrected" (FAC).
 - b. Full resubmittal of material with Engineer's disposition of "Revise and Resubmit" (R&R), until Engineer's disposition is "Furnish as Submitted" (FAS), "Furnish as Corrected" (FAC), or "Furnish as Corrected – Confirm" (FACC) that requires a partial resubmittal.

- c. Contractor shall be responsible for Engineer's charges to Owner if submittals are not approved within the number of specified submittals in accordance with the General Conditions. Engineer's charges shall include, but not limited to, additional review effort, meetings, and conference calls with Contractor, Subcontractor, or Supplier.

1.08 ENGINEER'S REVIEW

- A. Engineer's review of the Contractor's submittal shall not relieve Contractor's responsibility under the Contract Document in accordance with the General Conditions and as modified in the Supplemental Conditions. An acceptance of a submittal shall be intended to mean the Engineer does not have specific objection to the submitted material, subject to conformance with the Contract Drawings and Specifications.
- B. Engineer's review of Contractor's submittal shall be confined to general arrangement and compliance with the Contract Documents, and shall not be for the purpose of checking dimensions, weights, clearances, fittings, tolerances, interferences, coordination of Subcontractor work, etc.
- C. Review Dispositions:
 - 1. "Furnish as Submitted" (FAS) – No exceptions are taken.
 - 2. "Furnish as Corrected" (FAC) – Minor corrections are noted for Contractor's correction.
 - 3. "Furnish as Corrected – Confirm" (FACC) – Corrections are noted and partial resubmittal shall be made as noted.
 - 4. "Revise and Resubmit" (R&R) – Corrections are noted and complete resubmittal shall be made. Submittal does not conform to applicable requirements of the Contract Documents and is not acceptable. Revise submittal and re-submit to indicate acceptability and conformance with the Contract Documents.
 - 5. "Receipt Acknowledged" (RA) –
 - a. Information included in submittal conforms to the applicable requirements of the Contract Documents and is acceptable. No further action by Contractor is required relative to this submittal, and the Work covered by the submittal may proceed, and products with submittals with this disposition may be shipped or operated, as applicable.
 - b. Information included in submittal is for Project record purposes and does not require Engineer's review or approval.

6. "Rejected" (R) – Information included in submittal does not conform to the applicable requirements of the Contract Documents and is unacceptable. Contractor shall submit products and materials as specified in the Contract Documents or provide required information for substitution as specified in the Contract Documents for consideration by Engineer.
- D. Electronic Submittal Return to Contractor: Electronic submittals shall be returned electronically with dispositions provided.

PART 2 – PRODUCTS (NOT USED)

PART 3 – EXECUTION (NOT USED)

END OF SECTION

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SECTION 01 35 20
CONFINED SPACE ENTRY PLAN

PART 1 – GENERAL

1.01 SUMMARY

- A. Owner has determined that portions of the Site may constitute confined spaces or permit-required confined spaces, as defined in this Section.
- B. Contractor shall provide appropriate measures, including labor, supervision, equipment, protective devices, and incidentals, to protect the health and safety of personnel at the Site relative to confined spaces, and who may be affected by the Work in confined spaces including, without limitation: employees and agents of Contractor, Subcontractors, Suppliers, Owner, and Engineer, while engaged in performance of their respective duties at Site.
- C. Comply with requirements of Owner's confined space entry program, if any.

1.02 REFERENCES

- A. Definitions: The following words or terms are not defined but, when used in this Section, have the following meaning:
 - 1. "Confined spaces" are areas on or about the Site as defined in 29 CFR 1910.146(b) and 29 CFR 1926.1202. Confined spaces include, but are not limited to: storage tanks, process vessels, bins, boilers and similar spaces; ventilation or exhaust ducts and stacks; manholes, underground utility vaults and chambers, sewers, pipelines, tunnels; and open-topped spaces greater than four feet deep, such as pits, tubs, vaults, and vessels.
 - 2. "Entry permit" means the written or printed document provided by the employer of personnel entering permit-required confined space, to allow and control entry into permit-required confined space and that contains the information specified in 29 CFR 1910.146(f) and 29 CFR 1926.1206.
 - 3. "Permit-required confined space" means confined space as defined in 29 CFR 1926.146(b) and 29 CFR 1926.1202 and that has one or more of the following characteristics:
 - a. Contains or has potential to contain a hazardous atmosphere.
 - b. Contains material that has potential for engulfing an entrant.

- c. Has internal configuration such that an entrant could be trapped or asphyxiated by inwardly converging walls or floors, or by floor that slopes downward and tapers to a smaller cross-section.
 - d. Contains other recognized serious safety or health hazard.
 - 4. "Hot work permit" means the written authorization of employer of personnel entering a confined space to perform operations, such as riveting, welding, cutting, burning, and heating, capable of providing a source of ignition.
 - 5. "Host Employer" means the employer that owns or manages the property where construction is taking place.
 - 6. "Controlling Contractor" is the employer that has overall responsibility for construction at the worksite.
- B. Reference Standards: Comply with Laws and Regulations related to protecting personnel working in or entering confined spaces, including:
- 1. Code of Federal Regulations (CFR), Title 29, Part 1910, Occupational Safety and Health Standards.
 - 2. CFR, Title 29, Part 1926, Safety and Health Regulations for Construction.

1.03 PLAN REQUIREMENTS

- A. Review host employer's existing confined space inventory and entry procedures, if available, in order to prepare Site- and task-specific confined space entry plans which shall be incorporated into Contractor's Site-specific health and safety plan. Maintain copy of the confined space entry plan at the Site for access by employees, Owner and authorities having jurisdiction. Confined space entry plan shall include:
- 1. Results of Contractor's Site-specific hazard assessment to identify confined spaces that are permit-required confined spaces, including list of all such spaces that will be accessed for the Work. Update the list as required throughout the Project.
 - 2. Requirements for safeguarding access to, and restricting non-permitted personnel from access to, permit-required confined spaces during the Work.
 - 3. Project-specific procedures to be followed when entering or accessing permit-required confined spaces.
 - 4. Documentation of training provided to each person that will enter, or work in conjunction with entry to, permit-required confined spaces

5. Update the plan by adding copies of permits issued and records of entry to permit-required confined spaces, as required in this Section.

B. Confined Space Safety:

1. Personnel entering confined space shall be trained in accordance with 29 CFR 1926.1207 and 29 CFR 1910.146(g).
2. Comply with 29 CFR 1926 Subpart AA and requirements of authorities having jurisdiction.
3. Recordkeeping: Using forms required by Contractor, Owner, or authority having jurisdiction, issue for each instance of access to permit-required confined space, completed permit(s) and complete associated data sheet. File completed permits and data sheets in the Site-specific confined space entry plan and submit in accordance with this Section.
 - a. Permit for entry to permit-required confined space(s).
 - b. Permit for hot work in permit-required confined space(s).
 - c. Complete confined space data sheet.

1.04 SUBMITTALS

- A. If acceptable, written response for Submittals required in this Section will not be returned to Contractor.
- B. Submit the following to Owner; if submittals under this Section are furnished to Engineer, Engineer will forward all submittals under this Section to Owner without review.
 1. Procedures: Site-specific confined space entry plan, submitted upon request of Owner.
 2. Permits and Reports: For each time personnel enter a confined space, copies of completed permits required for confined space entry, and completed confined space data sheets, submitted upon request of Owner.

PART 2 – PRODUCTS (NOT USED)

PART 3 – EXECUTION (NOT USED)

END OF SECTION

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SECTION 01 42 00
REFERENCES

PART 1 – GENERAL

1.01 SUMMARY

- A. Definitions and terminology applicable to all the Contract Documents are included in the General Conditions and Supplementary Conditions.

1.02 REFERENCES

- A. Abbreviations and Acronyms: Common abbreviations that may be found in the Contract Documents are listed below:

alternating current	a-c
ampere	A
Architectural Barriers Act	ABA
Americans with Disabilities Act	ADA
Americans with Disabilities Act Accessibility Guidelines	ADAAG
ante meridian	a.m.
average	avg
biochemical oxygen demand	BOD
brake horsepower	bhp
British thermal unit	Btu
Centigrade (or Celsius)	C
chlorinated polyvinyl chloride	CPVC
Code of Federal Regulations	CFR
cubic inch	cu in
cubic foot	cu ft
cubic yard	cdu yd, or CY
cubic feet per minute	cfm
cubic feet per second	cfs

degree Centigrade (or Celsius)	degrees C or °C
degrees Fahrenheit	degrees F or °F
diameter	dia
direct current	d-c
dollars	\$
each	ea
efficiency	eff
Fahrenheit	F
feet	ft
feet per hour	fph
feet per minute	fpm
feet per second	fps
figure	Fig
flange	flg
foot-pound	ft-lb
gallon	gal
gallons per hour	gph
gallons per minute	gpm
gallons per second	gps
gram	g
grams per liter	g/L
Hertz	Hz
horsepower	hp or HP
hour	hr
human-machine interface	HMI
inch	in.
inches water gage	in. w.g.
inch-pound	in.-lb

inside diameter	ID
iron pipe size	IPS
thousand pounds	kips
thousand pounds per square inch	ksi
kilovolt-ampere	kva
kilowatt	kw
linear foot	lin ft or LF
liter	L
maximum	max
mercury	Hg
milligram	mg
milligrams per liter	mg/l or mg/L
milliliter	ml
millimeter	mm
million gallons per day	mgd or MGD
million gallons	MG
minimum	min
national pipe threads	NPT
net positive suction head	NPSH
net positive suction head available	NPSHA
net positive suction head required	NPSHR
nominal pipe size	NPS
number	no.
operator interface terminal	OIT
ounce	oz
ounce-force	ozf
outside diameter	OD
parts per hundred	pph

parts per million	ppm
parts per billion	ppb
polyvinyl chloride	PVC
post meridian	p.m.
pound	lb
pounds per square inch	psi
pounds per square inch absolute	psia
pounds per square inch gauge	psig
pounds per square foot	psf
process control system	PCS
programmable logic controller	PLC
revolutions per minute	rpm
second	sec
specific gravity	sp gr or SG
square	sq
square foot	sq ft or sf
square inch	sq in.
square yard	sq yd or SY
standard	std
standard cubic feet per minute	scfm
total dynamic head	TDH

B. Definitions: Terminology used in the Specifications includes:

1. "Indicated" refers to graphic representations, notes, or schedules on the Drawings, or to other paragraphs or schedules in the Specifications and similar locations in the Contract Documents.
2. "Shown", "noted", "scheduled", and "specified" are used to help the user locate the reference without limitation on the location.

3. “Installer”, “applicator”, or “erector” is Contractor or another entity engaged by Contractor, either as an employee or subcontractor, to perform a particular construction activity, including installation, erection, application or similar Work. Installers shall be experienced in the Work that installer is engaged to perform.
4. “Experienced”, when used with the term “installer” means having successfully completed a minimum of five previous projects similar in size and scope to this Project; being familiar with the special requirements indicated; being familiar with Laws and Regulations; and having complied with requirements of authorities having jurisdiction, and complying with requirements of the Supplier of the material or equipment being installed.
5. Trades: Use of a term such as “carpentry” does not imply that certain construction activities must be performed by accredited or unionized individuals of a corresponding generic name, such as “carpenter”, unless otherwise indicated in the Contract Documents or required by Laws or Regulations. Such terminology also does not imply that specified requirements apply exclusively to trade personnel of the corresponding generic name.
6. “Assigned specialists” and similar terms: Certain Sections of the Specifications require that specific construction activities be performed by specialists recognized as experts in those operations. Engage said specialists for those activities, and their engagement is a requirement over which Contractor has no option. These requirements do not conflict with enforcement of building codes and other Laws and Regulations. Also, such requirements are not intended to interfere with local trade union jurisdictional settlements and similar conventions. Such assignments shall not relieve Contractor of responsibility for complying with the requirements of the Contract Documents.

C. Reference Standards:

1. Refer to General Conditions, as may be modified by the Supplementary Conditions, relative to reference standards and resolving discrepancies between reference standards and the Contract Documents. Provisions of reference standards are in effect in accordance with the Specifications.
2. Copies of Standards: Each entity engaged in the Work shall be familiar with reference standards applicable to its construction activity. Copies of applicable reference standards are not bound with the Contract Documents. Where reference standards are needed for a construction activity, obtain copies of standards from the publication source.
3. Abbreviations and Names: Where reference standards, specifications, codes, manuals, Laws or Regulations, or other published data of international, national, regional or local organizations are referred to in the Contract Documents, the

organization issuing the standard may be referred to by their acronym or abbreviation only.

4. Following acronyms or abbreviations that may appear in the Contract Documents shall have the meanings indicated below. Listing is alphabetical by acronym.

AA	Aluminum Association
AABC	Associated Air Balance Council
AAMA	American Architectural Manufacturers Association
AASHTO	American Association of State Highway and Transportation Officials
ACI	American Concrete Institute
ACIFS	American Cast Iron Flange Standards
ACS	American Chemical Society
ADC	Air Diffusion Council
ADSC	International Association of Foundation Drilling.
AEIC	Association of Edison Illuminating Companies
AF&PA	American Forest and Paper Association
ABMA	American Bearing Manufacturers Association (formerly Anti- Friction Bearing Manufacturers Association (ABMA))
AGA	American Gas Association
AGMA	American Gear Manufacturers Association
AHDGA	American Hot Dip Galvanizers Association
AI	Asphalt Institute
AIA	American Institute of Architects
AIChE	American Institute of Chemical Engineers
AISC	American Institute of Steel Construction
AISI	American Iron and Steel Institute
AITC	American Institute of Timber Construction
ALSC	American Lumber Standards Committee
AMA	Acoustical Materials Association
AMCA	Air Movement and Control Association

AMP	National Association of Architectural Metal Manufacturers, Architectural Metal Products Division
ANSI	American National Standards Institute
APA	The Engineered Wood Association
API	American Petroleum Institute
APHA	American Public Health Association
AREA	American Railway Engineering Association
ARI	Air Conditioning and Refrigeration Institute
ASA	American Standards Association
ASAE	American Society of Agricultural Engineers
ASCE	American Society of Civil Engineers
ASHRAE	American Society of Heating, Refrigerating and Air Conditioning Engineers
ASME	American Society of Mechanical Engineers
ASNT	American Society for Non-Destructive Testing
ASQ	American Society for Quality
ASSE	American Society of Safety Engineers
ASTM	American Society for Testing and Materials
AWCI	Association of the Wall and Ceiling Industry
AWI	Architectural Woodwork Institute
AWPA	American Wood Protection Association
AWPI	American Wood Preservers Institute
AWS	American Welding Society
AWWA	American Water Works Association
BAAQMD	Bay Area Air Quality Management District
BHMA	Builders Hardware Manufacturers Association
BIA	Brick Industry Association
BOCA	Building Officials and Code Administrators
CBMA	Certified Ballast Manufacturers Association
CDA	Copper Development Association

CEMA	Conveyor Equipment Manufacturers Association
CGA	Compressed Gas Association
CISCA	Ceilings and Interior Systems Construction Association
CISPI	Cast Iron Soil Pipe Institute
CLFMI	Chain Link Fence Manufacturers Institute
CMAA	Crane Manufacturers Association of America
CPSC	Consumer Product Safety Commission
CRSI	Concrete Reinforcing Steel Institute
CSI	Construction Specifications Institute
DIN	Deutsches Institut für Normung eV (German Institute for Standardization)
DIPRA	Ductile Iron Pipe Research Association
EJCDC	Engineers Joint Contract Documents Committee
EJMA	Expansion Joint Manufacturers Association, Inc.
ETL	Intertek Testing Services, Inc. (formerly ETL Testing Laboratories, Inc.)
FCC	Federal Communications Commission
FEMA	Federal Emergency Management Agency
FHWA	Federal Highway Administration
FM	Factory Mutual (FM Global)
FRPI	Fiberglass Reinforced Plastics Institute
FS	Federal Specification
GA	Gypsum Association
GANA	Glass Association of North America
HEW	United States Department of Health, Education and Welfare
HI	Hydraulic Institute
HMI	Hoist Manufacturers Institute
HUD	United States Department of Housing and Urban Development
IBC	International Building Code

ICC	International Code Council
ICEA	Insulated Cable Engineers Association
IEEE	Institute of Electrical and Electronics Engineers
IESNA	Illuminating Engineering Society of North America
IFI	Industrial Fasteners Institute
IFCEA	Insulated Power Cable Engineers Association
IRI	Industrial Risk Insurers
ISA	Instrumentation, Systems, and Automation Society (formerly Instrument Society of America)
ISO	Insurance Services Office
IOS	International Organization for Standardization
LPI	Lightning Protection Institute
MIA	Marble Institute of America
ML/SFA	Metal Lath/Steel Framing Association
MS	Military Specifications
MSS	Manufacturers' Standardization Society
MMA	Monorail Manufacturers Association
NAAMM	National Association of Architectural Metal Manufacturers
NACE	National Association of Corrosion Engineers
NAPF	National Association of Pipe Fabricators, Inc.
NARUC	National Association of Regulatory Utilities Commissioners
NBHA	National Builders Hardware Association
NBS	United States Department of Commerce, National Bureau of Standards
NCDEQ	North Carolina Department of Environmental Quality
NCDOT	North Carolina Department of Transportation
NCMA	National Concrete Masonry Association
NEC	National Electric Code
NELMA	Northeastern Lumber Manufacturers' Association

NEMA	National Electrical Manufacturers Association
NESC	National Electrical Safety Code
NETA	International Electrical Testing Association
NFPA	National Fire Protection Association
NFRC	National Fenestration Rating Council
NGA	National Glass Association
NHLA	National Hardwood Lumber Association
NHPMA	Northern Hardwood and Pine Manufacturers Association
NIST	United States Department of Commerce, National Institute of Standards and Technology
NLGA	National Lumber Grades Authority
NRCA	National Roofing Contractors Association
NRMCA	National Ready Mixed Concrete Association
NSF	National Sanitation Foundation
NSSGA	National Stone, Sand, and Gravel Association
NTMA	National Terrazzo and Mosaic Association
OSHA	Occupational Safety and Health Administration
PCA	Portland Cement Association
PCI	Precast/Prestressed Concrete Institute
PEI	Porcelain Enamel Institute
PFI	Pipe Fabrication Institute
PPI	Plastics Pipe Institute
PGMC	Primary Glass Manufacturers Council
PS	Product Standards Section, United States Department of Commerce
RCSC	Research Council on Structural Connections (part of AISC)
RMA	Rubber Manufacturers Association
SAE	Society of Automotive Engineers
SBCCI	Southern Building Code Congress International, Inc.
SCAQMD	Southern California Air Quality Management District

SCPRF	Structural Clay Products Research Foundation
SCTE	Society of Cable Telecommunications Engineers
SDI	Steel Deck Institute
SDI	Steel Door Institute
SIGMA	Sealed Insulating Glass Manufacturing Association
SJI	Steel Joist Institute
SMACNA	Sheet Metal and Air Conditioning Contractor's National Association
SPI	Society of the Plastics Industry
SPIB	Southern Pine Inspection Bureau
SSPC	Society for Protective Coatings
SWI	Steel Window Institute
TCNA	Tile Council of North America
TEMA	Tubular Exchanger Manufacturers Association
TIA/EIA	Telecommunications Industry Association/Electronic Industries Alliance
UBC	Uniform Building Code
UL	Underwriters Laboratories, Inc.
USAB	United States Access Board
USDOE	United States Department of Energy
USEPA	United States Environmental Protection Agency
USGBC	United States Green Building Council
USGS	United States Geological Survey
USPHS	United States Public Health Service
WCLIB	West Coast Lumber Inspection Bureau
WCMA	Window Covering Manufacturers Association
WCMA	Wood Component Manufacturers Association
MDMA	Window and Door Manufacturers Association
WWEMA	Water and Wastewater Equipment Manufacturers Association
WWPA	Western Wood Products Association

PART 2 – PRODUCTS (NOT USED)

PART 3 – EXECUTION (NOT USED)

END OF SECTION

SECTION 01 45 23
MATERIALS TESTING SERVICES FURNISHED BY CONTRACTOR

PART 1 – GENERAL

1.01 SUMMARY

- A. Contractor is responsible for providing testing services as necessary to maintain their own internal quality control and to ensure they are meeting all Contract requirements. Contractor is advised that the Owner will be providing independent, third-party testing services for concrete, asphalt, soils, compaction, and welding.
- B. This specification addresses requirements for testing services specifically required to be provided by the Contractor. This section does not apply to any testing required to be provided by the Owner or Owner's representative.
- C. This section does not apply to any Special Inspections as required by Section 01 45 33. Special Inspections cannot be provided by the Contractor in accordance with the Governing Building Code.
- D. Contractor shall employ and pay for an independent Materials Testing Consultant to perform specified services covered by this specification. Consultant selected shall be subject to approval by Engineer.
- E. Inspection, sampling, and testing shall be as specified in the individual Specification Sections.
- F. Related Sections, but not limited to, the following:
 - 1. Section 01 45 33 – Special Inspections
 - 2. Section 01 88 16 – Watertightness Testing of Concrete Structures
 - 3. Section 03 21 00 – Reinforcing Steel
 - 4. Section 03 30 00 – Cast-in-Place Concrete
 - 5. Section 04 05 13 – Mortar and Masonry Grout
 - 6. Section 07 13 50 - Waterproofing
 - 7. Section 31 00 01 – Earthwork
 - 8. Section 31 05 16 – Aggregate Materials
 - 9. Section 31 23 24 – Flowable Fill

- 10. Section 32 10 00 – Paving and Surfacing
- 11. Section 33 05 61 – Utility Structures

1.02 ADMINISTRATIVE REQUIREMENTS

A. Contractor's Responsibilities:

- 1. Provide to laboratory representative samples of materials to be tested, in required quantities.
- 2. Provide labor and facilities:
 - a. To provide access to the Work to be tested, and where required, to Suppliers' operations.
 - b. To obtain and handle samples at the Site.
 - c. To facilitate inspections and tests.
 - d. For testing entity's exclusive use for storage and curing of test samples.
 - e. Forms for preparing concrete test beams and cylinders.
- 3. Notify Materials Testing Consultant and Engineer a minimum of 48 hours in advance of operations to allow for assignment of personnel and scheduling of tests.
- 4. Arrange with Testing Consultant and pay for additional services, sampling, and testing required for Contractor's convenience.
- 5. Provide to Testing Consultant the preliminary design mix proposed for concrete, and other material mixes that require testing by the testing laboratory.

B. Testing Consultant's Responsibilities:

- 1. Cooperate with Contractor and Engineer and provide qualified personnel promptly when notified.
- 2. Perform specified inspections, sampling, and testing of materials and methods of construction; comply with applicable standards; ascertain compliance with requirements of the Contract Documents.
- 3. Promptly notify Engineer and Contractor of irregularities or deficiencies in the Work observed during performance of services.

4. Submit specified quantity of report copies of inspections and tests to Contractor and Engineer.
5. Perform additional tests and services as required to ensure compliance with the Contract Documents.

C. Report Requirements:

1. Electronic Submittal of testing reports.
2. Include the following information:
 - a. Date issued.
 - b. Project title, number, and name of the Site.
 - c. Testing laboratory name and address.
 - d. Name and signature of inspector or person obtaining samples.
 - e. Date of inspection or sampling.
 - f. Record of temperature and weather.
 - g. Date of test.
 - h. Identification of material or product tested and associated Specification Section.
 - i. Location in the Project.
 - j. Type of inspection or test.
 - k. Results of tests and observations regarding compliance with the Contract Documents.

1.03 SUBMITTALS

- A. Submit copies of material and product test reports where required by the Contract Documents and as requested by Engineer.
- B. Quality Assurance Submittals:
 1. Qualifications statement indicating experience and facilities for tests required under the Contract Documents.
 2. Copy of report of inspection of facilities during most recent NIST inspection tour. Include memorandum of remedies of deficiencies reported during inspection.

3. Copy of certificate of calibration for each instrument or measuring device proposed for use, by accredited calibration agency.

1.04 QUALIFICATIONS

- A. Comply with applicable requirements of ASTM E329, Specification for Agencies Engaged in Construction Inspection and/or Testing.
- B. Laboratory shall be authorized to operate in the same State or Commonwealth as the Site. Where applicable, laboratory shall be certified by the authority having jurisdiction for the types of testing required.
- C. Testing equipment used by laboratory will be calibrated at maximum twelve month intervals by devices of accuracy traceable to either NIST's Standard Reference Materials (SRM), ISO 17025, General Requirements for the Competence of Testing and Calibration Laboratories, or certified by State, Commonwealth, or local bureau of weights and measures, or values of natural physical constants generally accepted in the engineering and scientific community.

PART 2 – PRODUCTS (NOT USED)

PART 3 – EXECUTION (NOT USED)

END OF SECTION

SECTION 01 45 33
SPECIAL INSPECTIONS

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. This Section defines the requirements for Special Inspections as required by Section 1704 of the International Building Code (IBC) and any State or local amendments.
- B. Either the Engineer of Record (EOR) or Registered Design Professional in Responsible Charge (RDPIRC) will prepare a Statement of Special Inspections, which identifies the type and extent of required Special Inspections.
- C. The Owner will retain one or more Special Inspections Agencies to perform Special Inspection services. These Agencies shall be independent from the Contractor and approved by the Building Official. The EOR may perform Special Inspection services where qualifications for a specific inspection task are met.
- D. The Contractor shall plan and conduct operations as to schedule and allow Special Inspections, providing adequate time and safe access for inspections. The Contractor shall coordinate requirements for Special Inspections with the Special Inspections Agency.
- E. Special Inspections shall be in addition to inspections performed by Building Officials that are specified in IBC Section 104.
- F. Special Inspections shall be in addition to any Structural Observations required by IBC Section 1704.6.
- G. Special Inspections do not supersede other inspections and testing required by the Contract Documents to satisfy the Contractor's quality control responsibility. Contractor shall be responsible for all costs associated with quality control requirements as required by other Sections of the Specifications.
- H. Special Inspections shall not relieve Contractor's obligation to perform and complete work in accordance with Contract Documents. Results of Special Inspections activities, including any discrepancies that are noted or not noted, shall never constitute an acceptance of work that is not in accordance with the Contract Documents.
- I. This Section does not apply to construction equipment, shoring, earth retention systems, and temporary structures used by the Contractor in construction and not detailed in the Contract Documents. The Contractor shall be solely responsible for means, methods, techniques, sequences, or procedures of construction and any associated building code requirements.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Special Inspections requirements apply to work detailed in other Sections of the Specifications. Special Inspections requirements shall be in addition to any other inspection or quality control requirements detailed in other Sections of the Specifications. See individual Specification Sections for type of work in question.

1.03 DEFINITIONS

- A. Periodic Special Inspections: The part-time or intermittent observation of work requiring Special Inspection by a Special Inspector who is present in the area where the work has been or is being performed and at the completion of the work.
- B. Continuous Special Inspections: The full-time observation of work requiring Special Inspection by a Special Inspector who is present in the area where the work is being performed.
- C. Engineer of Record (EOR): The engineer of each system in responsible charge for the design of each specific building system including structural, mechanical, electrical, and architectural components
- D. Registered Design Professional in Responsible Charge (RDPIRC): The RDPIRC in charge of Special Inspections during construction for each specific building system including structural, mechanical, electrical, and architectural components. The RDPIRC shall be a currently Registered Professional Engineer in the State or Commonwealth in which the project is located. The EOR may serve in this role.
- E. Special Inspections Agency: An established and recognized agency regularly engaged in conducting tests or furnishing inspection services, which has been approved by the Building Official and is retained by the Owner. The EOR may serve in this role where qualifications for specific inspection tasks are met.
- F. Special Inspector: Individual employed by or retained by the Special Inspections Agency who is qualified in inspection of specific aspects or components of the construction and conducts inspection activities in these specific aspects of the construction, as required by this Section. The EOR may serve in this role where qualifications for specific inspection tasks are met.
- G. Statement of Special Inspections: Document prepared by the EOR or RDPIRC and submitted to the Building Official which identifies the type and extent of required Special Inspections.
- H. Approved Fabricator: Fabricator who has been registered and approved by the Building Official to manufacture or fabricate specific components of the construction without Special Inspections.

1.04 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

- A. Without limiting the generality of the other requirements of the Specifications, all work herein shall conform to the applicable requirements of the following documents and all other documents referenced in the Specifications. All referenced Specifications, codes, and standards refer to the most current issue available at the time of Bid.
1. International Building Code
 2. ACI 318 – Building Code Requirements for Structural Concrete
 3. TMS 402/TMS 602 – Building Code for Masonry Structures/Specifications for Masonry Structures
 4. AISC – Code of Standard Practice
 5. AISC 341 – Seismic Provisions for Structural Steel Buildings
 6. AISC 360 – Specification for Structural Steel Buildings
 7. AISC 348 – Specification for Structural Joints Using High Strength Bolts
 8. AWS – Structural Welding Code
 9. ADMI – Aluminum Design Manual: A Specification for Aluminum Structures

1.05 SUBMITTALS

- A. The Contractor shall submit the following in accordance with Section 01 33 00 - Submittal Procedures.
1. The Contractor shall submit a written statement of responsibility to the Building Official and RDPIRC prior to beginning work. A statement is required from each Contractor who has responsibility for construction or fabrication of a main wind- or seismic-force-resisting system, designated seismic system, or a wind- or seismic-resisting-component listed in the Statement of Special Inspections.
 2. The Contractor shall submit qualifications of any fabricators they intend to use that may qualify as Approved Fabricators to the Special Inspections Agency for review.
- B. The Special Inspections Agency shall submit the following in accordance with Section 01 33 00 – Submittal Procedures.
1. The Special Inspections Agency shall provide a statement of qualifications showing relative experience, training, and certification(s) for each Special Inspector to the Building Official, if requested.
 2. The Special Inspections Agency shall review fabricator qualifications and submit them to the Building Official for approval as an Approved Fabricator if requested.

3. Special Inspectors shall keep detailed inspection records, including all inspections, tests, similar services, and any discrepancies and corrections. Any discrepancies and corrections shall be reported to the Building Official, the EOR, and the RDPIRC in all required reports, unless otherwise required by the Building Official.
4. The Special Inspections Agency shall submit Interim Reports to the Building Official and the RDPIRC documenting required Special Inspections and correction of any discrepancies at the frequency specified in the Statement of Special Inspections.
5. The Special Inspections Agency shall submit to the Building Official and the RDPIRC a Final Report documenting required Special Inspections and correction of any discrepancies. The Final Report shall be submitted at a point in time agreed upon by the Owner and the Building Official at the Pre-inspection Meeting.
6. Where work is done by Approved Fabricators, the Special Inspections Agency shall coordinate the submittal of a certificate of compliance to the Building Official, the EOR, and the RDPIRC.

1.06 SPECIAL INSPECTOR QUALIFICATIONS

- A. Special Inspectors shall meet minimum qualifications established by the Building Official and shall be approved by the Building Official.

1.07 OFF-SITE FABRICATIONS

- A. When structural elements or assemblies are fabricated off site, Special Inspections shall be performed in the fabricator's shop unless the fabricator is an Approved Fabricator. Special Inspections are not required if work is done on the premises of an Approved Fabricator.
- B. Fabricators shall maintain detailed fabrication and quality control procedures to ensure workmanship and conformance with Contract Documents and reference standards. The Special Inspections Agency shall review the fabricator's quality control procedures and coordinate required Special Inspections with the fabricator and the Contractor.
- C. The Contractor shall submit qualifications of fabricators seeking Approved Fabricator status to the Special Inspections Agency for review. Approval as an Approved Fabricator shall be given by the Building Official upon the recommendation of the Special Inspections Agency or upon review of the fabricator's written fabrication procedures and quality control manuals that provide a basis for control of materials and workmanship, with periodic auditing of fabrication and quality control practices by an Approved Agency or the Building Official.
- D. At completion of fabrication, the Approved Fabricator shall submit a certificate of compliance to the Owner or the RDPIRC for submittal to the Building Official stating that the work was performed in accordance with the approved Contract Documents.

PART 2 – PRODUCTS (NOT USED)

PART 3 – EXECUTION

3.01 PRE-INSPECTION MEETING

- A. At least two weeks prior to beginning work, a Pre-inspection Meeting shall be held to discuss the Special Inspection procedures and submittals. The following parties shall participate: EOR, RDPIRC, Special Inspections Agency representative, Contractor, Subcontractors, Testing Agencies, and Building Official. The type of meeting (in-person or teleconference) and location of meeting shall be determined by the Building Official.

3.02 STATEMENT AND SCHEDULE OF SPECIAL INSPECTIONS

- A. The Special Inspections Agency and all Special Inspectors are required to comply with all requirements of the Statement of Special Inspections and the Schedule of Special Inspections. Together, these documents identify materials, systems, components, and work that are required to have Special Inspections, the type and extent of Special Inspections, and whether they will be continuous or periodic. The Schedule of Special Inspections is included at the end of this Section. A form which may be used for the Statement of Special Inspections is also included at the end of this Section.

3.03 SPECIAL INSPECTIONS AGENCY REQUIREMENTS AND RESPONSIBILITIES

- A. The Special Inspections Agency shall be an established and recognized agency regularly engaged in conducting tests or furnishing inspection services, which has been approved by the Building Official and is retained by the Owner. The Agency shall demonstrate competence, to the satisfaction of the Building Official, for the inspection of the specific aspects of construction or operation requiring Special Inspection.
- B. The Special Inspections Agency shall maintain detailed inspection records, including a copy at the jobsite, and all records shall be available upon request by the EOR, RDPIRC or the Building Official. The Agency shall submit all required reports to the EOR, RDPIRC and Building Official. Where EOR approval is required for corrections, the Special Inspector shall maintain copies of all related correspondence and submit with all required reports. The Agency shall coordinate all required Special Inspection activities with the Special Inspectors, the Contractor, and any fabricators and shall coordinate designation of fabricators as Approved Fabricators when requested.

3.04 SPECIAL INSPECTORS' REQUIREMENTS AND RESPONSIBILITIES

- A. All Special Inspectors shall meet the qualification requirements determined by the Building Official for the specific type of inspection services they will be providing and shall be approved by the Building Official. Special Inspectors shall submit written documentation demonstrating their competence and experience or training to the Building Official for approval of their qualifications.

- B. Special Inspections shall be performed in accordance with all requirements of the Statement of Special Inspections, the Schedule of Special Inspections, the IBC, and any State or local amendments. Special Inspectors shall maintain detailed inspection records, including a copy at the jobsite, and all records shall be available upon request by the EOR, RDPIRC, or the Building Official. Special Inspectors shall submit all required reports to the RDPIRC and the Building Official. Where EOR approval is required for corrections, the Special Inspector shall maintain copies of all related correspondence and submit with all required reports. Special Inspectors shall coordinate inspection requirements and time when inspections can be conducted with the Contractor.
- C. Any discrepancies in work noted by the Special Inspector shall be brought to the immediate attention of the Contractor for correction. Special Inspectors shall coordinate correction of discrepancies with the Contractor. Any corrections of discrepancies that result in changes to the work as shown on the Contract Documents shall be approved by the EOR. If noted discrepancies are not corrected, the Special Inspector shall notify the Contractor, the EOR, the RDPIRC and the Building Official. All noted discrepancies and corrections shall be documented in all inspection records and all required reports.

3.05 CONTRACTOR RESPONSIBILITIES

- A. Each Contractor responsible for the construction or fabrication of a main wind- or seismic-force-resisting system, designated seismic system, or a wind- or seismic-resisting-component listed in the Statement of Special Inspections shall submit a Statement of Responsibility to the Building Official, RDPIRC, and EOR prior to the commencement of work. The Statement of Responsibility shall contain acknowledgement of the specific requirements contained in the Statement of Special Inspections.
- B. The Contractor shall coordinate requirements of Special Inspections with the Special Inspections Agency and the Special Inspectors and shall provide adequate time and access to conduct inspections. The Contractor is solely responsible for providing safe access and any necessary safety equipment required to conduct inspections. The Special Inspector shall not supervise, direct, control, or have authority over or be responsible for the Contractor's means, methods, techniques, sequences, or procedures of construction, or the safety precautions and programs incident thereto, or for any failure of the Contractor to comply with Laws and Regulations applicable to the performance of the Work.
- C. Special Inspections shall not relieve the Contractor's obligation to perform and complete work in accordance with the Contract Documents. Results of Special Inspections activities, including any discrepancies that are noted or not noted, shall never constitute an acceptance of work that is not in accordance with the Contract Documents.
- D. The Contractor shall provide advance notice of work to be conducted that will require Special Inspections. If the Special Inspector is delayed in inspecting the work due to

inadequate notice or completion of the work, the Contractor shall reimburse the Owner for the cost of additional subsequent Special Inspections.

- E. The Contractor shall promptly correct any discrepancies noted by the Special Inspectors. Any corrections of discrepancies that result in changes to the work as shown on the Contract Documents shall be approved by the EOR. Where EOR approval is required, the Contractor shall report the discrepancy to the EOR in accordance with provisions of the General Conditions. The EOR will authorize any changes to the Contract Documents required for the correction in accordance with provisions of the General Conditions. Copies of all correspondence related to the correction shall be submitted concurrently to the Special Inspections Agency.

3.06 BUILDING OFFICIAL OR AUTHORITY RESPONSIBILITIES

- A. The Building Official will approve qualifications of the Special Inspections Agency, all Special Inspectors, and any Approved Fabricators. The Building Official will approve all forms submitted by the Contractor, any Approved Fabricators, the EOR, the RDPIRC, the Special Inspections Agency, and the Special Inspectors. The Building Official and the Special Inspections Agency shall agree to the frequency of Interim Reports and the submittal deadline for the Final Report.

3.07 RDPIRC RESPONSIBILITIES

- A. The RDPIRC shall complete the Statement of Special Inspections and the Schedule of Special Inspections, unless previously completed by the EOR. The Statement of Special Inspections form included in this Section shall be used unless the Building Official has a preferred form for the Statement of Special Inspections, in which case the Building Official's form may be used and shall be completed by the RDPIRC.
- B. The RDPIRC shall review and coordinate certain aspects of the project, as determined by the Building Official, for compatibility with the design of the building, structure or building system, including, but not limited to, submittal documents prepared by others, deferred submittal documents and phased submittal documents.

3.08 OWNER RESPONSIBILITIES

- A. The Owner will retain a Special Inspections Agency to perform Special Inspections during construction. The Special Inspections Agency will retain the RDPIRC.

3.09 MINIMUM INSPECTION REQUIREMENTS

- A. Detailed requirements for Special Inspections are shown in the Statement of Special Inspections and the Schedule of Special Inspections, which references the IBC, applicable code standards, and any State or local amendments. Special Inspections shall be performed in accordance with all requirements of the Statement of Special Inspections, the Schedule of Special Inspections, the IBC, and any State or local amendments. Additional requirements for specific materials listed in other Sections of these Specifications shall also be satisfied. The frequency of inspections shall be

continuous or periodic as indicated in the Schedule of Special Inspections and in accordance with applicable building codes.

3.10 REPORTS

- A. Special Inspectors shall maintain detailed inspection records, including a copy at the jobsite, and all records shall be available upon request by the EOR, RDPIRC or the Building Official. The Special Inspections Agency shall submit all required reports to the Building Official, EOR, and RDPIRC as agreed upon with the Building Official. Reports shall indicate the inspections and testing performed and whether work inspected was or was not completed in conformance to Contract Documents and any corrective measures taken. Where EOR approval is required for corrections, the Agency shall maintain copies of all related correspondence and submit with all required reports.

3.11 SPECIAL INSPECTIONS FORMS

- A. This Section includes forms which may be used to meet requirements for written documentation during the performance of Special Inspections in accordance with the IBC. These forms may be replaced with forms meeting IBC requirements provided by the Building Official if available.

SCHEDULE OF SPECIAL INSPECTIONS (IBC 2021 VERSION)

1 – STEEL CONSTRUCTION (IBC 2021/AISC 360-16)

1.1 STRUCTURAL STEEL

Inspection Task		Frequency		Applicable to Project
		CONT	PER	Y/N
1. Inspection Tasks Prior to Welding:				
a.	Welder qualification records and continuity records			
	1) Quality Assurance provided by inspector		O	
	2) Quality Control provided by fabricator, erector, or contractor	P		
b.	WPS available	P		
c.	Manufacturer certifications for welding consumables available	P		
d.	Material identification (type/grade)		O	
e.	Welder identification system*		O	
f.	Fit-up of groove welds (including joint geometry)		O	
	1) Joint preparations			
	2) Dimensions (alignment, root opening, root face, bevel)			
	3) Cleanliness (condition of steel surfaces)			
	4) Tacking (tack weld quality and location)			
	5) Backing type and fit (if applicable)			
g.	Fit-up of CPJ groove welds of HSS T-, Y- and K-joints without backing (including joint geometry) - Quality Assurance provided by inspector		O	
	1) Joint preparations			
	2) Dimensions (alignment, root opening, root face, bevel)			
	3) Cleanliness (condition of steel surfaces)			
	4) Tacking (tack weld quality and location)			
h.	Configuration and finish of access holes		O	
i.	Fit-up of fillet welds		O	
	1) Dimensions (alignment, gaps at root)			
	2) Cleanliness (condition of steel surfaces)			
	3) Tacking (tack weld quality and location)			
j.	Check welding equipment		O	

Inspection Task		Frequency		Applicable to Project
		CONT	PER	Y/N
* The fabricator or erector, as applicable, shall maintain a system by which a welder who has welded a joint or member can be identified. Stamps, if used, shall be the low-stress type.				
2. Inspection Tasks During Welding:				
a.	Control and handling of welding consumables 1) Packaging 2) Exposure control		O	
b.	No welding over cracked tack welds		O	
c.	Environmental conditions 1) Wind speed within limits 2) Precipitation and temperature		O	
d.	WPS followed 1) Settings on welding equipment 2) Travel speed 3) Selected welding materials 4) Shielding gas type/flow rate 5) Preheat applied 6) Interpass temperature maintained (min/max) 7) Proper position (F, V, H, OH)		O	
e.	Welding techniques 1) Interpass and final cleaning 2) Each pass within profile limitations 3) Each pass meets quality requirements		O	
f.	Placement and installation of steel headed stud anchors	P		
3. Inspection Tasks After Welding:				
a.	Welds cleaned		O	
b.	Size, length, and location of welds	P		
c.	Welds meet visual acceptance criteria 1) Crack prohibition 2) Weld/base-metal fusion 3) Crater cross section 4) Weld profiles 5) Weld size 6) Undercut 7) Porosity	P		
d.	Arc strikes	P		
e.	k-area **	P		

Inspection Task		Frequency		Applicable to Project
		CONT	PER	Y/N
f.	Weld access holes in rolled heavy shapes and built-up heavy shapes***	P		
g.	Backing removed and weld tabs removed (if required)	P		
h.	Repair activities	P		
i.	Document acceptance or rejection of welded joint or member	P		
j.	No prohibited welds have been added without the approval of the EOR		O	
** When welding of doubler plates, continuity plates or stiffeners has been performed in the k-area, visually inspect the web k-area for cracks within 3 inches of the weld. *** After rolled heavy shapes (see AISC 360 Section A3.1c) and built-up heavy shapes (see AISC 360 Section A3.1d) are welded, visually inspect the weld access hole for cracks.				
4. Inspection Tasks Prior to Bolting:				
a.	Manufacturer's certifications available for fastener materials			
	1) Quality assurance provided by inspector	P		
	2) Quality control provided by fabricator, erector, or contractor		O	
b.	Fasteners marked in accordance with ASTM requirements		O	
c.	Correct fasteners selected for the joint detail (grade, type, bolt length if threads are to be excluded from shear plane)		O	
d.	Correct bolting procedure selected for joint detail		O	
e.	Connecting elements, including the appropriate faying surface condition and hole preparation, if specified, meet applicable requirements		O	
f.	Pre-installation verification testing by installation personnel observed and documented for fastener assemblies and methods used			
	1) Quality Assurance provided by inspector		O	
	2) Quality Control provided by fabricator, erector, or contractor	P		
g.	Protected storage provided for bolts, nuts, washers, and other fastener components		O	
5. Inspection Tasks During Bolting:				
a.	Fastener assemblies placed in all holes and washers and nuts are positioned as required		O	
b.	Joint brought to the snug-tight condition prior to the pre-tensioning operation		O	
c.	Fastener component not turned by the wrench prevented from rotating		O	

Inspection Task		Frequency		Applicable to Project
		CONT	PER	Y/N
d.	Fasteners are pre-tensioned in accordance with the RCSC Specification, progressing systematically from the most rigid point toward the free edges		O	
6. Inspection Tasks After Bolting:				
a.	Document acceptance or rejection of bolted connections	P		
Structural Steel Definitions: Observe (O) - The inspector shall observe these items on a random basis. Operations need not be delayed pending these inspections. Perform (P) - These tasks shall be performed for each welded joint or member and for each bolted connection.				

TABLE 1.1 - STRUCTURAL STEEL REFERENCES:

1. Welded Steel Construction Reference Standard AISC 360-16, Section N5.4.
2. Bolted Steel Construction Reference Standard AISC 360-16, Section N5.6.

1.2 COLD-FORMED STEEL DECK (IBC 2021/SDI QA/QC-17)

Inspection Task		Frequency		Applicable to Project
		CONT	PER	Y/N
1. Inspection or Execution Tasks Prior to Deck Placement:				
a.	Verify compliance of materials (deck and all deck accessories) with construction documents, including profiles, material properties, and base metal thickness	P		
b.	Document acceptance or rejection of deck and deck accessories	P		
2. Inspection or Execution Tasks After Deck Placement:				
a.	Verify compliance of deck and all deck accessories installation with construction documents	P		
b.	Verify deck materials are represented by the mill certifications that comply with the construction documents	P		
c.	Document acceptance or rejection of installation of deck and deck accessories	P		
3. Inspection or Execution Tasks Prior to Welding:				
a.	Welding procedure specifications (WPS) available		O	
b.	Manufacturer certifications for welding consumables available		O	

Inspection Task		Frequency		Applicable to Project
		CONT	PER	Y/N
c.	Material identification (type/grade)		O	
d.	Check welding equipment		O	

Inspection Task		Frequency		Applicable to Project
		CONT	PER	Y/N
4. Inspection or Execution Tasks During Welding:				
a.	Use of qualified welders		O	
b.	Control and handling of welding consumables		O	
c.	Environmental conditions (wind speed, moisture, temperature)		O	
d.	WPS followed		O	
5. Inspection or Execution Tasks After Welding:				
a.	Verify size and location of welds, including support, sidelap, and perimeter welds	P		
b.	Welds meet visual acceptance criteria	P		
c.	Verify repair activities	P		
d.	Document acceptance or rejection of welds	P		
6. Inspection or Execution Tasks Prior to Mechanical Fastening:				
a.	Manufacturer installation instructions available for mechanical fasteners		O	
b.	Proper tools available for fastener installation		O	
c.	Proper storage for mechanical fasteners		O	
7. Inspection or Execution Tasks During Mechanical Fastening:				
a.	Fasteners are positioned as required		O	
b.	Fasteners are installed in accordance with manufacturer's instructions		O	
8. Inspection or Execution Tasks After Mechanical Fastening:				
a.	Check spacing, type, and installation of support fasteners	P		
b.	Check spacing, type, and installation of sidelap fasteners	P		
c.	Check spacing, type, and installation of perimeter fasteners	P		
d.	Verify repair activities	P		

Inspection Task		Frequency		Applicable to Project
		CONT	PER	Y/N
e.	Document acceptance or rejection of mechanical fasteners	P		
Cold-Formed Steel Deck Definitions: Observe (O) – The inspector shall observe these items on an intermittent basis. Operations need not be delayed pending these inspections. Perform (P) – These tasks shall be performed for each item or element.				

TABLE 1.2 - COLD FORMED STEEL DECK REFERENCES:

1. SDI QA/QC – 2017.

1.3 OPEN-WEB STEEL JOISTS AND JOIST GIRDERS (IBC 2021/SJI 100-20 & SJI 200-15)

Inspection Task		Frequency		Applicable to Project	Reference Standard	IBC Reference
		CONT	PER	Y/N		
1. Inspection of open-web steel joists and joist girders:					SJI specifications listed in IBC Section 2207.1	1705.2.3
a	End connections – welding or bolted		X			
b	Bridging – horizontal or diagonal					
	1) Standard bridging		X			
	2) Bridging that differs from the SJI specifications listed in IBC Section 2207.1		X			

TABLE 1.3 - OPEN-WEB STEEL JOISTS AND JOIST GIRDERS REFERENCES:

1. SJI 100-20 & SJI 200-15.

2 - CONCRETE CONSTRUCTION (IBC 2021/ACI 318-19)

Inspection Task		Frequency		Applicable to Project	Reference Standard	IBC Reference
		CONT	PER	Y/N		
1*. Inspect reinforcement, including prestressing tendons, and verify placement			X		ACI 318: Ch 20, 25.2, 25.3, 26.6.1- 26.6.3	1705.3
2*. Reinforcing bar welding:					AWS D1.4, ACI 318: 26.6.4	1705.3
a	Verify weldability of reinforcing bars other than ASTM A706		X			
b	Inspect single-pass fillet welds, maximum 5/16"		X			
c	Inspect all other welds	X				
3. Inspect anchors cast in concrete			X		ACI 318: 17.8.2	1705.3
4. Inspect anchors post-installed in hardened concrete members: **					ACI 318: 17.8.2.4, ACI 318: 17.8.2	1705.3
a	Adhesive anchors installed in horizontally or upwardly inclined orientations to resist sustained tension loads	X				
b	Mechanical anchors and adhesive anchors not defined in 4.a		X			
5. Verify use of required design mix		X			ACI 318: Ch 19, 26.4.3, 26.4.4, 26.13.3.2	1705.3, 1904.1, 1904.2
6. Prior to concrete placement, fabricate specimens for strength tests, perform slump and air content tests, and determine the temperature of the concrete		X			ASTM C172, ASTM C31, ACI 318: 26.5, 26.12	1705.3
7. Inspect concrete and shotcrete placement for proper application techniques		X			ACI 318: 26.5	1705.3
8. Verify maintenance of specified curing temperature and techniques. Verify curing method and duration of curing for each member.			X		ACI 318: 26.5.3-26.5.5, 26.13.3.3	1705.3
9. Inspect prestressed concrete for:		X			ACI 318: 26.10	1705.3
a	Application of prestressing forces.					
b	Grouting of bonded prestressing tendons.					
10. Inspect erection of precast concrete members. Inspect sequence of erection and connection of precast members.			X		ACI 318: 26.9, 26.13.3.3	1705.3

Inspection Task		Frequency		Applicable to Project	Reference Standard	IBC Reference
		CONT	PER	Y/N		
11. For precast concrete diaphragm connections or reinforcement at joints classified as moderate or high deformability elements (MDE or HDE) in structures assigned to SDC C, D, E, OR F, inspect such connections and reinforcement in the field for:					ACI 318: 26.13.1.3, ACI 550.5	1705.3
a	Installation of the embedded parts.	X				
b	Completion of the continuity of reinforcement across joints.	X				
c	Completion of connections in the field.	X				
12. Inspect installation tolerances of precast concrete diaphragm connections for compliance with ACI 550.5.			X		ACI 318: 26.13.1.3	1705.3
13. Verify in-situ concrete strength, prior to stressing of tendons in post-tensioned concrete and prior to removal of shores and forms from beams and structural slabs.			X		ACI 318: 26.11.2	1705.3
14. Inspect formwork for shape, location, and dimensions of the concrete member being formed. Inspect construction and removal of forms and shoring.			X		ACI 318: 26.11.1.2(b), 26.13.3.3	1705.3
* Where applicable, see Table 7.2 - Special Inspections for Seismic Resistance - Concrete ** Specific requirements for Special Inspection shall be included in the research report for the anchor issued by an approved source in accordance with 17.8.2 in ACI 318, or other qualification procedures. Where specific requirements are not provided, Special Inspection requirements shall be specified by the registered design professional and shall be approved by the building official prior to the commencement of the work.						

NOTES:

1. ACI 318 Referenced Standard refers to the 2019 edition.
2. Concrete patios, driveways and sidewalks on grade are exempt from Special Inspection requirements.

3 - MASONRY CONSTRUCTION - LEVEL 2 QUALITY ASSURANCE (IBC 2021/TMS 402 & 602)

Inspection Task	Applicable to Project	Reference Standard		IBC Reference
	Y/N	TMS 402	TMS 602	
Prior to construction, verification of compliance of submittals.			ART. 1.5	1705.4
Prior to construction, verification of f'm, except where specifically exempted by the Code.			ART. 1.4B	
During construction, verification of slump flow and visual stability index (VSI) when self-consolidating grout is delivered to the project site.			ART. 1.5, 1.6.3	

Minimum Special Inspection		Frequency		Applicable to Project	Reference Standard		IBC Reference	
		CONT	PER		Y/N	TMS 402		TMS 602
1. As masonry construction begins, verify that the following comply:								
a	Proportions of site-prepared mortar.		X			ART. 2.1, 2.6A, 2.6C	1705.4	
b	Grade, type and size of reinforcement, connectors, and anchor bolts.		X			ART. 3.4, 3.6A		
c	Sample panel construction.		X			ART. 1.6D		
2. Prior on grouting, verify that the following comply:								
a	Grout space.		X			ART. 3.2D, 3.2F		
b	Placement of reinforcement, connectors, and anchor bolts.		X		SEC. 6.1, 6.3.1, 6.3.6, 6.3.7	ART. 3.2E, 3.4		
c	Proportions of site-prepared grout.		X			ART. 2.6B, 2.4 G.1.b		
3. Verify compliance of the following during construction:								
a	Materials and procedures with approved submittals.		X			ART. 1.5	1705.4	
b	Placement of masonry units and mortar joint construction.		X			ART. 3.3B		
c	Size and location of structural members.		X			ART. 3.3F		
d	Type, size, and location of anchors, including other details of anchorage of masonry to structural members, frames, or other construction.		X		SEC. 1.2.1(e), 6.2.1, 6.3.1			

Minimum Special Inspection		Frequency		Applicable to Project	Reference Standard		IBC Reference
		CONT	PER	Y/N	TMS 402	TMS 602	
e	Welding of reinforcement.	X			SEC. 6.1.6.1.2		1705.4
f	Preparation, construction, and protection of masonry during cold weather (temperature below 40° F) or hot weather (temperatures above 90° F).		X			ART. 1.8C, 1.8D	
g	Placement of grout complies.	X				ART. 3.5, 3.6C	
4. Observe preparation of grout specimens, mortar specimens, and/or prisms.			X			ART. 1.4B.2.a.3, 1.4B.2.b.3, 1.4B.2.c.3, 1.4B.3, 1.4B.4	1705.4

TABLE 3 - MASONRY CONSTRUCTION REFERENCES:

1. Level 2 quality assurance in accordance with TMS 402/602-16.

4 - DEEP FOUNDATION ELEMENTS (IBC 2021)

Inspection Task	Frequency		Applicable to Project	IBC Reference
	CONT	PER	Y/N	
1. Whenever there is reasonable doubt as to the structural integrity of a deep foundation element an engineering assessment shall be required, which shall include tests for defects performed in accordance with ASTM D4945, ASTM D5882, ASTM D6760 or ASTM D7949 or other approved method.	X			1705.10

4.1 DRIVEN DEEP FOUNDATION ELEMENTS (IBC 2021)

Inspection Task	Frequency		Applicable to Project	IBC Reference
	CONT	PER	Y/N	
1. Verify element materials, sizes and lengths comply with the requirements.	X			1705.7
2. Determine capacities of test elements and conduct additional load tests, as required.	X			
3. Inspect driving operations and maintain complete and accurate records for each element.	X			
4. Verify placement locations and plumbness, confirm type and size of hammer, record number of blows per foot of penetration, determine required penetrations to achieve design capacity, record tip and butt elevations and document any damage to foundation element.	X			
5. For steel elements, perform additional Special Inspections in accordance with Section 1705.2. (see Table 1.1)				1705.7, 1705.2
6. For concrete elements and concrete-filled elements, perform tests and additional Special Inspections in accordance with Section 1705.3. (see Table 2)				1705.7, 1705.3
7. For specialty elements, perform additional inspections as determined by the Registered Design Professional in Responsible Charge.				1705.7

4.2 CAST-IN-PLACE DEEP FOUNDATION ELEMENTS (IBC 2021)

Inspection Task	Frequency		Applicable to Project	IBC Reference
	CONT	PER	Y/N	
1. Inspect drilling operations and maintain complete and accurate records for each element.	X			1705.8
2. Verify placement locations and plumbness, confirm element diameters, bell diameters (if applicable), lengths, embedment into bedrock (if applicable) and adequate end-bearing strata capacity. Record concrete or grout volumes.	X			
3. For concrete elements, perform tests and additional Special Inspections in accordance with Section 1705.3. (See Table 2)				1705.8, 1705.3

4.3 HELICAL PILES (IBC 2021)

Inspection Task	Frequency		Applicable to Project	IBC Reference
	CONT	PER	Y/N	
1. Helical pile foundation installation: Information recorded shall include installation equipment used, pile dimensions, tip elevations, final depth, final installation torque and other pertinent installation data as required by the Registered Design Professional in Responsible Charge. Approved Geotechnical Report and Contract Documents shall be used to determine compliance.	X			1705.9

5 - SOILS (IBC 2021)

Inspection Task	Frequency		Applicable to Project	IBC Reference
	CONT	PER	Y/N	
1. Verify materials below shallow foundations are adequate to achieve the design bearing capacity.		X		1705.6
2. Verify excavations are extended to proper depth and have reached proper material.		X		
3. Perform classification and testing of compacted fill materials.		X		

Inspection Task	Frequency		Applicable to Project	IBC Reference
	CONT	PER	Y/N	
4. During fill placement, verify use of proper materials and procedures in accordance with the Geotechnical Report. Verify densities and lift thicknesses during placement and compaction of compacted fill.	X			1705.6
5. Prior to placement of compacted fill, inspect subgrade and verify that site has been prepared properly.		X		

6 - ARCHITECTURAL COMPONENTS* - (IBC 2021)

Inspection Task		Frequency		Applicable to Project	IBC Reference
		CONT	PER	Y/N	
1. Sprayed fire-resistant materials:					1705.15
a.	Special Inspection shall be based on the fire-resistance design as designated in the approved construction documents and shall be performed during construction, with an additional visual inspection after rough installation of electrical, automatic sprinkler, mechanical and plumbing systems, and suspension systems for ceilings, and before concealment, where applicable. Required sample size shall not exceed 110% of that specified by referenced standards. Special Inspections and tests shall comply with requirements of 1705.15.1 through 1705.15.6 and shall include the following: 1) Condition of substrates 2) Thickness of application 3) Density in pounds per cubic foot 4) Bond strength adhesion/cohesion 5) Condition of finished application		X		
2. Mastic and intumescent fire-resistant coatings:			X		1705.16
a.	Special Inspections shall be based on the fire-resistance design as designated in the approved construction documents and shall be performed during construction. Additional visual inspection shall be performed after the rough installation and,		X		

Inspection Task		Frequency		Applicable to Project	IBC Reference
		CONT	PER	Y/N	
	where applicable, prior to the concealment of electrical, automatic sprinkler, mechanical and plumbing systems.				
3. Exterior Insulation and Finish systems (EIFS):					1705.17
a.	Special Inspections are required for all EIFS applications. Exceptions: 1) EIFS applications installed over a water-resistive barrier with a means of draining moisture to the exterior 2) EIFS applications installed over masonry or concrete walls		X		
b.	A water-resistive barrier coating complying with ASTM E2570 requires Special Inspection of the water-resistive barrier coating where installed over a sheathing substrate.		X		
4. Smoke control:					1705.19
a.	Test scope shall be as follows: 1) During erection of ductwork and prior to concealment for the purposes of leakage testing and recording of device location 2) Prior to occupancy and after sufficient completion for the purposes of pressure difference testing, flow measurements and detection and control verification		X		
b.	Approved agencies for smoke control testing shall have expertise in fire protection engineering, mechanical engineering, and certification as air balancers.		X		
5. Fire-resistant penetrations and joints:					1705.18
a.	In buildings assigned to Risk Category III or IV, Special Inspections for through-penetrations, membrane penetration firestops, fire-resistant joint systems, and perimeter fire containment systems that are tested and listed in accordance with IBC Section 714.4.1.2, 714.5.1.2, 715.3.1 and 715.4 shall be in accordance with Section 1705.18.1 or 1705.18.2		X		
* Where applicable, see additional tasks in Table 7.3.2 Special Inspections for Seismic Resistance - Architectural Components					

7 - SPECIAL INSPECTIONS FOR SEISMIC RESISTANCE (IBC 2021)

Special Inspections and Testing for Seismic Resistance are required in accordance with IBC 1705.13.

Seismic Force Resisting Systems [required for SDC B, C, D, E or F]: _____

Designated Seismic Systems [required for SDC C, D, E or F]: _____

7.1 - SPECIAL INSPECTIONS FOR SEISMIC RESISTANCE - STRUCTURAL STEEL (IBC 2021/AISC 341)

Inspection tasks apply to:

- I. Seismic Force Resisting Systems in buildings and structures assigned to SDC B, C, D, E or F. Required inspections and tests are listed in Table 1.1 and Table 7.1.
Exceptions:
 - 1) For SDC B or C, not required where value of R used for design and detailing is based on "Steel Systems Not Specifically Detailed for Seismic Resistance, Excluding Cantilever Column Systems" as per ASCE 7 Table 12.2-1.
 - 2) For SDC D, E or F, not required where design and detailing in accordance with AISC 360 is permitted by ASCE 7, Table 15.4-1.
- II. Structural Steel elements in the Seismic Force Resisting Systems in buildings and structures assigned to SDC B, C, D, E or F other than those in item I above. This includes but is not limited to struts, collectors, chords and foundation elements. Required inspections and tests are listed in Table 1.1 and Table 7.1.

Exceptions:

- 1) For SDC B or C, not required where $R=3$ or less as per ASCE 7.
- 2) For SDC D, E or F, not required where design and detailing other than AISC 341 is permitted by ASCE 7, Table 15.4-1. Special Inspection shall be in accordance with applicable referenced standard in ASCE 7, Table 15.4-1.

Inspection Task*		Frequency		Applicable to Project
		CONT	PER	Y/N
1. Visual Inspection Tasks Prior to Welding - See Table 1.1 for Tasks				
2. Visual Inspection Tasks During Welding – See Table 1.1 for Tasks				
d.	WPS followed		O	
	8) Intermix of filler metals avoided unless approved			
g.	Use of qualified welders		O	
3. Visual Inspection Tasks After Welding - See Table 1.1 for Tasks				
e.	k-area **	P	D	
g.	Backing removed and weld tabs removed and finished, and fillet welds added (if required)	P	D	
i.	Document acceptance or rejection of welded joint or member	P	D	
k.	Placement of reinforcing or contouring fillet welds (if required)	P	D	

**** When welding of doubler plates, continuity plates or stiffeners has been performed in the k-area, visually inspect the web k-area for cracks within 3 inches of the weld. The visual inspection shall be performed no sooner than 48 hours following completion of the welding.**

4. Inspection Tasks Prior To Bolting - See Table 1.1 for Tasks

f.	Pre-installation verification testing by installation personnel observed and documented for fastener assemblies and methods used			
	1) Quality assurance provided by Inspector		O, D	
	2) Quality control provided by Fabricator, Erector, or Contractor	P		

5. Inspection Tasks During Bolting - See Table 1.1 for Tasks

6. Inspection Tasks After Bolting

a.	Document acceptance or rejection of bolted connections	P	D	
7.	Other inspection tasks			
a.	RBS requirements, if applicable			
	1) Contour and finish	P	D	
	2) Dimensional tolerances	P	D	
b.	Protected Zone - No holes and unapproved attachments made by fabricator or erector, as applicable	P	D	

8. Inspection Of Composite Structures Prior To Concrete Placement

a.	Material identification of reinforcing steel (type/grade)		O	
b.	Determination of carbon equivalent for reinforcing steel other than ASTM A706		O	
c.	Proper reinforcing steel size, spacing and orientation		O	
d.	Reinforcing steel has not been rebent in the field		O	
e.	Reinforcing steel has been tied and supported as required		O	
f.	Required reinforcing steel clearances have been provided		O	
g.	Composite member has required size		O	

9. Inspection Of Composite Structures During Concrete Placement

a.	Concrete: material identification (mix design, compressive strength, maximum large aggregate size, maximum slump)		O, D	
b.	Limits on water added at the truck or pump		O, D	
c.	Proper placement techniques to limit segregation		O	

10. Inspection Of Composite Structures After Concrete Placement

a.	Achievement of minimum specified concrete compressive strength at specified age		D	

11. Inspection Of H-Piles

a.	Protected zone - no holes and unapproved attachments made by the responsible contractor, as applicable	P	D	

* Tasks listed in Table 1.1 are not repeated here but are still required. Tasks listed in Table 7.1 apply in addition to tasks listed in Table 1.1.

Structural Steel Definitions:

Observe (O) - The inspector shall observe these items on a random daily basis. Operations need not be delayed pending these inspections.

Perform (P) - These inspections shall be performed prior to the final acceptance of the item.

Document (D) - The inspector shall prepare reports indicating that the work has been performed in accordance with the Contract Documents.

**7.2
SPECIAL**

INSPECTIONS FOR SEISMIC RESISTANCE - CONCRETE* (IBC 2021/ACI 318-19)

INSPECTION TASK	Frequency		Applicable to Project	Reference Standard	IBC Reference
	CONT	PER	Y/N		
1. Placement of reinforcement for Special Moment Frames, Boundary Elements of Special Structural Walls, and Coupling Beams	X			ACI 318 26.13.3	1705.13
2. Welding of Reinforcement for Special Moment Frames, Boundary Elements of Special Structural Walls, and Coupling Beams	X				
* Tasks listed in Table 2 are not repeated here but are still required. Tasks listed in Table 7.2 apply in addition to tasks listed in Table 2.					

7.3 SPECIAL INSPECTIONS FOR SEISMIC RESISTANCE - NONSTRUCTURAL COMPONENTS (IBC 2021/ASCE 7-16)

Inspection Task		Frequency		Applicable to Project	Reference Standard	IBC Reference
		CONT	PER	Y/N		
1. Nonstructural components assigned to SDC B,C,D,E or F:					ASCE 7 13.2.1	1705.13.2
a.	Submittal of the manufacturer's certification that the component is seismically qualified (if certification reqd by ASCE section 13.2.1).		X			
2. Designated seismic systems for nonstructural components:					ASCE 7 13.2.2	1705.13.4.
a.	For structures assigned to SDC C, D, E or F with designated seismic systems requiring seismic qualification in accordance with ASCE 7 Section 13.2.2:					
	1) Submittal of the manufacturer's certification that the designated seismic systems requiring seismic qualification comply with requirements of ASCE 7 Section 13.2.2.		X			
	2) The Special Inspector shall examine the designated seismic systems requiring seismic qualification and verify that the label, anchorage and mounting conform to the certificate of compliance.		X			

7.3.1 - PLUMBING, MECHANICAL AND ELECTRICAL COMPONENTS - (IBC 2021)

Inspection Task		Frequency		Applicable to Project	IBC Reference
		CONT	PER	Y/N	
1. Observe anchorage of electrical equipment for emergency and standby power systems in structures assigned to SDC C, D, E or F			X		1705.13.6
2. Observe anchorage of other electrical equipment in structures assigned to SDC E or F			X		1705.13.6
3. Observe installation and anchorage of piping systems designed to carry hazardous materials and their associated mechanical units in structures assigned to SDC C, D, E or F			X		1705.13.6
4. Observe installation and anchorage of ductwork designed to carry hazardous materials in structures assigned to SDC C, D, E or F			X		1705.13.6

Inspection Task		Frequency		Applicable to Project	IBC Reference
		CONT	PER	Y/N	
5. Observe installation and anchorage of vibration isolation systems in structures assigned to SDC C, D, E or F where the approved construction documents require a nominal clearance of ¼ inch or less between the equipment support frame and restraint			X		1705.13.6
6. Observe installation of mechanical and electrical equipment, including duct work, piping systems and their structural supports, where automatic sprinkler systems are installed in structures assigned to SDC C, D, E or F to verify one of the following:					1705.13.6
a.	Minimum clearances have been provided as required by Section 13.2.3 ASCE 7.		X		
b.	A nominal clearance of not less than 3 inches has been provided between automatic protection sprinkler system drops and sprigs and: structural members not used collectively or independently to support the sprinklers; equipment attached to the building structure; and other systems' piping.		X		
Exception: Where flexible sprinkler hose fittings are used, Special Inspection of minimum clearances is not required.					

7.3.2 - ARCHITECTURAL COMPONENTS* - (IBC 2021)

INSPECTION TASK		Frequency		Applicable to Project	IBC Reference
		CONT	PER	Y/N	
6. Observe erection and fastening of exterior cladding, interior and exterior nonbearing walls and interior and exterior veneer in structures assigned to SDC D, E or F. Exceptions:			X		
a.	Exterior cladding, interior and exterior nonbearing walls, and interior and exterior veneer 30 feet or less in height above grade or walking surface.				1705.13.5
b.	Exterior cladding and interior and exterior veneer weighing 5 psf or less.				
c.	Interior nonbearing walls weighing 15 psf or less.				
7. Observe anchorage of access floors in structures assigned to SDC D, E or F.			X		1705.13.5.1
* Tasks listed in Table 6 are still required. Tasks listed in Table 7.3.2 apply in addition to tasks listed in Table 6.					

7.3.3 - STORAGE RACKS - (IBC 2021)

INSPECTION TASK		Frequency		Applicable to Project	IBC Reference
		CONT	PER	Y/N	
1. Steel storage racks and steel cantilevered storage racks that are 8 feet in height or greater and assigned to SDC D, E, or F shall be provided with the following periodic Special Inspection:					1705.13.7
a.	Materials used, to verify compliance with one or more of the material test reports in accordance with the approved construction documents		X		
b.	Fabricated storage rack elements		X		
c.	Storage rack anchorage installation		X		
d.	Completed storage rack system, to indicate compliance with the approved construction documents.		X		

7.3.4 - SEISMIC ISOLATION SYSTEMS (IBC 2021)

INSPECTION TASK		Frequency		Applicable to Project	IBC Reference
		CONT	PER	Y/N	
1. Observe seismic isolation systems in seismically isolated structures assigned to SDC B, C, D, E or F during the fabrication and installation of isolator units and energy dissipation devices			X		1705.13.8

8 - SPECIAL INSPECTIONS FOR WIND RESISTANCE (IBC 2021)

Special Inspections for Wind Resistance are required in accordance with IBC 1705.12.

8.1 - WIND RESISTING COMPONENTS:

INSPECTION TASK	Frequency		Applicable to Project	IBC Reference
	CONT	PER	Y/N	
1. Roof covering, roof deck and roof framing connections		X		1705.12.3
2. Exterior wall covering and wall connections to roof and floor diaphragms and framing		X		

9. Special Inspections Agency Contact Information:	
1.	
2.	
3.	
4.	

STATEMENT OF SPECIAL INSPECTIONS

PROJECT: _____
LOCATION: _____
PERMIT APPLICANT: _____
APPLICANT'S ADDRESS: _____
ARCHITECT OF RECORD: _____
STRUCTURAL ENGINEER OF RECORD: _____
MECHANICAL ENGINEER OF RECORD: _____
ELECTRICAL ENGINEER OF RECORD: _____
REGISTERED DESIGN PROFESSIONAL IN RESPONSIBLE CHARGE: _____

This Statement of Special Inspections is submitted in accordance with Section 1704 of the International Building Code. It shall be considered in conjunction with the Schedule of Special Inspections included in this Specification Section 01 45 33. If applicable, it includes *Requirements for Seismic Resistance and/or Requirements for Wind Resistance*.

Are Requirements for Seismic Resistance included in the Statement of Special Inspections? ☐ Yes ☐ No

Are Requirements for Wind Resistance included in the Statement of Special Inspections? ☐ Yes ☐ No

The Special Inspector(s) shall keep detailed records of all inspections, including a copy at the jobsite. All records shall be available upon request by the Engineer or the Building Official. Any discrepancies shall be brought to the immediate attention of the Contractor. If the discrepancies are not corrected, the discrepancies shall be brought to the attention of the Building Official and the Engineer prior to completion of that phase of work. The Special Inspections Agency shall furnish Interim Reports to the Building Official and to the Engineer at the frequency indicated in the Statement of Special Inspections. A Final Report shall be submitted to the Building Official and the Engineer at the time agreed upon by the Owner and the Building Official.

Frequency of Interim Report submittals to the Building Official:

___ Weekly ___ Bi-Weekly ___ Monthly Other; specify: _____

Frequency of Interim Report submittals to the Engineer:

___ Weekly ___ Bi-Weekly ___ Monthly Other; specify: _____

Special Inspections do not relieve the Contractor of the obligation to comply with the Contract Documents. Jobsite safety and means and methods of construction are solely the responsibility of the Contractor.

Statement of Special Inspections Prepared by:

Type or print name

Signature

Date

Building Official's Acceptance:

Type or print name

Signature

Date

Registered Design Professional's Seal

STATEMENT OF SPECIAL INSPECTIONS

REQUIREMENTS FOR SEISMIC RESISTANCE

See the Schedule of Special Inspections for inspection and testing requirements.

Seismic Design Category: _____

Statement of Special Inspection for Seismic Resistance Required (Yes/No): _____

Description of seismic force-resisting system subject to special inspection and testing for seismic resistance:

Description of designated seismic systems in accordance with Chapter 13 of ASCE 7 subject to special inspection and testing for seismic resistance. Special inspector shall verify that the label, anchorage and mounting of these systems conforms to the Contract Documents and Approved Submittals:

Description of additional seismic systems and components requiring special inspections:

Description of additional seismic systems and components requiring testing:

Statement of Responsibility:

Each Contractor responsible for the construction or fabrication of a system or component described above must submit a Statement of Responsibility.

STATEMENT OF SPECIAL INSPECTIONS

REQUIREMENTS FOR WIND RESISTANCE

See the Schedule of Special Inspections for inspection and testing requirements.

Basic Wind Speed (3 second gust): _____ m.p.h.

Wind Exposure Category: _____

Statement of Special Inspection for Wind Resistance Required (Yes/No): _____

Description of main wind force-resisting system subject to special inspection for wind resistance:

Description of wind force-resisting components subject to special inspection for wind resistance:

Statement of Responsibility:

Each Contractor responsible for the construction or fabrication of a system or component described above must submit a Statement of Responsibility.

INTERIM REPORT OF SPECIAL INSPECTIONS

City/County of:							
Project Name/Address:				Inspection Type(s) Coverage:			
				☐ Continuous		☐ Periodic	
Describe Inspections Made, Including Locations:							
Tests Made:							
Total Inspection Time Each Day	Date:						
	Hours:						
List items requiring Special Inspection, and any discrepancies and corrections. If Engineer approval is required for any corrections, note this, and indicate that approval was obtained. Attach copies of all related correspondence.							
Comments:							

To the best of my knowledge, work inspected was in accordance with the Contract Documents and applicable standards except as noted above.

Signed: _____ Date: _____

Print Full Name: _____ I.D.: _____

Phone Number: _____

This report is to be submitted to the Building Official and the Engineer. A copy shall be maintained at the jobsite.

FINAL REPORT OF SPECIAL INSPECTIONS

PROJECT: _____
LOCATION: _____
PERMIT APPLICANT: _____
APPLICANT'S ADDRESS: _____

ARCHITECT OF RECORD: _____
STRUCTURAL ENGINEER OF RECORD: _____
MECHANICAL ENGINEER OF RECORD: _____
ELECTRICAL ENGINEER OF RECORD: _____
REGISTERED DESIGN PROFESSIONAL IN RESPONSIBLE CHARGE: _____

To the best of my information, knowledge, and belief, Special Inspections required for this Project in accordance with Section 1704 of the International Building Code and any State or local amendments have been performed, and all work has been completed in accordance with the Contract Documents and all applicable standards, except as indicated.

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

This Final Report includes information submitted in previous Interim Reports numbered _____ to _____, as well as any Special Inspections, discrepancies, and corrections occurring since the last Interim Report, dated _____.

All items requiring Special Inspection are listed below. All inspections, tests, and similar services that were performed are listed and any discrepancies and corrections are indicated. If Engineer approval was required for any corrections, this is noted, and copies of all related correspondence are attached.

(Attach 8 1/2"x11" continuation sheet(s) if required to complete the description of corrections)

Prepared By:

Special Inspection Agency:

Type or print name

Signature _____ Date _____

Special Inspector's Seal



CONTRACTOR'S STATEMENT OF RESPONSIBILITY

Each Contractor responsible for the construction or fabrication of a main-wind- or seismic-force-resisting system, designated seismic system, or a wind- or seismic-resisting-component listed in the Statement of Special Inspections must submit this Statement of Responsibility prior to commencement of work on the system or component.

Project: _____

Contractor's Name: _____

Address: _____

License No.: _____

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

Contractor's Acknowledgement of Special Requirements

I hereby acknowledge that I have received, read, and understand the Statement of Special Inspections and its requirements.

Name and Title (type or print)

Signature

Date

FABRICATOR'S CERTIFICATE OF COMPLIANCE

Each approved fabricator that is exempt from Special Inspection of shop fabrication and implementation procedures per Section 1704 of the International Building Code must submit this Fabricator's Certificate of Compliance at the completion of fabrication.

Project: _____

Fabricator's Name: _____

Address: _____

Description of structural members and assemblies that have been fabricated:

[illegible]

I hereby certify that items described above were fabricated on my premises in strict accordance with the Contract Documents and applicable standards.

Name and Title (type or print)

Signature _____

Date _____

Attach copy of Building Official's approval of fabricator as an Approved Fabricator.

NOTIFICATION OF FAILURE TO CORRECT DISCREPANCY

City/County of:
Project Name/Address:
List discrepancies, proposed correction, and Contractor response. If Engineer approval is required for any corrections, note this, and indicate whether approval was obtained. Attach copies of all related correspondence.
Comments:

Signed: _____

Date: _____

Print Full
Name: _____

I.D.: _____

Phone
Number: _____

This report is to be submitted to the Building Official, the Contractor, and the Engineer.

END OF SECTION

SECTION 01 51 00
TEMPORARY UTILITIES

PART 1 – GENERAL

1.01 SUMMARY

- A. Contractor shall provide temporary utilities required for the Project and to complete the Work.
1. Make arrangements with utility service companies for temporary services and obtain required permits and approvals for temporary utilities.
 2. Pay utility service costs, including connection fees, required for the Work as needed.
 3. Continuously maintain adequate utilities for all purposes during the Project, until removal of temporary utilities and temporary facilities. At minimum, provide and maintain temporary utilities through Substantial Completion and removal of temporary field offices and sheds.
 4. Should Owner occupy part of the Project prior to Substantial Completion of the entire Work, cost of utilities consumed via temporary utilities serving the portion occupied by Owner will be shared proportionately between Owner and Contractor as mutually agreed to by the parties.
 5. Maintain, including cleaning, temporary utilities and continuously provide consumables as required.
 6. Temporary utilities and temporary facilities shall be adequate for personnel using the Site and requirements of Project.
 7. Provide temporary utilities and temporary facilities in compliance with Laws and Regulations and, when applicable, requirements of utility owners.
- B. Provide the following temporary utilities:
1. Electricity and lighting.
 2. Telephone and communications.
 3. Heating.
 4. Sanitary facilities.

5. Water service.
6. First-aid facilities.
7. Fire protection.

1.02 ADMINSTRATIVE REQUIREMENTS

A. Use of Owner's System:

1. Existing Utility Systems: Do not use systems in existing buildings or structures for temporary utilities without Owner's written permission and mutually acceptable basis agreed upon by the parties for proportionate sharing of costs between Owner and Contractor.
2. Use of Permanent Utility Systems Provided Under the Project:
 - a. Permanent lighting, water, heating, ventilating, and fire protection systems and first-aid facilities may be used to provide temporary utilities and temporary facilities if the following are met:
 - 1) Obtain Owner's written permission to use permanent systems.
 - 2) Permanent systems to be used for temporary utilities or temporary facilities shall have achieved Substantial Completion, including complete functionality of all controls.
 - 3) Contractor shall pay all costs while using permanent system, including operation, maintenance, replacement of consumables, and provide replacement parts.
 - b. Do not use the following permanent facilities:
 - 1) Telephone and communication facilities.
 - 2) Sanitary facilities.

1.03 SYSTEM DESCRIPTION

A. Electricity and lighting:

1. Contractor shall provide electrical and lighting service for construction field offices, sheds, storage containers, etc. and as required for the Work.
2. General 120/240 V service requirements:

- a. Contractor shall provide 120/240 V, single phase, 3-wire temporary system for small power requirements and general lighting.
 - b. Contractor shall provide main disconnect, overcurrent protection, meter outlet, branch circuit breakers, and wiring for temporary service to the Contractor's field office service connections. Contractor shall provide equipment and appurtenances in accordance with electricity service provider and applicable standards and codes
 - c. Contractor shall register the 120/240 V electrical service meter in the Contractor's name and shall be responsible for electrical charges at no additional cost to the Owner.
 - d. Contractor shall provide electrical service other than 120/240 V, single phase, 3-wire service as required for the Work at the Contractor's own expense.
3. General lighting requirements:
- a. Contractor shall provide a minimum of 10 foot candles for enclosed and partially enclosed structures for performing the Work.
 - b. Contractor shall provide a night lighting circuit for security. Light intensity shall be a minimum of 2 foot-candles.
4. Contractor shall energize the electrical system 15-minutes prior to and following regular work day hours at the Site. Required from Monday through Friday, all inclusive.
5. Contractor shall energize the night lighting system at end of typical working day and de-energize at start of typical working day. System shall be continuously energized on Saturdays, Sundays, and holidays.
6. Contractor shall provide an independent grounding cable connected directly to the structure, building, and equipment for erection and fabrication by electrical welders. Grounding by adjacent conduit, piping, etc. shall be prohibited at the Site.
7. Contractor shall coordinate usage of temporary electrical system with Subcontractors, Suppliers, and Owner including the following:
- a. Usage is suitable for 120V, single phase, 60 Hz operation with a maximum operating input of 1,500 volt-amperes.
 - b. One unit connected to a single outlet.
 - c. Restrict usage in case of overloading circuits to correct loading.

B. Telephone and communications: Contractor shall provide temporary telephone and communications required for its operations at the Site and for summoning emergency medical assistance.

C. Heating:

1. Contractor shall provide temporary heating, ventilation coverings and enclosures necessary to protect the Work and materials against wetness and temperature damage, to dry out the Work, and to facilitate the Work in structures.
2. Equipment, fuel, materials, personnel and methods used shall be adequate to maintain critical installation temperatures and ventilation of Work at all times in areas where necessary to perform the Work.
3. Enclosed structures shall have a minimum temperature of 50°F, unless otherwise specified, where Work is performed.
4. Contractor shall provide sufficient heat to maintain a minimum temperature of 65°F before and during application of interior finishing, painting, coating, etc.
5. Contractor shall replace any Work damaged by dampness or insufficient/abnormal heating at no cost to the Owner.

D. Sanitary facilities:

1. Contractor shall provide suitably-enclosed chemical or self-contained toilets for Contractor's employees and visitors to the Site. Location of temporary toilets shall be acceptable to Owner and screened from public observation.
2. Facilities shall be maintained and provided in accordance with State or Commonwealth Labor Regulations and local ordinances. Contents shall be removed and disposed in accordance with local and state or commonwealth regulations as required.
3. Contractor shall be prohibited from committing nuisances within, on, or in the vicinity of the Site.

E. Water service:

1. Contractor shall provide temporary water service for the Work including for construction purposes, sanitary facilities, fire protection, field office, and cleaning purposes.
2. Contractor shall provide potable water for Contractor's personnel either by portable containers or drinking fountains.

3. Contractor shall provide temporary hose bibs, hoses, and watertight barrels for the distribution of water.
4. Contractor shall provide freeze protection for water service.

F. First-aid facilities:

1. Contractor shall provide temporary first-aid stations at or immediately adjacent to the Site's major work areas. Contractor shall provide temporary first-aid stations inside its temporary field office. Locations of first-aid stations shall be determined by Contractor's safety representative.
2. Contractor shall provide list of emergency telephone numbers at each hardwired telephone at the Site. List shall be in accordance with the list of emergency contact information required in Section 01 31 19 – Project Meetings.

G. Fire protection:

1. Contractor shall comply with NFPA 241, Safeguarding Building Construction, Alteration, and Demolition Operations, and requirements of fire marshals and authorities having jurisdiction at the Site.
2. Contractor shall provide temporary fire exits, fire extinguishers, hoses and safety devices as required by authorities having jurisdiction.
3. Contractor shall notify Engineer, Owner, and fire marshals in the event of fire at the Site including, but not limited to, fuel tanks and similar hazardous utilities and devices. Contractor shall cooperate with Owner of fuel tank and utilities to prevent occurrence of fire or explosion.
4. Contractor shall perform safety precautions and comply with fire marshal's instructions in the event of fire.

PART 2 – PRODUCTS

2.01 EQUIPMENT

- A. Materials and equipment for temporary systems may be new or used but shall be adequate for purposes intended and shall not create unsafe conditions and shall comply with Laws and Regulations.
- B. Provide required materials, equipment, and facilities, including piping, wiring, and controls.

- C. Electrical system requirements: System shall consist of wiring, switches, insulated supports, poles, fixtures, sockets, receptacles, lamps, guards, cutouts and fuses as required for completion of the Work.

PART 3 – EXECUTION

3.01 INSTALLATION

- A. Install temporary facilities in neat, orderly, manner, and make structurally, mechanically, and electrically sound throughout.
- B. Location of Temporary Utilities and Temporary Facilities:
 - 1. Locate temporary systems for proper function and service.
 - 2. Temporary systems shall not interfere with or provide hazards or nuisances to: the Work under this and other contracts, movement of personnel, traffic areas, materials handling, hoisting systems, storage areas, finishes, and work of utility companies.
 - 3. Do not install temporary utilities on the ground, with the exception of temporary extension cords, hoses, and similar systems in place for short durations.
- C. Modify and extend temporary systems as required by progress of the Work.

3.02 MAINTENANCE

- A. Maintain temporary systems to provide safe, continuous service as required.
- B. Properly supervise operation of temporary systems:
 - 1. Enforce compliance with Laws and Regulations.
 - 2. Enforce safe practices.
 - 3. Prevent abuse of services.
 - 4. Prevent nuisances and hazards caused by temporary systems and their use.
 - 5. Prevent damage to finishes.
 - 6. Ensure that temporary systems and equipment do not interrupt continuous progress of construction.

- C. At end of each work day, check temporary systems and verify that sufficient consumables are available to maintain operation until work is resumed at the Site. Provide additional consumables if the supply on hand is insufficient.
- D. Contractor shall replace broken and burned out lamps, blown fuses, and damaged wiring and appurtenances as required to maintain adequate and safe operating conditions.
- E. Contractor shall permit subcontractors and others at a mutually agreed arrangement to use temporary electrical system that meet the following requirements:
 - 1. Equipment are suitable for 120 V, single phase, 60 Hz operation.
 - 2. Operating input does not exceed 1,500 volt-amperes.
 - 3. Single piece of equipment connected to one outlet.
 - 4. Contractor shall restrict use of equipment as required to prevent overloading circuits.

3.03 CLOSEOUT ACTIVITES

- A. Completely remove temporary utilities, facilities, equipment, and materials when no longer required. Repair damage caused by temporary systems and their removal and restore the Site to condition required by the Contract Documents; if restoration of damaged areas is not specified, restore to preconstruction condition.
- B. Contractor is responsible for and shall return to original condition those portions of permanent electric system used in completing the Work.
- C. Where temporary utilities are disconnected from existing utility, provide suitable, watertight or gastight (as applicable) cap or blind flange, as applicable, on service line, in accordance with requirements of utility owner.
- D. When permanent utilities and systems that were used for temporary utilities, upon Substantial Completion replace all consumables such as filters and light bulbs and parts used during the Work.

END OF SECTION

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SECTION 01 52 00
CONSTRUCTION FACILITIES

PART 1 – GENERAL

1.01 SUMMARY

- A. Contractor shall provide construction facilities for performance of the Work, including the following:
1. Contractor's field office, sheds, and storage containers that shall be erected within 30 days of Notice to Proceed on the Project.
 2. Engineer's field office provided with specified temporary utility services that shall be erected within 30 days of Notice to Proceed on the Project.
 3. Project sign and panel that shall be erected within 21 days of Notice to Proceed on the Project.

1.02 FACILITY DESCRIPTION

- A. Contractor's Field Office, Sheds, and Storage:
1. Contractor shall provide and maintain a field office at the Site(s), including temporary utility services specified.
 2. Size and Furnishings: As required by Contractor.
 3. Features: Exterior Contractor identification sign, night lighting for security, and temporary utilities specified in Section 01 51 00 – Temporary Utilities.
 4. Location: As shown on the Contract Documents.
 5. Contractor shall provide and maintain one set of Contract Documents, latest approved Shop Drawings, Field Orders, request for interpretations, clarification notices, Work Change Directives, proposal requests, Change Proposals, Change Orders, and other pertinent Project related correspondence.
- B. Engineer's Field Office:
1. Contractor shall provide Engineer's field office for Resident Project Representative (RPR).
 2. Requirements:

- a. Separate structure with a minimum of 720 sq ft of floor area.
- b. Separate covered porch with a minimum of 72 sq ft of floor area at main entrance to structure. Cover shall have separate roof and rainproof seal to main structure.
- c. Doors and windows provided with locking devices and hardware to prevent unauthorized entry. Door keys shall be provided to Engineer for the duration of the Project. Door keys will be returned to Contractor following completion of Project.
- d. Functional, totally enclosed restroom and mirror shall be provided.
- e. Minimum temporary utilities requirements:
 - 1) Heating: Maintain 68°F in winter.
 - 2) Cooling: Maintain 75°F in summer.
 - 3) Interior electrical outlets: Minimum one outlet per wall of structure.
 - 4) Electrical service: Adequate temporary electrical service for fully functional field office.
 - 5) Individual, direct line telephone service with equipment for up to four persons.
 - 6) Individual, direct high-speed internet service (DSL or cable), at minimum 50 Mbps up and down Internet speed, with hardwired networking up to four persons and Wi-Fi for exclusive use by the Engineer.
 - 7) Potable water service to water closet and lavatory.
 - 8) Interior and exterior lighting: Conforms to Section 01 51 00 – Temporary Utilities and as specified in this Section.

3. Furnishing:

2	Flat top desk, 2-1/2 x 5 feet, with drawers at each end
1	Plywood drawing table, 3 x 6 feet tilt top with drafting stool
12	Straight chairs
2	Four-drawer, legal size steel filing cabinets with lock and key (HON 210P Series full-suspension files)

1	23-gallon metal or heavy-duty plastic waste baskets with lids
3	28-quart metal or heavy-duty plastic waste baskets
1	Hanging drawing racks with appurtenances
2	Wall-mounted fire extinguishers
1	Bookcase with 4 shelves, 3 feet wide
3	Metal/plastic office folding tables, 30 x 60 inches (minimum)
1	Metal/plastic office folding table, 30 x 96 inches (minimum)
1	Steel storage cabinets (72" H x 36" W x 24" D) with four adjustable shelves and locks
1	First aid cabinet (conforms with OSHA requirements for construction site of up to five people)
2	Tilt/swivel type desk chairs
1	4 cu ft capacity refrigerator
1	1.4 cu. ft. countertop microwave with double-oven cart
1	Laser copying/printing/scanner/facsimile machine with local service contract (printing/scanning in full color up to 11" x 17" paper size)
1	Office hard drive (1 TB minimum) and router networked for up to 4 personnel with high speed internet and 4-in-1 printer

4. Exterior Engineer identification sign: 24" x 36" plywood sign painted white with blue, centered 3-inch high lettering with the following inscription:

Field Office

Hazen and Sawyer

Office Location

5. Location: As shown on the Contract Documents.
- a. It is anticipated that a single Engineer's Field Office will be located at the P.O. Hoffer WTF, serving both project locations.
6. Consumables: Contractor shall provide consumables and supplies for the Engineer's Field Office including, but not limited to, waste basket heavy-duty liners, floor entry mats, mud-cleaning brushes, paper towels, toilet paper, printer ink, copying machine paper (all sizes), etc., for the duration of the Contract.

7. Cleaning services: Contractor shall provide qualified, professional cleaning services to clean Engineer's field office a minimum of two times per week for the duration of the Project.
8. Contractor shall respond and address maintenance issues that occur at the Engineer's field office with 24 hours notification.

C. Project Identification Sign:

1. Contractor shall provide in accordance to this Section.
2. Contractor shall maintain project identification sign for the duration of the Contract.
3. Contractor shall remove and dispose of project identification sign at the completion of the Project when notified by the Engineer.
4. Contractor shall not receive additional payment for deterioration or replacement of names and other pertinent sign information throughout the duration of the Project.

1.03 SUBMITTALS

- A. Action/Informational Submittals: Project identification sign layout, details, and materials of construction.

PART 2 – PRODUCTS

2.01 COMPONENTS

A. Project Identification Sign

1. Sign Panel: 3/4-inch thickness (minimum) marine plywood rabbeted in a 2" x 4" wood frame. Panel shall be fastened to sign supports with six 3/8" diameter galvanized bolts, nuts and washers (minimum).
2. Sign Supports: Two, 4" x 4" treated wood posts.
3. Fasteners and Hardware: Galvanized.
4. Painting: Supports, trim and back of sign panel shall be painted with two coats (minimum) of same paint for sign face. Paint shall be exterior grade paint, suitable for wood application and in accordance with Section 09 90 00 – Painting.

PART 3 – EXECUTION (NOT USED)

END OF SECTION

SECTION 01 55 00
CONTRACTOR ACCESS AND PARKING

PART 1 – GENERAL

1.01 SUMMARY

- A. Contractor shall provide and maintain temporary laydown and employee parking areas and appurtenances required during the Project for use by Contractor, other contractors employed on the Project, Owner's, and emergency vehicles, as shown on the Drawings.
- B. Laydown and employee parking areas shall be designed and maintained by Contractor and shall be fully passable to vehicles in all weather conditions.

1.02 ADMINISTRATIVE REQUIREMENTS

- A. Access roads:
 - 1. Contractor shall construct and maintain such temporary access roads as required to perform the Work.
 - 2. Contractor shall construct access roads, where possible, in locations over the areas of future road systems.
 - 3. Access roads shall be located within the property lines of the Owner unless the Contractor independently secures easements for use and convenience.
 - a. Contractor shall submit written documentation to the Engineer for Contractor secured easements across privately held property.
 - b. Easement agreements shall specify terms and conditions of use and provisions for Site restoration.
 - c. Written release from property owner certifying that terms of the easement agreement have been complied by the Contractor shall be furnished to the Engineer prior to final payment.
- B. Use of existing access roads:
 - 1. Contractor will be allowed to use Owner's existing roads as shown on the Drawings.
 - 2. Prevent interference with traffic on existing roads and parking areas. At all times, keep access roads and entrances serving the Site clear and available to Owner,

Owner's employees, emergency vehicles, and other contractors. Do not use access roads or Site entrances for parking or storage of materials or equipment.

3. Contractor shall indemnify and hold harmless Owner and Engineer from expenses caused by Contractor's operations over existing roads and parking areas.
4. Schedule deliveries to minimize use of driveways and Site entrances.
5. Contractor shall suitably maintain existing access road at Contractor's expense for the duration of the Contract time.

C. Contractor parking areas:

1. Contractor employee vehicles shall park in area(s) designated by Owner or as shown on the Drawings.
2. Contractor shall construct and maintain parking area at the Site.

D. State/Commonwealth and local regulations:

1. Contractor shall obtain and pay all cost associated with bonds required by authorized entity (i.e. State or Commonwealth Department of Transportation) for the use of State or Commonwealth maintained roads.
2. Contractors shall obey traffic laws and comply with requirements, rules and regulations of the authorized entity (i.e. State or Commonwealth Department of Transportation), including local authorities having jurisdiction, to maintain warning signs, lights, barriers, etc. for the protection of traffic on public roadways.

E. Site security:

1. Contractor shall safely guard all the Work, the Project, products, equipment, and property from loss, theft, damage, and vandalism until Substantial Completion. Contractor's duty includes safely guarding Owner's property in vicinity of the Work and Project, and other private property in the vicinity of the Project from injury and loss in connection with performance of the Project.
2. Employ watchmen as required to provide required security and prevent unauthorized entry.
3. Costs for security required under this Section shall be paid by Contractor.
4. Make no claim against Owner for damage resulting from trespass.
5. Pay full compensation for, or repair or replace, damage to property of Owner and others arising from failure to furnish adequate security.

6. Provide temporary fencing in accordance with the Contract Documents.
7. Security requirements specified in the Section shall begin as soon as the contractor delivers materials to the Site and/or begins work, and shall continue until the date of Final Completion.
8. Procedures:
 - a. Contractor shall conform to Owner's security procedures and access restrictions at Site throughout entire Project.
 - b. Contractor, including Subcontractors and Suppliers, shall comply with the following:
 - 1) Personnel Identification: All Contractor personnel shall wear at all times on-Site a badge bearing Contractor's name, employee's name and, as applicable, employee number.
 - 2) Parking: Do not park outside of designated Contractor parking area, which is shown on the Drawings. Prepare and maintain parking area as required. Personal vehicles are not allowed outside Contractor parking area.
9. Contractor shall provide and maintain temporary security fencing if existing security fencing or barriers are breached or temporarily removed for the Project at no additional cost to the Owner. Temporary security fencing shall be equal to existing, unless otherwise specified, and provided and maintained in a manner satisfactory to Engineer and Owner.

PART 2 – PRODUCTS (NOT USED)

PART 3 – EXECUTION

3.01 INSTALLATION

- A. Contractor shall determine if and where temporary fencing is necessary, unless existing security fencing is damaged, which will be determined by Engineer and Owner.
- B. Install temporary fencing used for site security in accordance with the Contract Documents and fence manufacturer's instructions. Provide temporary fencing for site security so that integrity of site security is maintained throughout the Project.
- C. Maintain temporary fencing. Repair damage to temporary fencing and replace fencing when required to maintain site security.

- D. Remove temporary fencing when permanent site security fencing is in place and fully functional, or when otherwise directed by Owner or Engineer.

END OF SECTION

SECTION 01 57 00
TEMPORARY CONTROLS

PART 1 – GENERAL

1.01 SUMMARY

- A. Contractor shall provide and maintain methods, equipment, and temporary construction as required to control environmental conditions at the Site and adjacent areas.
- B. Maintain controls until no longer required.
- C. Temporary controls include, but are not limited to, the following:
 - 1. Dust control.
 - 2. Noise controls.
 - 3. Pest and rodent control.
 - 4. Pollution control.

PART 2 – PRODUCTS (NOT USED)

PART 3 – EXECUTION

3.01 DUST CONTROL

- A. Contractor shall take measures to control dust from Contractor's operations and prevent spillage of excavated materials on public roads.
- B. Contractor shall remove spillage of excavated materials, debris and dust from public roads by methods approved by Engineer.
- C. Contractor shall provide temporary dust-proof partitions where required to protect unaltered portions of existing structures and facilities and as directed by Engineer or Owner. Temporary partitions shall be provided where demolition Work is required, to protect equipment and material, and shall consist of the following:
 - 1. Wood studs with plywood on both sides and extend from floor to ceiling.
 - 2. Closure plate at floor and ceiling.
 - 3. One door (minimum) with hardware.

- D. Contractor shall refer to applicable sections of local and state/commonwealth regulations on dust control for additional guidance.
 - 1. Contractor shall apply water at locations, quantities, and frequencies required by Engineer to control dust for nuisance prevention to Owner, Engineer, and properties in the vicinity of the Site.
 - 2. Dust control and cleaning measures shall be provided at no additional cost to the Owner.

3.02 NOISE CONTROL

- A. Contractor's vehicles and equipment shall minimize noise emissions to greatest degree practicable. Provide mufflers, silencers, and sound barriers when necessary.
- B. Noise levels shall comply with Laws and Regulations, including OSHA requirements and local ordinances.
- C. Noise emissions shall not interfere with the work of Owner or others.

3.03 PEST AND RODENT CONTROL

- A. Provide rodent and pest control as required to prevent infestation of the Site and storage areas.
- B. Employ methods and use materials that do not adversely affect conditions at the Site or on adjoining properties.
- C. In accordance with laws and regulations, promptly and properly dispose of pests and rodents trapped or otherwise controlled.

3.04 POLLUTION CONTROL

- A. General:
 - 1. Provide means, methods, and facilities required to prevent contamination of soil, water, and atmosphere caused by discharge of noxious substances from construction operations.
 - 2. Equipment used during construction shall comply with Laws and Regulations.
- B. Spills and Contamination:
 - 1. Provide equipment and personnel to perform emergency measures required to contain spills and to remove contaminated soils and liquids.

2. Excavate contaminated material and properly dispose of off-site, and replace with suitable compacted fill and topsoil.
- C. Protection of Surface Waters: Implement special measures to prevent harmful substances from entering surface waters. Prevent disposal of wastes, effluents, chemicals, and other such substances in or adjacent to surface waters and open drainage routes, in sanitary sewers, or in storm sewers.
- D. Atmospheric Pollutants:
1. Provide systems for controlling atmospheric pollutants related to the Work.
 2. Prevent toxic concentrations of chemicals and vapors.
 3. Prevent harmful dispersal of pollutants into atmosphere.
- E. Solid Waste:
1. Provide systems for controlling and managing solid waste related to the Work.
 2. Prevent solid waste from becoming airborne, and from discharging to surface waters and drainage routes.
 3. Properly handle and dispose of solid waste.

END OF SECTION

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SECTION 01 61 00
PRODUCT REQUIREMENTS AND OPTIONS

PART 1 – GENERAL

1.01 SUMMARY

- A. Section includes:
1. Common requirements for products.
 2. Contractor's options for selecting products.
 3. Requirements for consideration of "or equal" products.
 4. Warranty requirements of products.

1.02 REFERENCES

- A. Definitions:
1. "Products" includes materials, equipment, machinery, components, fixtures, systems, and other goods incorporated in the Work. Products do not include machinery and equipment used for preparing, fabricating, conveying, erecting, or installing the Work. Products include Owner-furnished goods incorporated in the Work where use of such goods is specifically required in the Contract Documents.
 2. "Special Warranties" includes additions or modifications to standard warranty requirements specified in the Contract Documents.

1.03 SUBMITTALS

- A. Warranty Log Book:
1. Submit warranty log book prepared specifically for this Project. Submittal shall include a summary listing of all equipment and material warranties furnished in the Contract, date received, and start/end date of warranty period. Individual warranty documentation shall be provided in the submittal.
 2. Submit prior to submittal of final application for payment.
- B. Patent Documentation: Submit licensing arrangement and agreement documentation.

05-04-20

1.04 REQUIREMENT

A. Common Products:

1. Provide products that have not been previously incorporated into another project or facility unless otherwise indicated in the Contract Documents.
2. Provide products of the same generic kind from a single source.
3. Provide products complete with accessories, trim, finish, fasteners, and other items shown, indicated, or required for a complete installation for the indicated use and performance.
4. Standard Products: When available, and unless custom or nonstandard options are specified or indicated, provide standard products of types that have been produced and used successfully in similar situations on other projects.
5. Visual Matching: Where required in the Contract Documents, provide products that match referenced existing construction, approved mock-ups, or approved Sample, as determined by Engineer.
6. Where the Contract Documents include the phrase “as selected” for product color, finish pattern, option, or similar phrase, provide products selected by Engineer as follows:
 - a. Standard Range: Where the Contract Documents include the phrase “standard range of colors, patterns, textures” or similar phrase, provide color, pattern, density, or texture selected by Engineer from manufacturer’s product line that does not include premium items.
 - b. Full Range: Where the Contract Documents include the phrase “full range of colors, patterns, textures” or similar phrase, Engineer will select color, pattern, density, or texture from manufacturer’s entire product line, including standard and premium items.

B. Product Compatibility:

1. Similar products by the same Supplier shall be compatible with each other, unless otherwise indicated in the Contract Documents.
2. Provide products compatible with products previously selected or installed on the Project.

C. Product Options:

1. For products specified only by reference standard or description, without reference to Supplier, provide products meeting that standard, by a Supplier or from a source that complies with the Contract Documents.
2. For products specified by naming one or more products or Suppliers, provide the named products that comply with the Contract Documents, unless an "or equal" or substitute product is approved by Engineer.
3. For products specified by naming one or more products or Suppliers and the term, "or equal", when Contractor proposes a product or Supplier as an "or equal", submit to Engineer a request for approval of an "or equal" product or Supplier.
4. For products specified by naming only one product or manufacturer and followed by words indicating that no substitution is allowed, there is no option and no substitution will be allowed.

D. Concerning Patents:

1. Owner shall be provided a guarantee by Contractor and equipment Supplier that equipment and material furnished in accordance with the Contract Documents is not the subject of patent litigation.
2. Patent litigation or controversy shall include, but not limited to, the following:
 - a. Actual furnished equipment and material the is subject or could be subject to patent litigation or is known to infringe on a patent.
 - b. Furnished equipment and material that may result in a process that use of equipment and material in a manner that infringes upon or violates a patent.
3. When patent infringement may occur, Contractor and Supplier shall submit license arrangements among parties, including Contractor, Supplier, and patent owner (controller of patent) at a minimum, which shall permit use of equipment and material as specified in the Contract Documents.
4. Supplier shall indemnify and hold harmless Owner and Engineer against all claims, costs, losses, and damages arising out of or relating to any infringement or patent rights or copyrights incident to the use of equipment and material specified in the Contract Documents and as required in General Conditions and as modified in the Supplemental Conditions.

E. "Or Equal" Products:

1. For proposed products not named in the Contract Documents and considered as an "or equal" as defined in the General Conditions, Contractor shall request in writing Engineer's approval of the "or equal". Request for approval of an "or equal"

product shall accompany the Shop Drawing or product data submittal for the proposed product and shall include:

- a. Contractor's request that the proposed product be considered as an "or equal" in accordance with the General Conditions, accompanied by Contractor's certifications required in the General Conditions.
- b. Documentation adequate to demonstrate that proposed product does not require revisions to the Contract Documents, that proposed product is consistent with the Contract Documents, and that proposed product will produce results and performance required in the Contract Documents, and that proposed product is compatible with other portions of the Work.
- c. Detailed comparison of significant qualities of proposed product with the products and manufacturers named in the Contract Documents. Significant qualities include attributes such as performance, weight, size, durability, visual effect, performance and specific features and requirements shown or indicated.
- d. Evidence that proposed product manufacturer will furnish warranty equal to or better than specified, if any.
- e. List of similar installations for completed projects with project names and physical addresses of installation along with the names, telephone numbers, email addresses and physical address of design professionals and owners associated with the referenced installation, if requested.
- f. Samples, if requested.
- g. Other information requested by Engineer.

1.05 WARRANTY

- A. Warranties specified for products shall be in addition to, and run concurrent with, Contractor's general warranty and guarantee and requirements for the required correction period. Disclaimers and limitations in specific product warranties do not limit Contractor's general warranty and guarantee.
 1. Product manufacturer's warranty is preprinted written warranty published by product manufacturer and specifically endorsed by product manufacturer to Owner.
 2. Equipment and material shall be guaranteed to be free from defects in workmanship, design, and/or materials for a period of one (1) year unless otherwise specified in the individual Specification Section for a Special Warranty.

3. Warranty period shall start on the date of the particular equipment and material is substantially complete, which includes requirements specified in Section 01 75 00 – Checkout and Startup Procedures for start-up certification and specified elsewhere in the Contract Documents.
 4. Warranty requirements may be added to or modified in the individual Specification Sections. Special warranty is written warranty required by or incorporated into the Contract Documents, either to extend time limit provided by product manufacturer's warranty or to provide increased rights to Owner.
 5. Special warranty information, if any, will be located in the Specification Section for that product.
- B. Requirements for Special Warranties: Provide written special warranty document that contains appropriate terms and identification, ready for execution by product manufacturer and Owner. Submit draft warranty with submittals required for product.
1. Manufacturer's Standard Form: Modified to include Project-specific information and properly executed by product manufacturer and other parties as appropriate.
 2. Specified Form: When specified forms are included in the Contract Documents, prepare written document, properly executed by product manufacturer and Owner, using appropriate form.
 3. Refer to Specifications for content and requirements for submitting special warranties.
- C. Submit product manufacturer's warranties and special warranties as submittals in accordance with Schedule of Submittals accepted by Engineer.

PART 2 – PRODUCTS (NOT USED)

PART 3 – EXECUTION (NOT USED)

END OF SECTION

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SECTION 01 65 00
PRODUCT DELIVERY REQUIREMENTS

PART 1 – GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. General requirements for preparing for shipping, delivering, and handling materials and equipment.
 - 2. Contractor shall make all arrangements for transporting, delivering, and handling of materials and equipment required for prosecution and completion of the Work.

1.02 SUBMITTALS

- A. Refer to individual Specification Sections for submittal requirements relative to delivery and handling materials and equipment.

1.03 SHIPMENT REQUIREMENTS

- A. When practical, factory-assemble materials and equipment. Match mark or tag separate parts and assemblies to facilitate field assembly. Cover machined and unpainted parts that may be damaged by the elements with strippable, protective coating.
- B. Package materials and equipment to facilitate handling, and protect materials and equipment from damage during shipping, handling, and storage. Mark or tag outside of each package or crate to indicate the associated purchase order number, bill of lading number, contents by name, Owner's contract name and number, Contractor name, equipment number, and approximate weight. Include complete packing lists and bills of materials with each shipment.
- C. Protect materials and equipment from exposure to the elements and keep thoroughly dry and dust-free at all times. Protect painted surfaces against impact, abrasion, discoloration, and other damage. Lubricate bearings and other items requiring lubrication in accordance with manufacturer's instructions.
- D. Advance Notice of Shipments:
 - 1. Keep Engineer informed of delivery of all materials and equipment to be incorporated in the Work.
- E. Do not ship materials and equipment until:

1. Related Shop Drawings, Samples, and other submittals have been approved or accepted (as applicable) by Engineer, including, but not necessarily limited to, Submittals associated with the materials and equipment being delivered.
2. Manufacturer's instructions for handling, storing, and installing the associated materials and equipment have been submitted to and accepted by Engineer in accordance with the Specifications.
3. Results of source quality control testing (factory testing), when required by the Contract Documents for the associated materials or equipment, have been reviewed and accepted by Engineer.
4. Facilities required for handling materials and equipment in accordance with manufacturer's instructions are in place and available.
5. Required storage facilities have been provided.

1.04 DELIVERY REQUIREMENTS

A. Scheduling and Timing of Deliveries:

1. Arrange deliveries of materials and equipment in accordance with the accepted Progress Schedule and in ample time to facilitate inspection prior to installation.
 - a. Equipment and material shall not be delivered to the Site prior to 90 days in advance of scheduled installation.
 - b. Partial payment requests will not be processed for materials delivered prior to 90 days before installation or for materials that are improperly stored.
2. Schedule deliveries to minimize space required for and duration of storage of materials and equipment at the Site or delivery location, as applicable.
3. Coordinate deliveries to avoid conflicting with the Work and conditions at Site, and to accommodate the following:
 - a. Work of other contractors and Owner.
 - b. Owner's operations and maintenance.
 - c. Storage space limitations.
 - d. Availability of equipment and personnel for handling materials and equipment.
 - e. Owner's use of premises.

4. Deliver materials and equipment to the Site during regular working hours.
5. Deliver materials and equipment to avoid delaying the Work and the Project, including work of other contractors, as applicable. Deliver anchor system materials, including anchor bolts to be embedded in concrete or masonry, in ample time to avoid delaying the Work.

B. Deliveries:

1. Shipments shall be delivered with Contractor's name, Subcontractor's name (if applicable), Site name, Project name, and contract designation clearly marked.
2. Site may be listed as the "ship to" or "delivery" address; but Owner shall not be listed as recipient of shipment unless otherwise directed in writing by Engineer.
3. Provide Contractor's telephone number to shipper; do not provide Owner's telephone number.
4. Arrange for deliveries while Contractor's personnel are at the Site. Contractor shall receive and coordinate shipments upon delivery. Shipments delivered to the Site when Contractor is not present will be refused by Owner, and Contractor shall be responsible for the associated delays and additional costs, if incurred.

C. Containers and Marking:

1. Have materials and equipment delivered in manufacturer's original, unopened, labeled containers.
2. Clearly mark partial deliveries of component parts of materials and equipment to identify materials and equipment, to allow easy accumulation of parts, and to facilitate assembly.

D. Inspection of Deliveries:

1. Immediately upon delivery, Contractor shall inspect shipment to verify that:
 - a. Materials and equipment comply with the Contract Documents and approved or accepted (as applicable) submittals.
 - b. Quantities are correct.
 - c. Materials and equipment are undamaged.
 - d. Containers and packages are intact and labels are legible.
 - e. Materials and equipment are properly protected.

2. Promptly remove damaged materials and equipment from the Site and expedite delivery of new, undamaged materials and equipment, and remedy incomplete or lost materials and equipment to furnish materials and equipment in accordance with the Contract Documents, to avoid delaying progress of the Work.
3. Advise Engineer in writing when damaged, incomplete, or defective materials and equipment are delivered, and advise Engineer of the associated impact on the Progress Schedule.

1.05 HANDLING REQUIREMENTS

- A. Provide equipment and personnel necessary to handle materials and equipment, including those furnished by Owner, by methods that prevent soiling or damaging materials and equipment and packaging.
- B. Provide additional protection during handling as necessary to prevent scraping, marring, and otherwise damaging materials and equipment and surrounding surfaces.
- C. Handle materials and equipment by methods that prevent bending and overstressing.
- D. Lift heavy components only at designated lifting points.
- E. Handle materials and equipment in safe manner and as recommended by the manufacturer to prevent damage. Do not drop, roll, or skid materials and equipment off delivery vehicles or at other times during handling. Hand-carry or use suitable handling equipment.

PART 2 – PRODUCTS (NOT USED)

PART 3 – EXECUTION (NOT USED)

END OF SECTION

SECTION 01 66 00
PRODUCT STORAGE AND PROTECTION REQUIREMENTS

PART 1 – GENERAL

1.01 SUMMARY

- A. General requirements of storing and protecting equipment and materials.

1.02 STORAGE

- A. Store and protect materials and equipment in accordance with manufacturer's recommendations and the Contract Documents.
- B. Contractor shall make all arrangements and provisions necessary for, and pay all costs for, storing materials and equipment. Construction equipment, and materials and equipment to be incorporated into the Work shall be placed to avoid injuring the Work and existing facilities and property, and so that free access is maintained at all times to all parts of the Work and to public utility installations in vicinity of the Work. Store materials and equipment neatly and compactly in locations that cause minimum inconvenience to Owner, other contractors, public travel, and owners, tenants, and occupants of adjoining property. Arrange storage in manner to allow easy access for inspection.
- C. Areas available at the Site for storing materials and equipment are shown or indicated in the Contract Documents, or as approved by Engineer.
- D. Store materials and equipment to become Owner's property to facilitate their inspection and ensure preservation of quality and fitness of the Work, including proper protection against damage by freezing, moisture, and high ambient temperatures. Store in indoor, climate-controlled storage areas all materials and equipment subject to damage by moisture, humidity, heat, cold, and other elements, unless otherwise acceptable to Owner.
- E. Contractor shall be fully responsible for loss or damage (including theft) to stored materials and equipment.
- F. Do not open manufacturer's containers until time of installation, unless recommended by the manufacturer, directed by Engineer or otherwise specified in the Contract Documents.
- G. Do not store materials or equipment in structures being constructed unless approved by Engineer in writing.

- H. Do not use lawns or other private property for storage without written permission of the owner or other person in possession or control of such premises.
- I. Contractor shall not store unnecessary equipment and materials at the Site.
- J. Contractor shall prevent structures from being loaded with a weight that endanger its security and/or safety of persons.
- K. Stored equipment and materials shall not be placed within 10 feet of fire hydrants.
- L. Gutters, drainage channels and inlets shall be kept unobstructed at all times.

1.03 PROTECTION

- A. Contractor shall provide temporary storage containers/facilities, if required, to protect equipment and materials at the Site.
- B. Equipment to be incorporated into the Work shall be boxed, crated, or otherwise completely enclosed and protected during shipping, handling, and storage, in accordance with Section 01 65 00 – Product Delivery Requirements.
- C. Store all materials and equipment off the ground (or floor) on raised supports such as skids or pallets.
- D. Protect painted surfaces against impact, abrasion, discoloration, and other damage. Painted equipment surfaces that are damaged or marred shall be repainted in their entirety in accordance with equipment manufacturer and paint manufacturer requirements, to the satisfaction of Engineer.

1.04 SPECIFIC STORAGE REQUIREMENTS

- A. Uncovered:
 - 1. The following types of materials may be stored outdoors without cover on supports so there is no contact with the ground:
 - a. Piping, except polyvinyl chloride (PVC) or chlorinated PVC (CPVC) pipe.
- B. Covered:
 - 1. The following materials and equipment may be stored outdoors on supports and completely covered with covering impervious to water:
 - a. Grout and mortar materials.
 - b. Rough lumber.

- c. PVC and CPVC pipe.
 - 2. Tie down covers with rope, and slope covering to prevent accumulation of water.
- C. Fully Protected:
- 1. All materials and equipment not named as uncovered or covered in this Section, shall be stored on supports in buildings or trailers that have concrete or wooden flooring, roof, and fully closed walls on all sides. Covering with plastic sheeting or similar material in space without floor, roof, and walls is not acceptable. Comply with the following:
 - a. Provide heated storage for materials and equipment that could be damaged by low temperatures or freezing.
 - b. Provide air-conditioned storage for materials and equipment that could be damaged by high temperatures.
 - c. Protect mechanical and electrical equipment from being contaminated by dust, dirt, and moisture.
 - d. Maintain humidity at levels recommended by manufacturers of electrical and electronic equipment.
 - e. Energize space heaters for electrical equipment and material.
- D. Maintenance of Storage: On scheduled basis, periodically inspect stored materials and equipment to ensure that:
- 1. Condition and status of storage facilities is adequate to provide required storage conditions.
 - 2. Required environmental conditions are maintained on continuing basis.
 - 3. Materials and equipment exposed to elements are not adversely affected.

1.05 RECORDS

- A. Keep up-to-date account of materials and equipment in storage to facilitate preparation of Applications for Payment, if the Contract Documents provide for payment for materials and equipment not incorporated in the Work but delivered and suitably stored at the Site or at another location agreed to in writing.

PART 2 – PRODUCTS (NOT USED)

PART 3 – EXECUTION (NOT USED)

END OF SECTION

SECTION 01 71 23
FIELD ENGINEERING

PART 1 – GENERAL

1.01 SUMMARY

- A. Contractor shall provide field engineering and professional services of the types indicated for the Project, including:
1. Furnishing civil, structural, and other professional engineering services specified or required to execute Contractor's construction methods.
 2. Developing and making all detail surveys and measurements required for construction.
 3. Keeping a transit, theodolite, or total station (theodolite with electronic distance measurement device); leveling instrument; and related implements such as survey rods and other measurement devices, at the Site at all times, and having a skilled instrument person available when necessary for laying out the Work.
 4. Being solely responsible for all locations, dimensions and levels. No data other than Change Order, Work Change Directive, or Field Order shall justify departure from dimensions and levels required by the Contract Documents.
 5. Rectifying all Work improperly installed because of not maintaining, not protecting, or removing without authorization established reference points, stakes, marks, and monuments.
 6. Providing such facilities and assistance necessary for Engineer to check lines and grade points placed by Contractor.
- B. Related Sections:
1. Section 01 25 00 – Substitution Procedures
 2. Section 01 26 00 – Contract Modification Procedures
 3. Section 01 61 00 – Product Requirements and Options
 4. Section 01 78 39 – Project Record Documents

1.02 ADMINISTRATIVE REQUIREMENTS

- A. Departures from Contract Drawings:

1. Contract Drawings show the extent and arrangement of the Work.
2. Contractor shall notify Engineer of departures from the Drawings that the Contractor deems required for incorporation of the Work at the Site in accordance with Section 01 26 00 – Contract Modification Procedures.
3. Contractor shall provide field engineering services for equipment and materials that require modifications to existing structures, auxiliary equipment, piping, electrical controls that are not indicated for modifications in the Contract Documents.

1.03 SERVICES AND RESPONSIBILITIES

A. Contractor's Field Engineer:

1. Contractor shall employ and retain field engineer at the Site capable of performing field engineering tasks required, including:
 - a. Provide reports to Engineer on the Work.
 - b. Check formwork, reinforcing, inserts, structural steel, bolts, sleeves, piping and other equipment and materials for conformance with Contract Documents.
 - c. Maintain field office files and drawings, record documents, and coordination with Subcontractors.
 - d. Prepare layout and coordination drawings for construction operations.
 - e. Check and coordinate Work for conflicts, interferences, and discrepancies with notification to Engineer.
 - f. Cooperate with Engineer and Owner in observing the Work and field inspections.
 - g. Review and coordinate the Work with Shop Drawings and other submittals.

B. Contractor's Surveyor:

1. Contractor shall employ or retain the services, as needed, at the Site a surveyor with experience and capability of performing surveying and layout tasks required in the Contract Documents and as required for the Work. Surveyor's tasks include, but are not necessarily limited to, the following:
 - a. Providing required surveying equipment, including transit or theodolite, level, stakes, and surveying accessories.

- b. Establishing required lines for constructing all facilities, structures, pipelines, and site improvements.
- c. Preparing and maintaining professional-quality, accurate, well organized, legible notes of all measurements and calculations made while surveying and laying out the Work.
- d. Complying with requirements of the Contract Documents relative to surveying and related work.

1.04 SUBMITTALS

A. Action/Informational Submittals:

- 1. Surveying:
 - a. Plan for conducting survey Work, submitted ten days prior to beginning of survey Work.
 - b. Field books after completing survey Work.
 - c. Certified survey in accordance with this Section.
- 2. Certificates: Signed Contractor or Contractor's surveyor certifying elevations and locations of Work are in conformance with Contract Documents, with explanations of deviations.
- 3. Qualification Statements: Contractor's surveyor.

PART 2 – PRODUCTS (NOT USED)

PART 3 – EXECUTION

3.01 SURVEYING

- A. Contractor shall establish baselines for location of equipment, materials and structures of the Work with bench marks and batter boards adjacent to Work.
- B. Contractor shall provide detailed surveys necessary for the Work including, but not limited to, slope stakes, batter boards, working points, lines and elevations.
- C. Specific surveying:
 - 1. Contractor shall have weirs surveyed by professional, licensed surveyor.

2. Contractor shall adjust weirs within a tolerance of +/- 0.05-inches of elevations shown on the Contract Documents.
3. Surveyed points for weirs shall be no greater than 10-feet spacing, and no less than two points per section of weir plate.

3.02 CLOSEOUT ACTIVITIES

- A. Contractor shall provide Project record documents for field engineering and surveying in accordance with Section 01 78 39 – Project Record Documents.
- B. Contractor shall provide certified weir elevation survey report in accordance with the requirements specified in this Section.

3.03 PROTECTION

- A. Contractor shall preserve and protect bench marks, reference points and stakes. Contractor shall re-establish damaged, destroyed, or lost bench marks, reference points and stakes. Contractor shall remove and re-install equipment and material installed based on Contractor established bench marks, reference points and stakes that have been damaged, destroyed, or lost at no additional cost to Owner.
- B. Contractor shall preserve and protect existing and new control points, property markers and monuments during construction of the Work. Contractor shall establish and replace damaged or lost control points, property markers and monuments due to Contractor's construction activities at no cost to the Owner. Contractor shall provide computations and calculations to establish location of replacement Work.

END OF SECTION

SECTION 01 71 33
PROTECTION OF WORK AND PROPERTY

PART 1 – GENERAL

1.01 SUMMARY

- A. Section Includes:
 - 1. Protection of existing utilities and structures.
 - 2. Protection of installed equipment and materials.
 - 3. Protection during inclement weather.
 - 4. Reporting of accidents.
 - 5. Barricades and warning signals.
- B. Contractor shall be responsible for taking all precautions, providing all programs, and taking all actions necessary to protect the Work and all public and private property and facilities from damage, as specified in the General Conditions, Supplementary Conditions, and this Section.
- C. To prevent damage, injury, or loss, Contractor's actions shall include the following:
 - 1. Storing apparatus, materials, supplies, and equipment in an orderly, safe manner that does not unduly interfere with progress of the Work or work of other contractors or utility companies.
 - 2. Providing suitable storage facilities for equipment and materials subject to damage or degradation by exposure to weather, theft, breakage, or other cause.
 - 3. Placing upon the Work or any part thereof only loads consistent with the safety and integrity of that portion of the Work and existing construction.
 - 4. Frequently removing and disposing of refuse, rubbish, scrap materials, and debris caused by Contractor's operations so that, at all times, the Site is safe, orderly, and workmanlike in appearance.
- D. Contractor has full responsibility for preserving public and private property and facilities on and adjacent to the Site. Direct or indirect damage done by, or on account of, any act, omission, neglect, or misconduct by Contractor in executing the Work, shall be restored by Contractor, at their expense to condition equal to that existing before damage was done.

- E. Contractor shall comply with safety regulations required by Owner or authorities having jurisdiction. Contractor shall comply with and correct unsafe conditions created or caused by Contractor's personnel. In the event Contractor fails to comply, Owner receives the right to take necessary measures to correct conditions or practices for reimbursement by Contractor.

1.02 REFERENCES

A. Definitions:

1. "Existing utilities" shall refer to both publicly-owned and privately-owned utilities such as, but are not limited to, electric power and lighting, telephone, water, gas, storm drains, process lines, sanitary sewers and all appurtenant structures.
2. "Surface structures" are existing buildings, structures, and other facilities at or above ground surface, including their foundations or any extension below ground surface. Surface structures include, but are not limited to, buildings, tanks, walls, channels, open drainage, exposed piping and utilities, poles, exposed wires, posts, signs, markers, curbs, walks, fencing, and other facilities visible at or above ground surface.

1.03 SITE CONDITIONS

A. Location of Existing Utilities and Structures:

1. Contractor shall confirm and verify location of existing utilities and structures at the Site prior to commencing the Work.
2. Contractor shall notify and obtain approval from authority having jurisdiction prior to performing the Work in the vicinity of the existing utilities and structures.

PART 2 – PRODUCTS (NOT USED)

PART 3 – EXECUTION

3.01 PROTECTION OF EXISTING UTILITIES AND STRUCTURES

A. General:

1. Contractor shall satisfy Engineer that methods and procedures for protection have been approved by authorities having jurisdiction prior to proceeding with the Work.
2. Contractor shall provide temporary support and protection, as required, to existing utilities and structures during the Work, including support of excavation.

- a. Temporary support and protection of existing utilities shall be provided in accordance with requirements of the authority having jurisdiction.
 - b. Temporary support and protection of existing structures shall be provided as required to ensure structural integrity is not compromised.
3. Contractor shall be responsible for costs incurred for temporary support or protection provided by a third-party or authority having jurisdiction to insure safety of the existing utility, Owner, and public and private parties.

B. Existing Buried Utilities:

1. Contractor shall perform field investigate to identify conflicts or interferences between existing utilities and utility Work prior to excavation Work.
 - a. Investigation of conflicts and interferences shall be performed on Site locations, elevations, slopes, etc. of the existing utilities determined during the field investigations.
 - b. Contractor shall notify Engineer and Owner in writing of identified conflicts or interferences. Contractor shall not proceed with the Work until written authorization is provided by the Engineer.
 - c. Identified conflicts and interferences shall be handled in accordance with the Contract Documents. If required, potential modification to the Contract Documents shall be performed in accordance with Section 01 26 00 – Contract Modification Procedures.
2. Contractor shall perform the Work to prevent disruption of existing service and damage to existing utilities.
 - a. Temporary connections shall be provided, as required, to provide un-interrupted service of existing utilities.
 - b. Contractor shall repair damage to existing utilities as directed by the Engineer or the authority having jurisdiction at Contractor's own expense.
 - c. Contractor shall be responsible for damages and repair costs to the authority having jurisdiction if third-party or authority having jurisdiction personnel repair damaged existing utilities.

C. Protection of Existing Structures:

1. Contractor shall sustain existing surface structures in existing place and protect from direct or indirect injury located within or adjacent to the limits of the Work.

Such sustaining and supporting shall be done carefully and as required by the party owning or controlling such structure or facility.

2. Contractor shall bear all risks attending the presence or proximity of all surface structures within or adjacent to limits of the Work, in accordance with the Contract Documents.
 3. Contractor shall be responsible for damage and expense for direct or indirect injury caused by their Work to structures and facilities.
 4. Contractor shall repair immediately damage caused by their Work, to the satisfaction of owner of damaged structure or facility at no cost to the Owner.
 5. Contractor shall provide temporary weather protection for existing structures and buildings where exterior walls or roofs are modified or disturbed in the Work. Contractor shall be responsible for damages due to inadequate protection of existing structures and building.
- D. Relocation of Surface Structures: Existing surface facilities, including but not limited to guard rails, posts, guard cables, signs, poles, markers, curbs, and fencing, that are temporarily removed to facilitate the Work shall be replaced and restored to their original condition at Contractor's expense.

3.02 PROTECTION OF INSTALLED EQUIPMENT AND MATERIALS

- A. Contractor shall protect installed equipment and materials to prevent damage, injury or loss from subsequent operations. Remove protection facilities when no longer needed prior to completion of the Work.
- B. Control traffic to prevent damage to equipment, materials, and surfaces.
- C. Coverings: Provide coverings to protect materials and equipment from damage.

3.03 PROTECTION DURING INCLEMENT WEATHER

- A. Contractor shall not perform Work during inclement or unsuitable weather that will affect the quality of the completed Work.
- B. Contractor shall take necessary precautions in the event of impending inclement weather to protect equipment, materials and Work from damage or deterioration due to floods, driving rain, wind, or snow storms.
 1. Owner reserves the right to require additional protection measures beyond Contractor's proposed protection measures to protect the Work.

2. Contractor shall not claim additional compensation for additional protection measures required by Owner nor for damages to equipment, material, or Work due to the inclement weather.
- C. When directed by Engineer, Contractor shall stop Work and protect new Work by protective covering during rain storms for, but not limited to, the following:
1. Concrete mixing and placement.
 2. Paving placement.
 3. Masonry installation.
 4. Buried piping, valve and appurtenance installation.
 5. Additional inclement weather requirements and limitations are specified in individual Specification Sections.

3.04 REPORTING OF ACCIDENTS

- A. Contractor shall immediately report, in writing, to Engineer and Owner accidents out of, or in conjunction with, the performance of Work.
1. Accident reporting includes on Site and adjacent to Site, which cause death, personal injury, or property damage.
 2. Written report shall provide full details and witness statements.
 3. If claim is made against Contractor, Supplier, or Subcontractor due to accident, Contractor shall promptly report facts, in writing, to Engineer and Owner, with full account of the claim.
- B. Contractor shall immediately report death, serious injury, or serious damage caused by telephone or messenger to Engineer and Owner.

3.05 BARRICADES AND WARNING SIGNALS (NOT USED)

END OF SECTION

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SECTION 01 73 00
DEMOLITION AND EXECUTION OF WORK

PART 1 – GENERAL

1.01 SUMMARY

A. Section includes:

1. Contractor shall provide labor, materials, tools, equipment, and incidentals shown, specified, and required for execution of the Work as specified in this Section, including the following:
 - a. Construction Electronic Documentation
 - b. Demolition
 - c. Cutting and Coring
 - d. Patching
 - e. Installation
2. Requirements for demolition, removal and disposal of existing buildings, structures, pavement, curbs, and sidewalks and electrical, plumbing, heating and ventilation equipment and materials as indicated in the Contract Documents for demolition.
3. General requirements for installation of equipment and material. Additional installation requirements are included in the individual Specification Sections.
4. General requirements for connections to existing facilities. Requirements for tie-ins and shutdowns necessary to complete the Work are included in Section 01 14 00 – Coordination with Owner's Operations.
 - a. To extent possible, materials, equipment, systems, piping, and appurtenances that will be placed into service upon completion of connection to existing facilities shall be checked, successfully tested, and in condition for operation prior to making connections to existing facilities, if valves, gates, or similar watertight and gastight isolation devices are not provided at the connection point.
5. Requirements for cutting and coring, and rough and finish patching of holes and openings in existing construction. Provide cutting, coring, fitting, and patching, including attendant excavation and fill, required to complete the Work, and to:

- a. Remove and replace defective Work.
- b. Remove samples of installed Work as specified or required for testing.
- c. Remove construction required to perform required alterations or additions to existing work.
- d. Connect to completed Work not performed in proper sequence.
- e. Remove or relocate existing utilities and pipes that obstruct the Work in locations where connections must be made.
- f. Make connections or alterations to existing or new facilities.

B. Related Sections:

- 1. Section 01 14 00 – Coordination with Owner's Operations
- 2. Section 01 51 00 – Temporary Utilities
- 3. Section 01 57 00 – Temporary Controls
- 4. Section 01 61 00 – Product Requirements and Options
- 5. Section 01 66 00 – Product Storage and Protection Requirements
- 6. Section 01 74 00 – Cleaning and Waste Management
- 7. Section 01 79 00 – Instruction of Owner's Personnel
- 8. Section 02 41 00 – Site Demolition

1.02 REFERENCES

A. Definitions:

- 1. "Manufacturer's installation instructions" includes manufacturer's written instructions; drawings; illustrative, wiring, and schematic diagrams; diagrams identifying external connections; and other such information pertaining to installation of equipment and materials. Installation instructions are printed instructions, including those attached to the equipment and materials, all inclusive.
- 2. "Salvage" items are equipment and materials shown on the Contract Documents for selective removal by the Contractor to furnish to the Owner. Contractor shall be responsible for removal, handling, and depositing of equipment and material to location designated by Owner.

B. Reference Standards:

1. 29 CFR 1910, OSHA.
2. ANSI A10, Construction and Demolition Operations

1.03 ADMINISTRATIVE REQUIREMENTS

A. Coordination:

1. Review installation procedures under other Sections and coordinate Work that must be performed with or before the Work specified in this Section.
2. Notify other contractors in advance of Work for connections to existing facilities to prevent delay of the Work.
3. Remove and dispose of equipment and materials indicated for demolition on the Contract Documents, unless indicated as salvage items for the Owner. Contractor shall obtain ownership of removed equipment and materials following Engineer and Owner approval. Disposal of equipment and materials shall be in accordance with the Contract Documents

B. Sequencing:

1. Contractor shall remove and demolish equipment and materials in sequence specified in Section 01 14 00 – Coordination with Owner's Operation and following approval by Engineer and Owner.
2. Contractor shall replace equipment and materials removed without proper authorization from Engineer, which are necessary for the operation of the existing facilities. Re-installation of equipment and materials shall be to the satisfaction of the Engineer at no cost to the Owner

C. Title to Equipment and Materials:

1. Equipment and materials indicated for demolition and removal in the Contract Documents, and not designated as Owner's salvaged items, shall become the Contractor's property following removal from the Site. Contractor shall be responsible for legally disposing of the equipment and material.
2. Contractor shall have no right or title to any of the equipment, materials, or other items to be removed until the elements have been removed from the Site.
3. Contractor shall not sell or assign or attempt to sell or assign any interest in the equipment, materials, or other items until removal from Site.

4. Contractor shall have no claim against the Owner because of the absence of equipment, fixtures, and materials.

D. Salvage Equipment and Materials:

1. Contract Documents indicate equipment and materials that shall be retained by Owner. Owner has the right to request any demolished equipment and materials be retained at their discretion.
2. Contractor shall move salvaged equipment and materials to storage areas located at the Site as instructed by Owner.
3. Architectural equipment and materials may be salvaged for incorporation into the Work when approved by Engineer.

- E. Use of Explosives: Contractor shall not use explosives or blasting equipment and material in the Work in accordance with the Contract Documents.

1.04 SUBMITTALS

A. Action/Informational Submittals:

1. Construction electronic documentation as specified in this Section.
2. Demolition Plan: Submit detailed description of methods, equipment, and sequence for demolition Work, including means of ensuring stability of structures during demolition activities.
3. Cutting and Patching Request:
 - a. Submit written request to Engineer, well in advance of executing cutting or alteration that affects one or more of the following:
 - 1) Design function or intent of Project.
 - 2) Work of Owner or other contractors.
 - 3) Structural value or integrity of an element of the Project.
 - 4) Integrity or effectiveness of weather-exposed or moisture-resistant elements or systems.
 - 5) Efficiency, operational life, maintenance, or safety of operational elements.
 - 6) Visual qualities of sight-exposed elements.

- b. Request shall include:
 - 1) Identification of Project and contract name and number.
 - 2) Description of affected Work of Contractor and work of others (if any).
 - 3) Necessity for cutting.
 - 4) Effect on work of Owner, other contractors (if any), and on structural or weatherproof integrity of Project.
 - 5) Description of proposed Work, including scope of cutting and patching; trades who will be executing the Work; products proposed to be used; extent of refinishing; schedule of operations; alternatives to cutting and patching, if any.
 - 6) Designation of entity responsible for cost of cutting and patching, when applicable.
 - 7) Written permission of other contractors (if any) whose work will be impacted.
- 4. Recommendation Regarding Cutting and Patching:
 - a. Should conditions of work, or schedule, indicate a change of materials or methods, submit written recommendation to Engineer including:
 - 1) Conditions indicating change.
 - 2) Recommendations for alternative materials or methods.
 - 3) Items required with substitution request, in accordance with the substitution request requirements of the Contract Documents and Section 01 61 00 – Product Requirements and Options.
- 5. Product Data: Submit manufacturer's product data for the protective compound to be applied to core-drilled surfaces and cut concrete surfaces, as well as means of protecting exposed reinforcement or other metal embedments.
- 6. Informational Submittal: Submit written indication designating the day and time that the construction associated with cutting and patching will be uncovered, to allow observation. Do not begin cutting or patching operations until submittal is accepted by Engineer.
- 7. Comply with submittal requirements of individual Specification Sections for patching materials.

1.05 SITE CONDITIONS

- A. Owner does not assume responsibility for the actual condition of structures and equipment to be demolished and removed.
- B. Existing Site conditions shall be maintained to the greatest extent possible by the Owner to the time of Notice to Proceed.
- C. Contractor shall perform investigations, explorations, and probes as necessary at the Site prior to initiating demolition Work to ascertain any required protective measures before proceeding with demolition and removal. Contractor shall give particular attention to shoring and bracing requirements to prevent damage to the Work and existing structures.
- D. Contractor shall verify measurements, dimensions and other conditions of each existing structure, system, equipment, and material indicated in the Contract Documents for new Work prior to ordering equipment and materials.

PART 2 – PRODUCTS

2.01 MATERIALS

- A. General:
 - 1. Provide materials and products in accordance with the individual Specification Sections and the Contract Documents.
 - 2. Provide materials and products that visually match existing adjacent surfaces to fullest extent possible for exposed surfaces.
 - 3. If not indicated in the Contract Documents, provide materials and products that are identical to existing materials and products affected by the Work.
 - 4. If identical materials and products are unavailable, provide materials and products that shall equal or exceed performance requirements of existing materials and products.
- B. Protective Coating Applied to Core-Drilled Surfaces and Cut Concrete Surfaces:
 - 1. All concrete surfaces exposed due to cutting or core drilling shall be coated with an epoxy resin coating such as Sikagard 62 by Sika Corporation, Durakote 240 by Tamms Industries or approved equal.
 - 2. Reinforcement or other metal embedment exposed by concrete cutting or core drilling shall be burned back a minimum of ½ inch below surface and resulting void shall be filled with an epoxy resin binder.

PART 3 – EXECUTION

3.01 CONSTRUCTION ELECTRONIC DOCUMENTATION

A. Pre-Construction Documentation

1. Contractor shall take photographic and video documentation of the Site where Work is being performed. Engineer and Owner reserve the right to be present during documentation.
2. Contractor shall provide both photographic and video documentation at grade-level and aerial of the Site prior to commencing Work.
3. Contractor shall submit pre-construction documentation to Engineer and Owner for review. Contractor, Engineer, and Owner shall visit Site to field verify electronic documentation prior to commencing the Work. Site visit verification shall establish existing conditions prior to commencing Work.

B. Construction Progress Documentation

1. Contractor shall document Work progress at locations and construction as directed by Engineer, at a minimum.
2. Contractor shall provide electronic documentation prior to and following any shutdown, switchover, demolition, de-commissioning, cutting, patching, repair, etc. Engineer and Owner reserve the right to be present during documentation.
3. Contractor shall document following exposure of buried utilities, piping, valve, appurtenances, and other underground elements.
4. Engineer reserves the right to provide construction progress documentation to confirm Contractor electronic documentation.

C. Post-Construction Documentation

1. Contractor shall take photographic and video documentation of the Site where Work has been completed and prior to Substantial Completion or partial utilization by Owner. Engineer and Owner reserve the right to be present during documentation.
2. Contractor shall provide both photographic and video documentation at grade-level and aerial of the Site following completion of the Work.

D. Submittal Requirements:

1. Documentation shall be time stamped for verification, including date and time.

2. Documentation shall be organized in a logical manner, such as by structure, building, physical site location, etc. for easy of comparison.
3. Photographic documentation shall be high resolution electronic versions.
4. Documentation shall be submitted to Engineer for review and approval prior to commence Work and at completion of the Work.

3.02 DEMOLITION

A. General:

1. Demolition Work shall comply with the applicable provisions and recommendation of ANSI A10, Construction and Demolition Operations standards, all governing codes, and as specified in this Section.
2. Contractor shall furnish competent and experienced personnel for the various type of demolition and removal Work. Demolition and removal Work shall be performed with regard to the safety of Owner employees, individuals at the Site, and the public.
3. Contractor shall confirm absence of embedded utilities prior to cutting, coring, or demolishing existing concrete and facilities. Verification shall be performed by portable x-ray, ground penetrating radar, or other non-invasive methods.
 - a. Contractor shall notify Engineer and Owner if embedded utilities are located during the investigation. Contractor shall clearly mark and document location of embedded utilities prior to performing the Work.
 - b. Contractor shall be responsible for repair and damages caused by exploration, investigation, and performance of the Work at no additional cost to Owner.
4. Contractor shall remove temporary work, such as enclosures, signs, guards, etc. when such temporary Work is no longer required or when directed at the completion of the Work.
5. Contractor shall perform patching, restoration and Work in accordance with individual Specification Sections and details shown on Contract drawings.
6. Contractor shall be responsible for damage caused by demolition Work to existing structures, equipment and materials indicated for reuse or to remain at no additional cost to Owner.
7. Contractor shall maintain a clean working environment during the demolition Work in accordance with Section 01 74 00 – Cleaning and Waste Management.

8. Contractor shall proceed with the demolition work in a sequence designed to maintain the plant in operation in accordance with Section 01 14 00 – Coordination with Owner's Operations.
9. Excavation caused by demolition shall be backfilled with fill free from rubbish and debris. Select fill or structural fill shall be used where specifically required on Contract Drawings.
10. All debris resulting from the demolition and removal work shall be disposed of by the Contractor at a properly permitted facility as part of the work of this Contract. All regulations covering material handling and disposal shall be followed. Material designated by the Engineer to be salvaged shall be stored on the construction site as directed. All other material shall be disposed of off-site by the Contractor at his expense. Burning of any debris resulting from the demolition will not be permitted at the site.

B. Protection during Demolition:

1. Contractor shall provide, erect, and maintain catch platforms, lights, barriers, weather protection, warning signs and other items as required for proper protection of the public, occupants of the building, personnel engaged in demolition Work, and adjacent construction.
2. Contractor shall provide and maintain weather protection at exterior openings to fully protect the interior premises against damage from the elements until such openings are closed by the Work.
3. Contractor shall provide and maintain temporary protection of the existing structure designated to remain where demolition, removal and Work is being done, connections made, materials handled, or equipment moved. Temporary protection shall be provided in accordance with Section 01 71 33 – Protection of Work and Property.
4. Contractor shall take necessary precautions to prevent dust from rising by wetting demolished masonry, concrete, plaster, and similar debris. Unaltered portions of the existing buildings affected by the operations in the Contract Documents shall be protected by dust proof partitions and other adequate means. Dust control shall be provided in accordance with Section 01 57 00 – Temporary Controls.
5. Contractor shall provide adequate fire protection in accordance with Section 01 51 00 – Temporary Utilities and authorities having jurisdiction.
6. Contractor shall perform the demolition Work with minimum traffic interference. Contractor shall not close or obstruct walkways, passageways, or stairways. Contractor shall not store or place materials in passageways, stairs, or other means of egress.

7. Contractor shall minimize disturbances to exterior walls and roofs to small sections that are readily repaired and patched to maintain watertight conditions in existing structures and buildings.

C. Performance of Demolition:

1. Equipment, piping, valves, and appurtenances:
 - a. Contractor shall drain equipment, piping, valves, and appurtenances prior to demolition Work. Contractor shall be responsible for collection, transport, and disposal of drained contents at no additional cost to the Owner.
 - b. Contractor shall provide line stops, plugs, blind flanges, etc. for equipment, piping, valves, and appurtenance required to remain in service during the Project. Contractor shall provide temporary or permanent supports in accordance with the Contract Documents.
 - c. Supports, pedestals and anchors shall be removed with the equipment and piping unless otherwise noted in the Contract Documents.
 - d. Concrete bases, anchor bolts and other supports shall be removed to approximately 1 inch below the surrounding finished area and the recesses shall be filled with epoxy resin binder.
 - e. Wall and roof openings shall be closed, and damaged surfaces shall be patched to match the adjacent areas, in accordance with the Contract Documents and as directed by the Engineer.
 - f. Wall sleeves, wall pipes, and wall castings shall be plugged or blanked off in accordance with the Contract Documents and as directed by the Engineer.
 - g. Openings in concrete shall be closed in accordance with the Contract Documents and as directed by the Engineer.
2. Electrical components and equipment:
 - a. Contractor shall de-energize panelboards, lighting fixtures, switches, circuit breakers, electrical conduits, motors, limit switches, pressure switches, instrumentation such as flow, level and/or other meters, wiring, and similar electrical equipment prior to removal.
 - b. Contractor shall relocate or isolate electrical equipment and materials that serve equipment, piping, valves, and appurtenance that are to remain in service during the Project. Relocation or isolation Work shall be sequenced and scheduled in accordance with Section 01 14 00 – Coordination with Owner's Operations.

3. Reused and relocated equipment:

- a. Contractor shall receive approval from Engineer prior to removal and relocation of equipment and material. Equipment and materials removed by Contractor prior to Engineer's approval that is required for Owner's operation of the facility shall be reinstalled at no cost to the Owner.
- b. Prior to removal and relocation Work, equipment and materials indicated for reuse and relocation shall be operated by Owner with Contractor and Engineer present to witness existing functionality and operation.
- c. Contractor shall provide personnel responsible for reinstallation of equipment and material for the removal Work.
- d. Contractor shall be responsible and provide storage and protection of equipment and materials in accordance with Section 01 66 00 – Product Storage and Protection Requirements until relocation and reinstallation Work is performed.
- e. Contractor shall provide replacement equipment and material that is damaged during the removal Work at new cost to the Owner. Contractor shall be responsible to provide same type, model, electrical components, etc. equipment and material as approved by Engineer and Owner.

4. Structural removal:

- a. Contractor shall provide and install temporary shoring, struts, and bracing required for the demolition Work to ensure stability during entire demolition process.
- b. Contractor shall cut and remove structural material at the interface of demolition Work and the existing structural element. Cutting and removal shall occur in small sections, including masonry units, to prevent instability of structural elements.
- c. Contractor shall patch, repair, and refinish adjacent surfaces that remain following demolition Work.
 - 1) Adjacent surfaces shall be repaired and refinished to the condition prior to the demolition Work and in accordance with the Contract Documents.
 - 2) Adjacent surfaces shall be cleaned of dirt, grease, loose paint, etc., prior to refinishing.

- d. Contractor shall limit cutting of existing roof areas designated to remain to the limits required for the proper installation of the Work.
 - 1) Cut and remove insulation, joists, flashing, membranes, shingles, and metals, etc. in accordance with the Contract Documents and as directed by the Engineer for installation of the Work.
 - 2) Provide temporary weather tight protection as required until new roofing and flashings are installed.
- 5. Architectural repairs and removal Work, not specifically shown on the Drawings, may include, but not limited to, the following:
 - a. Brickwork: Re-pointing; removing and replacing broken, cracked, disintegrating and missing materials.
 - b. Windows: Removing cracked or disintegrating sealant material; replacing missing or broken glass; re-caulking and sealing frames; glazing sealants.
 - c. Re-finishing: Removing rust, sealing, or peeling paint from surfaces by scraping, sanding or wire brushing; priming and repainting surfaces.
 - d. Roofing: Patching and repairing membrane or built-up roofing; metal flashing repair; correcting roof pitch to eliminate ponding; cleaning and/or replacing roof drains.
 - e. Masonry: Cutting and installing new expansion and control joints.
 - f. Parapets: Removing and construction of new walls and copings; clean and patching of copings; replacing copings where broken.
 - g. Concrete surfaces: Patching, cleaning, sealing and resurfacing floors, walls, lintels, sills, and trim. Replace lintels where broken. Patching or replacing broken, spalled, cracked and disintegrating concrete encased steel columns and piers.
 - h. Openings: Cutting and modifying as required for new Work. Provide new lintels, doors, and frames.
 - i. Doors: Patching and refinishing doors and frames.
 - j. Ceilings: Patching, refinishing, and replacing.
 - k. Guards, handrails, and appurtenances: Cleaning and repainting steel materials. Replacing steel material with new aluminum material.

- I. Demolished Exterior Openings: Remove window sash, frame, sill, stool and trim at exterior doors indicated for enclosure and sealing. Provide brick and/or masonry block for closure and sealing.

D. Maintenance during Demolition:

1. Contractor shall maintain the buildings, structures, and public properties free from accumulations of waste, debris and rubbish, generated by the demolition Work.
2. Contractor shall provide cleaning and waste management of demolition equipment and materials in accordance with Section 01 74 00 – Cleaning and Waste Management.

3.03 CUTTING AND CORING

A. General:

1. Contractor shall notify Engineer in writing and receiving Engineer's approval prior to cutting load bearing walls (concrete or masonry) and structural concrete floors.
2. Perform cutting and coring to limit extent of patching required.
3. Structural Elements: Do not cut or core structural elements in manner that would change structural element's load-carrying capacity or load deflection ratio.
4. Operating Elements: Do not cut or core operating elements in manner that would reduce capacity to perform as intended. Do not cut or core operating elements or related components in manner that would increase maintenance requirements or decrease operational life or safety.
5. Replace, patch, and repair materials and surfaces cut or damaged during cutting and coring Work. Contractor shall use methods that do not void required or existing warranties.
6. Provide temporary or permanent bypass provisions prior to cutting existing pipe, conduit, ductwork, or other utilities serving facilities scheduled to be removed or relocated in accordance with the Contract Documents.
7. Inspection: Examine and prepare surfaces prior to commencing Work. Contractor shall report unsatisfactory or questionable conditions to Engineer in writing. Contractor shall not proceed with the Work until unsatisfactory conditions are corrected.
8. Preparation:

- a. Provide temporary support required to maintain structural integrity, to protect adjacent Work from damage, and to support the element(s) to be cut or cored.
 - b. Protection of Existing Construction During Cutting and Coring:
 - 1) Protect existing structures, equipment, and materials during cutting and coring to prevent damage.
 - 2) Provide protection from adverse weather conditions that will be exposed during cutting and coring Work.
 - 3) Avoid interference with use of adjoining areas or interruption of free passage to adjoining areas.
9. Restoration:
- a. Clean equipment, materials, piping systems, valves, conduit and appurtenances that were damaged due to the Work prior to applying paint or other finishing materials.
 - b. Restore damaged pipe coverings, including insulation, to original condition.

B. Cutting:

1. General:
- a. Cut existing structures and appurtenances that provide surfaces for installation or repair of the Work. Cut existing construction using methods to minimize damage and disturbance to retained and adjoining construction elements.
 - b. Cutting equipment used shall be hand or small power tools suitable for sawing or grinding. Avoid using hammering or chopping equipment for cutting Work.
 - c. Cut holes and slots as small as possible and to size required for incorporation of the Work and in accordance with the Contract Documents.
 - d. Cut or drill from exposed or finished side to concealed side to avoid marring finished surfaces.
 - e. Provide adequate bracing of area to be cut prior to cutting.
 - f. Provide equipment and material to remove cut spoils.

- g. Provide temporary protection for cut openings where and when Work is not being performed.
 - 2. Concrete and Masonry:
 - a. Cut through concrete and masonry using concrete wall saw with diamond saw blades.
 - b. Provide control for slurry generated during sawing on both sides of element being cut.
 - c. After cutting concrete and before installing new Work on or through the opening, coat exposed concrete and steel with protective coating material specified in this Section. Apply protective coating in accordance with manufacturer's instructions.

C. Coring:

- 1. Core-drill holes through concrete and masonry walls, slabs, or arches, in accordance with the Contract Documents, unless written authorization is furnished by Engineer.
- 2. Protection: Protect existing structures, equipment, materials, utilities, and adjacent areas from water and other damage by core-drilling Work.
- 3. Coring:
 - a. Perform coring with non-impact rotary tool using diamond core-drills.
 - b. Size holes for pipe, conduit, sleeves, equipment, or mechanical seals, as required, to be installed through the penetration and in accordance with the Contract Documents.
 - c. After core-drilling and before installing equipment and material through the penetration, coat exposed concrete and steel with protective coating material specified in this Section. Apply protective coating in accordance with manufacturer's instructions.
- 4. Cleaning: Vacuum or otherwise remove slurry and tailings from the work area following core-drilling.

3.04 PATCHING

A. General:

- 1. Construction shall be patched by filling, repairing, refinishing, closing-up, and similar methods at completion of the Work.

2. Provide equipment and materials in accordance with the Contract Documents for patching Work. Comply with manufacturer's installation instructions.
3. Provide airtight connections to pipes, sleeves, ducts, conduit, and other penetrations through surfaces when patching the Work. Provide durable patching seams that minimize visual appearance.
4. Patched areas shall be tested to demonstrate integrity of installation as directed by the Engineer. Contractor shall provide testing equipment, material, and services for patch testing.

B. Restoration:

1. Restore exposed finishes of patched areas to minimize evidence of patching and refinishing.
2. Contractor shall extend refinishing and restoration into adjoining areas to blend patched areas with existing adjacent areas.
 - a. Refinish to nearest intersection for continuous surfaces.
 - b. Refinish the entire assembly and system for equipment and materials.
 - c. Repair and rehang existing ceilings to provide an even-plane surface of uniform appearance.
 - d. Apply plaster and finishes to match adjacent interior walls and partition areas for openings sealed with brick and/or masonry block.

3.05 INSTALLATION

- A. Install equipment and materials in accordance with the Contract Documents, approved Shop Drawings, and manufacturer's installation instructions. When manufacturer's installation instructions conflict with the Contract Documents, obtain interpretation or clarification from Engineer before proceeding.
- B. Preparation of surfaces shall be performed prior to installation of equipment and material.
 1. New floor finishes: Repair and patch with concrete, asphalt latex type emulsion and underlayment as required for existing surfaces or new flooring surfaces.
 2. Ceramic tile flooring or bases installed over concrete floors: Grind away cove, if present, for installation of new Work.
- C. Concrete surfaces shall achieve compression strength in accordance with the Contract Documents prior to installation of equipment and materials.

1. Anchor bolts and templates shall be provided by Contractor and as specified in the individual Specification Sections.
 2. Concrete foundations shall be treated with sealer to prevent oil from seeping into concrete as specified in the individual Specification Sections.
- D. Maintain the work area in a broom-clean condition while installing materials and equipment.
- E. Contractor shall be responsible for equipment for hoisting, lifting, moving, rigging, etc. for installation of equipment and materials.
1. Contractor shall be responsible for design of temporary installation system used for the installation Work, unless otherwise indicated in the Contract Documents.
 2. Contractor shall be responsible for damage to existing structure, equipment, and material caused prior, during, and following installation of the Work with the Contractor furnished temporary installation system at no cost to Owner. Repairs shall be in accordance with the Contract Documents, shall return to condition prior to installation Work, and as directed by the Engineer.
 3. Owner's hoists, monorails, bridge cranes, rigging, etc. shall not be used by the Contractor unless written authorization is provided by Owner.
- F. Alteration or repair of new equipment and materials shall not be permitted without written authorization from Engineer.
- G. Field welding or burning of new equipment and materials shall not be permitted unless indicated in the Contract Documents or without written authorization from Engineer.
- H. Contractors shall install temporary shoring and bracing where necessary during installation of the Work where required:
1. System shall be provided in accordance with the Contract Documents and code requirements.
 2. Temporary system shall consist of adjustable sound timbers or rolled shapes easily removable following installation of the Work.
 3. Contractor shall be responsible for damage to existing structures and new Work during installation, utilization, and removal of the temporary system at new additional cost to the Owner.
- I. Manufacturer's Installation Services: Provide competent, qualified manufacturer's representatives of equipment and material for services specified in the individual Specification Sections, including, but not limited to:

1. Supervising installation
2. Checking the completed installation
3. Adjusting and testing of equipment and materials
4. Instructing Owner's operations and maintenance in accordance with Section 01 79 00 – Instruction of Owner's Personnel.

END OF SECTION

SECTION 01 73 23
ANCHORAGE AND BRACING OF NONSTRUCTURAL COMPONENTS

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. Furnish all equipment, labor, materials, and services required to design and provide anchorage and bracing for all nonstructural components in accordance with the Contract Documents and Building Code requirements, including the seismic design requirements of Chapter 13 in ASCE 7.
- B. This Section covers requirements for only the anchorage and bracing of nonstructural components. Design requirements for nonstructural components (other than their anchorage and bracing) are covered in the Section for that component.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 01 45 33 – Special Inspections
- B. Section 05 05 23 – Metal Fastening
- C. Section 05 10 00 – Metal Materials
- D. Further requirements for anchorage and bracing are included in other Sections of the Specifications. See Section for the specific nonstructural component in question.

1.03 DEFINITIONS

- A. Nonstructural components: All architectural, mechanical, electrical, or plumbing elements or systems and their supports or attachments provided under this contract which are permanently attached to new or existing structures.
 - 1. Architectural nonstructural components include, but are not limited to, interior nonstructural walls and partitions, exterior wall panels and glazing elements, glass curtain walls, skylights, cabinets, suspended ceilings, fascia, and cladding.
 - 2. Mechanical nonstructural components include, but are not limited to, HVAC units, fans, water and wastewater treatment process equipment, instrumentation cabinets, piping and ductwork.
 - 3. Electrical nonstructural components include, but are not limited to, conduit systems, cable tray systems, boxes, transformers, panelboards, switchboards, switchgear, busway, individual motor controllers, motor control centers, variable frequency drives, automatic transfer switches, and lighting systems.

4. Plumbing nonstructural components include, but are not limited to, sprinkler systems and associated piping, and sump pumps.
- B. Attachment: Elements including anchor bolts, welded connections, and mechanical fasteners which secure nonstructural components or supports to the structure.
 - C. Essential Components: Nonstructural components considered necessary to public safety for which the component importance factor I_p is required by chapter 13 in ASCE 7 to be taken as 1.5, including:
 1. Life safety systems which must function following an earthquake, including but not limited to, sprinklers for fire protection, emergency lighting, egress corridors and stairways, and smoke purge systems.
 2. Components which contain, convey or support toxic, highly toxic, or explosive substances where the quantity of the material exceeds a threshold quantity established by the Building Code.
 3. Components which are within or attached to an Occupancy or Risk Category IV structure as defined in ASCE 7 Chapter 1 and are needed for continued operation of the facility or failure could impair the continued operation of the facility.
 4. Components which contain, convey, or support hazardous substances and are attached to a structure or portion thereof classified by the Building Code as a hazardous occupancy.
 - D. Nonbuilding Structures: All self-supporting structures which are supported by an independent foundation or by other structures which include, but are not limited to, storage tanks, silos, exhaust stacks, storage racks, and towers.
 - E. Delegated Design: Design of a structure or structural element(s) which has been deferred by the contract documents to be performed during the project construction stage, by a registered design professional retained by the Contractor and with the design submitted as a shop drawing to the Engineer.

1.04 REQUIREMENTS

- A. Anchorage and bracing of nonstructural components shall be designed and installed to resist the controlling load combination of gravity loads, operational forces (including static and dynamic), wind forces, seismic forces and any other applicable forces required in accordance with the governing Building Code.
- B. Anchorage and bracing of nonstructural components shall comply with seismic design requirements of ASCE 7 Chapter 13 unless the nonstructural component meets the criteria to be exempt. The following nonstructural components are exempt from

requirements specific to seismic anchorage and bracing: (See herein for Seismic Design Category)

1. Storage cabinets no more than 6 feet tall, furniture, and movable equipment, regardless of Seismic Design Category.
2. All architectural, mechanical, electrical, and plumbing nonstructural components in Seismic Design Category A.
3. All mechanical, electrical, and plumbing nonstructural components in Seismic Design Category B.
4. Architectural nonstructural components in Seismic Design Category B, other than parapets, provided that $I_p = 1.0$.
5. Mechanical, electrical, and plumbing nonstructural components in Seismic Design Category C provided that either:
 - a. $I_p = 1.0$, and the component is positively attached to the structure, or
 - b. Component weighs 20 lbs. or less, or 5 lb/ft or less for distribution systems.
6. Mechanical, electrical, and plumbing nonstructural components in Seismic Design Category D, E or F that are positively attached to the structure, provided that either:
 - a. $I_p = 1.0$, component weighs 400 lbs or less and its center of mass is 4 ft or less above a floor level, and flexible connections are provided between the components and associated ductwork, piping and conduit: or
 - b. Component weighs 20 lbs. or less, or 5 lb/ft or less for distribution systems.
7. Other exemptions as allowed by the Specifications, Codes and Standards referenced herein.

1.05 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

- A. Without limiting the generality of the Specifications, all work herein shall conform to or exceed the applicable requirements of the following documents. The Building Code shall be the version in effect at the time of Bid within the jurisdiction where the Work is located. All other referenced specifications, codes, and standards refer to the version as referenced by the Building Code. If no version is referenced by the Building Code, then the most current issue available at the time of Bid shall be used.
 1. International Building Code
 2. ASCE/SEI 7 Minimum Design Loads for Buildings and Other Structures

3. NFPA 13 Standard for Installation of Sprinkler Systems
4. FEMA 412 Installing Seismic Restraints for Mechanical Equipment
5. FEMA 413 Installing Seismic Restraints for Electrical Equipment
6. FEMA 414 Installing Seismic Restraints for Duct and Pipe
7. SMACNA Sheet Metal and Air Conditioning Contractors' National Association, Seismic Restraint Manual: Guidelines for Mechanical Systems
8. ACI 318 Building Code Requirements for Structural Concrete and Commentary
9. ACI 355.2 Qualifications of Post-Installed Mechanical Anchors in Concrete
10. ACI 355.4 Qualifications of Post-Installed Adhesive Anchors in Concrete

1.06 SUBMITTALS

- A. Submit the following in accordance with Section 01 33 00 – Submittal Procedures.
 1. Anchorage and bracing submittals for all architectural, mechanical, electrical, and plumbing nonstructural components, elements and systems that do not have a design for anchorage and bracing provided within the Contract Documents. Submittals shall include the following:
 - a. Component manufacturer's cut sheets and fabrication details for equipment bases and foundations, including dimensions, structural member sizes, support point locations and equipment operational loads. Equipment anchorage details shall clearly indicate anchor size, pattern, embedment, and edge distance requirements to satisfy operational, wind, seismic and other forces required by the governing Building Code. Details shall also indicate grout, bearing pads, isolators, etc. required for complete installation.
 - b. Design calculations, signed and sealed by a Professional Engineer registered in the State or Commonwealth in which the project is located. Design shall include all loads and load combinations required by the governing Building Code. Separate calculation submittals for vertical and lateral load support systems shall not be allowed.
 - c. Detailed Shop Drawings, signed and sealed by a Professional Engineer registered in the State or Commonwealth in which the project is located, showing specific details of the support design including material, installation, attachments, connection hardware, etc., and the layout and location of all

hangers and supports (resisting both gravity and lateral loads), including bracing orientation and direction of force(s) to be resisted.

- d. Seismic loads and requirements are not required to be included in design for anchorage and bracing of components which are exempt in accordance with Section 1.04B.
- e. For components required to be certified as seismically qualified in accordance with paragraph 1.06.A.1.f below, submit installation guidelines provided by the equipment manufacturer for proper seismic mounting of the equipment.
- f. Seismic qualification testing shall be based on ASCE 7 and on a nationally recognized testing standard procedure such as ICC-ES AC 156.

1.07 DESIGN REQUIREMENTS

- A. Mechanical fasteners used to secure nonstructural components shall meet the requirements of Section 05 05 23 – Metal Fastening. Post-installed concrete anchors shall be prequalified for use in seismic applications.
- B. No reaction loads (either vertical or lateral) from nonstructural component anchorage and bracing shall be allowed on any element where design has been delegated unless the additional loads on the element have been coordinated with the delegated designer and the submittal is accompanied by a sealed letter from the delegated designer indicating the element has been designed to support the reaction loads.
- C. Reaction loads from nonstructural component anchorage and bracing shall be transferred directly to the primary structural members (girders, beams, etc.), with no components supported from secondary members (purlins, bracing, etc.) unless otherwise approved.
- D. No holes shall be drilled into any structural steel for attachment of component supports without prior approval of the Engineer.
- E. Attachments of nonstructural component anchorage and bracing that cause overstressing of any structural element shall not be permitted.
- F. Seismic Requirements
 - 1. Seismic anchorage and bracing for nonstructural components shall be subject to the current local Building Code in conjunction with the seismic provisions of the International Building Code (IBC) Section 1613 and referenced ASCE 7 Chapter 13.
 - 2. Where the weight of a nonstructural component is greater than or equal to 25 percent of the effective seismic weight (as defined by ASCE 7) of the structure it is

attached to, the component shall be classified as a nonbuilding structure for purposes of seismic design. Seismic design for nonbuilding structures shall comply with Building Code requirements in conjunction with the provisions of ASCE 7 Chapter 15.

3. Nonstructural components shall be assigned to the same Seismic Design Category as the structure they occupy or to which they are attached. Design of seismic support system and anchorage shall incorporate the site-specific seismic criteria given on the Contract Drawings. Criteria shall include site-specific spectral response coefficients, Site Class, Seismic Design Category, and Risk Category.
4. Component Importance Factor I_p shall be 1.5 for all essential nonstructural components noted in item 1.03.E above. All other nonstructural components shall utilize $I_p = 1.0$ unless noted otherwise.
5. Components shall be anchored and braced for earthquake forces both in the vertical and each orthogonal direction. Seismic anchorage and bracing shall limit deflections of components per ASCE 7, and the displacements shall not impede component functionally and containment.
6. Anchorage design shall account for disparate seismic response behavior of supporting structures. Seismic supports or bracing shall not cross structural expansion joints. Nonstructural components shall not be attached to multiple structural elements which may respond differently during a seismic event without provisions to accommodate independent movement. Flexible expansion loops or offsets, flexible joints, bellows type pipe expansion joints, couplings, etc. shall be provided at structure expansion joints to allow for independent structure movement and thermal movement of piping, ductwork, and conduit. Minimum movement capability in the vertical and each orthogonal direction shall equal the width of the joint.
7. Provide flexible connections, piping, conduit, etc. at foundation levels where below grade utilities enter the structure.
8. Design of support system for components with multiple attachments shall consider the stiffness and ductility of the supporting members. Equipment designed as free-standing shall only be attached at its base. Use of non-free-standing equipment requiring both vertical and lateral attachment is contingent upon loads applied to the structure and requires approval by the Engineer.
9. The seismic anchorage and bracing design shall be based on actual equipment data (dimensions, weight, center of gravity, etc.) obtained from the specifications or the approved equipment manufacturer. The equipment manufacturer shall verify the attachment points on the equipment can safely withstand the combination of seismic, self-weight and other loads imposed.

PART 2 – PRODUCTS

2.01 MATERIALS

- A. Anchorage and bracing of nonstructural components shall be constructed of appropriate materials and connecting hardware to provide a continuous load path between the component and supporting structure of sufficient strength and stiffness to resist the calculated design seismic forces and displacements.
- B. Component anchorage, bracing and connection materials shall be compatible with and in general match the component and component gravity support materials. Contact between dissimilar metals shall be prevented.

PART 3 – EXECUTION

3.01 INSTALLATION OF ANCHORAGE AND BRACING

- A. No anchorage and bracing of nonstructural components shall be installed prior to review and acceptance by the Engineer and permitting agency.
- B. Equipment shall be installed per the manufacturer's recommendations. Fasteners shall meet manufacturer's requirements.
- C. Following installation, all anchorage and bracing and seismically qualified equipment shall be inspected. See Section 01 45 33 – Special Inspections for requirements.

END OF SECTION

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SECTION 01 74 00
CLEANING AND WASTE MANAGEMENT

PART 1 – GENERAL

1.01 SUMMARY

- A. Administrative and procedural requirements for progress and closeout cleaning at the Site.
 - 1. Contractor shall execute cleaning during the Project, at completion of the Work, and as required by the General Conditions and this Section.
 - 2. Maintain in a clean manner the Site, the Work, and areas adjacent to or affected by the Work.
- B. Administrative and procedural requirements for disposing of non-hazardous excavation and construction waste.
 - 1. Contractor shall comply with the requirements and procedures for construction waste management and disposal, including developing and implementing a plan for construction waste management and disposal.
 - 2. Extent of required construction waste management and disposal includes within the Project limits, as shown or indicated.

1.02 REFERENCES

- A. Definitions:
 - 1. "Waste Management Coordinator" is the person responsible for implementing, monitoring, and reporting the status of the Waste Management Plan. Although available for other assignments, the Waste Management Coordinator shall be present at the Site full time for the duration of the Work.
 - 2. "Construction waste" is building and site improvement materials and other solid waste resulting from construction, remodeling, renovation, or repair operations. Construction waste includes packaging.
 - 3. "Demolition waste" is building and site improvement materials resulting from demolition or selective demolition operations.
 - 4. "Disposal" is removal to an off-Site location of demolition and construction waste and subsequent sale, recycling, reuse, or disposal in a landfill or incinerator

conforming to Laws and Regulations and acceptable to authorities having jurisdiction.

- B. Reference Standards: NFPA 241, Safeguarding Construction, Alteration, and Demolition Operations

1.03 ADMINSTRATIVE REQUIREMENTS

- A. Waste Management Plan:

1. General: Develop preliminary plan consisting of waste identification. Indicate quantities by weight or volume. Use the same units of measure throughout waste management plan.
2. Waste Identification: Indicate anticipated types and quantities of excavation waste generated by the Work.
3. Waste Reduction Work Plan: List each type of waste and whether waste will be disposed of in landfill or incinerator. Include points of waste generation, total quantity of each type of waste, quantity for each means of recovery, and handling and transportation procedures.
 - a. Salvaged Materials for Reuse: For materials that will be salvaged and reused in the Work, describe methods for preparing salvaged materials before incorporating them into the Work.
 - b. Disposed Materials: Provide information on how and where materials will be disposed. Include name, address, and telephone number of each landfill and incinerator facility that will be used.
 - c. Handling and Transportation Procedures: Provide information on the method(s) that will be used for separating recyclable waste including sizes of containers, container labeling, and designated location at the Site where materials separation will be located.

- B. Failure of Contractor to Maintain Clean Site and Waste Management Plan:

1. Owner will provide written notification to Contractor for failure to maintain a clean Site and waste management plan.
2. Written notification shall provide five (5) days for Contractor to remedy Site cleaning and waste management to the Engineer's and Owner's satisfaction.
3. Following the five (5) day remedy period, Owner shall without prejudice to any other rights provide services to clean Site to the satisfaction of Owner and

Engineer. Contractor shall be responsible for reimbursement of Owner's costs and expenses for the cleaning work.

1.04 SUBMITTALS

A. Action/Informational Submittals:

1. Preliminary Waste Management Plan: Prepare in accordance with this Section and submit within 14 days of the Notice to Proceed and prior to removing waste from the Site.
2. Final Waste Management Plan: Submit within 14 days of receiving Engineer's comments on the preliminary waste management plan.

B. Closeout Submittals:

1. Landfill and Incinerator Disposal Records: Provide copy of receipt and acceptance of waste by landfills and incinerator facilities licensed to accept them. Submit manifests, weight tickets, receipts, and invoices.

1.05 DELIVERY, STORAGE AND HANDLING

- A. Replace loaded containers with empty containers as demand requires.
- B. Deposit recyclable materials in containers free from debris.
- C. Transport and deposit waste in containers to minimize dust. Close container covers immediately after materials are deposited.

PART 2 – PRODUCTS (NOT USED)

PART 3 – EXECUTION

3.01 PROGRESS CLEANING

- A. General: Clean the Site, work areas, and other areas occupied by Contractor at least weekly. Dispose of materials in accordance with the General Conditions and the following:
1. Comply with NFPA 241 for removing combustible waste materials and debris.
 2. Do not hold non-combustible materials at the Site more than three days if the temperature is expected to rise above 80 degrees F. When temperature is less than 80 degrees F, dispose of non-combustible materials within seven days of their generation.

3. Provide suitable containers for storage of waste materials and debris.
4. Containerize hazardous and unsanitary waste materials separately from other waste. Mark containers appropriately.

B. Work Areas:

1. Clean areas where the Work is in progress to level of cleanliness necessary for proper execution of the Work.
2. Remove liquid spills promptly and immediately report spills to Owner, Engineer, and authorities having jurisdiction.
3. Where dust would impair proper execution of the Work, broom-clean or vacuum entire work area, as appropriate.
4. Concealed Spaces: Remove debris from concealed spaces before enclosing the space.

C. Installed Work: Keep installed Work clean. Clean installed surfaces according to written instructions of manufacturer or fabricator of material or equipment installed, using only cleaning agents and methods specifically recommended by material or equipment manufacturer. If manufacturer does not recommend specific cleaning agents or methods, use cleaning agents and methods that are not hazardous to health and property and that will not damage exposed surfaces.

D. Exposed Surfaces: Clean exposed surfaces and protect as necessary to ensure freedom from damage and deterioration until Substantial Completion.

E. Cutting and Patching:

1. Clean areas and spaces where cutting and patching are performed. Completely remove paint, mortar, oils, putty, and similar materials.
2. Thoroughly clean piping, conduit, and similar features before applying paint or other finishing materials. Restore damaged pipe covering to its original condition.

F. During handling and installation of materials and equipment, clean and protect construction in progress and adjoining materials and equipment already in place. Apply protective covering where required for protection from damage or deterioration, until Substantial Completion.

G. Clean completed construction as frequently as necessary throughout the construction period.

3.02 EXCAVATION WORK NEAR PUBLIC OR PRIVATE PROPERTY

- A. Contractor shall provide cleaning and either temporary or permanent restoration where Work is located in or near streets, right of ways, easements, or private property.
- B. Contractor shall backfill, compact, grade, and restore excavation or disturbed area to functional condition to permit pedestrian or vehicular traffic and original use of the area as the Work progresses.
- C. Temporary storage of excavation spoils, including earth, stones, boulders, and debris, shall be removed from the Site or area of disturbance.

3.03 CLOSEOUT CLEANING

- A. Complete the following prior to requesting inspection for Substantial Completion:
 - 1. Clean and remove from the Site rubbish, waste material, debris, and other foreign substances.
 - 2. Sweep paved areas broom-clean. Remove petrochemical spills, stains, and other foreign deposits.
 - 3. Hose-clean sidewalks and loading areas.
 - 4. Rake grounds that are neither planted nor paved to a smooth, even-textured surface.
 - 5. Repair pavement, roads, sod, and other areas affected by construction operations and restore to specified condition; if condition is not specified, restore to pre-construction condition.
 - 6. Clean exposed exterior and interior hard-surfaced finishes to dirt-free condition, free of spatter, grease, stains, fingerprints, films, and similar foreign substances.
 - 7. Leave the Site clean, and in neat, orderly condition, satisfactory to Owner and Engineer.

3.04 WASTE MANAGEMENT IMPLEMENTATION

- A. General: Implement the waste management plan approved by Engineer. Provide handling, containers, storage, signage, transportation, and other items required to implement the waste management plan during the Project.
- B. Training: Train all installers, Subcontractors, and Suppliers as required on proper waste management procedures required for the Work.

1. Distribute the waste management plan as required within three days of Engineer's approval.
 2. Distribute the waste management plan to Contractor's personnel, Subcontractors, and Suppliers prior to these entities starting the Work. Review with installers, Subcontractors, and Suppliers the waste management plan's procedures and locations established for salvage, recycling, and disposal.
- C. Site Access and Temporary Controls: Conduct waste management operations to ensure minimum interference with roads, streets, walks, walkways, and other adjacent facilities. Designate and label specific areas of the Site necessary for separating materials to be disposed.

3.05 WASTE DISPOSAL

- A. General: Except for items or materials to be recycled, or otherwise reused, remove waste materials from the Site and properly dispose of waste in facility such as permitted landfill or incinerator or other method acceptable to authorities having jurisdiction.
1. Except as otherwise specified, remove from the Site all waste and debris from the Work as it accumulates. Upon completion of the Work, remove materials, equipment, waste, and debris and leave the Site clean, neat, and orderly. Comply with the Contract Documents regarding cleaning and removal of trash, debris, and waste.
 2. Remove and transport debris in a manner that will prevent spillage on adjacent surfaces and areas.
 3. Properly dispose of waste materials, surplus materials, debris, and rubbish off the Site.
 4. Do not discharge volatile or hazardous substances, such as mineral spirits, oil, or paint thinner, into storm sewers or sanitary sewers.
 5. Do not discharge wastes into surface waters or drainage routes.
- B. Burying: Do not bury rubbish and waste materials at the Site.
- C. Burning: Do not burn waste materials at the Site.
- D. Disposal: Transport waste materials to proper location at site other than Owner's property for disposal in accordance with Laws and Regulations. Contractor shall be solely responsible for complying with Laws and Regulations regarding storing, transporting, and disposing of waste.

END OF SECTION

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SECTION 01 75 00
CHECKOUT AND STARTUP PROCEDURES

PART 1 – GENERAL

1.01 SUMMARY

- A. Section Includes:
 - 1. Checkout of products and equipment.
 - 2. Startup procedures of products and equipment
- B. Contractor shall initially start up and place equipment installed under the Contract into successful operation, in accordance with the equipment manufacturer's written instructions and as instructed by Supplier at the Site.
- C. Provide all material, labor, tools, and equipment required to complete equipment checkout and start-up.
- D. Provide chemicals, lubricants, and other required operating fluids.
- E. General activities include:
 - 1. Cleaning, as required under other provisions of the Contract Documents.
 - 2. Removing temporary protective coatings.
 - 3. Checking and correcting (if necessary) leveling plates, grout, bearing plates, anchorage devices, fasteners, and alignment of piping, conduits, and ducts that may place stress on the connected equipment.
 - 4. All adjustments required.

1.02 ADMINISTRATIVE REQUIREMENTS

- A. Definitions:
 - 1. Displacement, as used herein, shall mean total peak-to-peak movement of vibrating equipment, in mils; velocity or speed of the vibration cycle, measured in distance per time, velocity and acceleration of the vibration cycle. Displacement, velocity and acceleration shall be measured by instruments/equipment equal to IRD Mechanalysis, Bentley, Nevada.
- B. Coordination:

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1. Coordinate checkout and start-up with other contractors performing Work at the Site.
2. Do not start up system or subsystem for continuous operation until all components of that system or subsystem, including instrumentation and controls, have been tested to the extent practicable and proven to be operable as intended by the Contract Documents.
3. Responsibility for proper operation is by Contractor.
4. Supplier shall be present during checkout, start-up, and initial operation, except as otherwise specified.
5. Do not start up system, unit process, or equipment without submitting acceptable preliminary operations and maintenance manuals by Contractor, in accordance with Section 01 78 23 – Operations and Maintenance Data.

C. Contractor's Requirements Prior to Owner's Responsibility:

1. Owner will assume responsibility for the equipment upon Substantial Completion.
2. Prior to turning over to Owner responsibility for operating and maintaining system or equipment shall be in accordance with this Section and the following requirements:
 - a. Submit acceptable final operations and maintenance manuals in accordance with Section 01 78 23 – Operations and Maintenance Data.
 - b. Provide training of operations and maintenance personnel in accordance with Section 01 79 00 – Instruction of Owner's Personnel.
 - c. Complete system field quality control testing in accordance with the Contract Documents including, but not limited to, the following:
 - 1) Start-up certification shall be performed and completed by the equipment Supplier for the equipment and material prior to be placed into intended use by Owner as specified in the Contract Documents.
 - 2) Equipment and material shall be operated for a minimum 30-day operational period to verify performance. In addition to specific requirements specified in the individual specification sections, process data that is recorded in the PLC shall be submitted to the Engineer in tabular format showing hourly process performance data. A log of all alarms shall also be submitted, along with notes describing corrective measures applied in response to alarm condition.

- 3) If equipment and material does not perform satisfactorily during the 30-day operational period, then the warranty period start shall be delayed until satisfactory performance is verified.
 - a) Contractor shall repair or replace equipment and material that does not perform satisfactorily at no cost to Owner.
 - b) Contractor shall furnish all equipment and material, labor, and incidentals necessary to provide equipment and material to the performance level required by the Contract Documents.
- d. Obtain from Engineer final certificate of Substantial Completion for either entire Work or the portion being turned over to Owner.

1.03 SUBMITTALS

- A. Startup Schedule: Detailed summary of schedule, duration, manpower requirement, and Contractor's means and methods for startup.
- B. Vibration testing results
- C. Closeout Submittals: Manufacturer's certification of installation in accordance with this Section.
- D. Startup testing and operational demonstration performance data.

PART 2 – PRODUCTS (NOT USED)

PART 3 – EXECUTION

3.01 PRELIMINARY REQUIREMENTS

- A. Prior to the start-up of the facilities, Contractor shall have prepared and tested all equipment, subsystems and systems in accordance with the requirements of the individual Specification Section to check its ability for sustained operation, including inspections and adjustments by Manufacturer's representative.
- B. Contractor shall develop and submit schedule in accordance with this Section.
- C. After the facilities are sufficiently complete to permit start-up, Contractor shall furnish competent personnel to start-up the facilities. Contractor will be responsible for startup of all facilities constructed under this Contract. During the initial start-up period the Contractor shall check and provide for mechanical operation in accordance with the Contract Documents.

3.02 FIELD QUALITY CONTROL

A. Manufacturers' Field Services:

1. When specified, furnish services of factory trained representatives of material and equipment manufacturers as specified, including supervising installation, adjusting, checkout, start-up, and testing of materials and equipment.
2. Certification:
 - a. When services by manufacturer are required at the Site, within 14 days after first test operation of equipment, submit to Engineer a letter from manufacturer, on manufacturer's letterhead, stating that materials and equipment are installed in accordance with manufacturer's requirements and installation instructions, and in accordance with the Contract Documents.
 - b. Include in the final operations and maintenance manual for the associated equipment a copy of the letter or completed form, as applicable.
3. Manufacturer shall bring any discrepancies to the immediate attention of the Contractor for correction. Contractor shall promptly correct any discrepancies noted by the Manufacturer. Manufacturer shall coordinate correction of discrepancies with the Contractor. Discrepancies and their correction shall be noted in inspection records and in all required reports. Any corrections that result in changes to the work as shown on the Contract Documents shall be approved by the Engineer prior to their execution.

3.03 VIBRATION TESTING

- A. Stationary rotating equipment, products and materials shall have vibration testing performed at the Site with a rated horsepower exceeding 40 horsepower.
- B. Vibration testing shall be performed by an experienced factory-trained and authorized third-party analysis expert shall be provided for and paid for by the Contractor. Each unit or pump system shall be tested separately without duplicate equipment running. All field testing shall be done in the presence of the Engineer. The Engineer shall be furnished with seven (7) certified copies of vibration test data for each test performed.
- C. General testing requirements:
 1. Variable speed drives – Tests shall be conducted at the full range of speeds between maximum and minimum.
 2. Two-speed drives – Tests shall be conducted at both speeds.

3. Constant-speed drives – Tests shall be conducted under various loading conditions as determined by the Engineer.
4. Frequency of vibration, in frequency (i.e. Hz, cycles per second) and cycles per minute (cpm), shall be determined when vibration exceeds specified levels or as otherwise necessary. Vibration shall be measured on the bearing housing and the motor, unless other additional locations are deemed necessary by the Engineer and/or specified, the vibration analyst and/or published industry standards.
5. Vibration shall be checked in the radial and axial directions. Vibration shall be limited to the latest version of the following published standards: ISO; Hydraulic Institute (HI).
 - a. Unless otherwise specified elsewhere, axial vibration shall not exceed 0.1 in/sec; and radial vibration shall not exceed 0.2 in/sec. For pumps radial vibration shall not exceed that permitted by the Hydraulic Institute Standards except that, at vibration frequencies in excess of 8,000 cpm, the velocity shall not exceed 0.2 in/sec.
6. Noise or vibration in any rotating equipment which the Engineer judges to be excessive or damaging, shall be cause for rejection.

D. Test results:

1. Contractor shall correct deficiencies within thirty days when vibration field test results exceed source quality control tests results, Manufacturer's recommendations, or the limits specified in the Contract Documents.
2. After corrections have been completed, the vibration testing shall be re-run at the Contractor's expense and the results re-submitted to the Engineer for review.

3.04 SYSTEM START-UP

- A. Equipment and materials shall be provided in conformance with the manufacturer's installation instructions and in accordance with the Contract Documents.
- B. Provide start-up services as specified in the individual Specification Sections.
- C. Contractor shall furnish consumables required for startup including, but not limited to, electricity, water, chemicals and lubrication. Contractor shall provide a plan for disposal of water used for testing unless otherwise specified in the Contract Documents.
- D. General system requirements:
 1. Start-up of the plant by Contractor shall include all mechanical systems, including but not limited to, pumps, compressors, and like equipment, and the ventilating, air

conditioning (or heating), plumbing, and electrical systems. Start-up of either the heating or air conditioning systems is dependent upon the time of year that the plant start up is initiated. Contractor will be required to return at the beginning of the next heating or air conditioning season (whichever is applicable) to start the appropriate system.

2. Cleaning as required under provisions of the Contract Documents.
3. Remove temporary protective coatings.
4. Flushing and replacing greases and lubricants as required by Manufacturer
5. Lubrication.
6. Verify the following:
 - a. Shaft and coupling alignments and reset where needed.
 - b. Set motor, pump and other equipment rotation, safety interlocks, and belt tensions.
 - c. Leveling plates, grout, bearing plates, anchor bolts, fasteners, and alignment of piping, conduits and ducts that may apply stress on equipment.
7. Valves:
 - a. Tighten packing glands to ensure no leakage but allow valve stems to operate without galling.
 - b. Replace packing in valves to retain maximum adjustment after system is determined to be complete.
 - c. Replace packing on valves that continue to leak.
 - d. Remove and repair bonnets that leak.
 - e. After cleaning, coat packing gland threads and valve stems with surface preparation of "Molycote" or "Fel-Pro".
8. Verify that control valve seats are free of foreign matter and are properly positioned for intended service.
9. Tighten flanges and other pipe joints after system has been placed in operation.
10. Replace gaskets that show signs of leakage after tightening.
11. Inspect all joints for leakage:

- a. Promptly remake each joint that appears to be faulty; do not wait for rust other corrosion to form.
 - b. Clean threads on both parts and apply compound and remake joints.
- 12. After system has been placed in operation, clean valve seats and headers in fluid system to ensure freedom from foreign matter.
- 13. Remove rust, scale, and foreign matter from equipment and renew defaced surfaces.
- 14. Repair damaged insulation.

END OF SECTION

SECTION 01 77 19
CLOSEOUT REQUIREMENTS

PART 1 – GENERAL

1.01 SUMMARY

- A. Section Includes:
1. Substantial Completion.
 2. Final inspection.
 3. Request for final payment.

1.02 REFERENCES

- A. Definitions:
1. Substantial completion procedures for requesting and documenting are in the General Conditions, as modified by Supplemental Conditions.
 2. Final inspection procedures for requesting and documenting are in the General Conditions, as modified by Supplemental Conditions.

1.03 ADMINISTRATIVE REQUIREMENTS

- A. Request for Final Payment:
1. Procedure: Submit request for final payment in accordance with the Agreement and General Conditions, as may be modified by the Supplementary Conditions.
- B. Request for final payment shall include:
1. Documents required for progress payments in Section 01 29 76 – Progress Payment Procedures.
 2. Documents required in the General Conditions, as may be modified by the Supplementary Conditions.
 3. Releases or Waivers of Lien Rights:
 - a. Provide a final release or waiver by Contractor and each Subcontractor and Supplier that provided Contractor with labor, material, or equipment totaling \$10,000 or more.

- b. Provide list of Subcontractors and Suppliers for which release or waiver of Lien is required.
 - c. Each release or waiver of Lien shall be signed by an authorized representative of the entity submitting release or waiver to Contractor, and shall include Subcontractor's or Supplier's corporate seal, when applicable.
 - d. Release or waiver of Lien may be conditional upon receipt of final payment.
 - e. Manufacturer's Affidavit of Release of Liens – furnish a separate, completed form from the manufacturer.
4. Consent of Surety Company to Final Payment.

PART 2 – PRODUCTS (NOT USED)

PART 3 – EXECUTION (NOT USED)

END OF SECTION

SECTION 01 78 23
OPERATION AND MAINTENANCE DATA

PART 1 – GENERAL

1.01 SUMMARY

- A. Section Includes: Requirements for operation and maintenance data, manuals, and documentation.
1. Submit operation and maintenance data, in accordance with this Section and in accordance with requirements elsewhere in the Contract Documents, as instructional and reference manuals by operations and maintenance personnel at the Site.
 2. Required operation and maintenance data groupings are listed in this Section. At minimum, submit operation and maintenance data for:
 - a. All equipment and systems
 - b. Valves, gates, actuators, and related accessories
 - c. Instrumentation and control devices
 - d. Electrical gear
 3. For each operation and maintenance manual, submit the following:
 - a. Preliminary Submittal: Printed and bound copy of entire operation and maintenance manual or electronic copy, except for test data and service reports by Supplier.
 - b. Final Submittal: Printed and bound copy of complete operations and maintenance manual and electronic copy, including test data and service reports by Supplier.

1.02 ADMINISTRATIVE REQUIREMENTS

- A. Quantity Required and Timing of Submittals:
1. Preliminary Submittal:
 - a. Electronic Copies: One electronic copy, PDF format. Shall be bookmarked.
 - b. Submit to Engineer, whichever occurs first:

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- 1) 60 days prior to starting training of operations and maintenance personnel.
 - 2) 30 days prior to field quality control testing at the Site.
- c. Furnish preliminary operation and maintenance data submittal in acceptable form and content, as determined by Engineer, before associated materials and equipment will be eligible for payment.
2. Preliminary Submittal shall be reviewed by Engineer. One printed or electronic copy shall be returned to Contractor with required revisions noted.
3. Final Submittal: Provide 14 days prior to checkout and startup procedures specified in Section 01 75 00 – Checkout and Startup Procedures, unless Submittal is specified as required prior to an interim Milestone.
 - a. Printed Copies: Two copies.
 - b. Electronic Copies: One copy, PDF format, bookmarked.

B. Format of Printed Copies:

1. Binding and Cover:
 - a. Bind each operation and maintenance manual in durable, permanent, stiff-cover binder(s), comprising one or more volumes per copy as required. Binders shall be minimum one-inch wide and maximum of three-inch wide. Binders for each copy of each volume shall be identical.
 - b. Provide the following information on cover of each volume:
 - 1) Title: "OPERATING AND MAINTENANCE INSTRUCTIONS".
 - 2) Name or type of material or equipment covered in the manual.
 - 3) Volume number, if more than one volume is required, listed as "Volume ___ of ___", with appropriate volume-designating numbers filled in.
 - 4) Name of Project and, if applicable, Contract name and number.
 - 5) Name of building or structure, as applicable.
 - c. Provide the following information on spine of each volume:
 - 1) Title: "OPERATING AND MAINTENANCE INSTRUCTIONS".
 - 2) Name or type of material or equipment covered in the manual.

- 3) Volume number, if more than one volume is required, listed as "Volume ___ of ___", with appropriate volume-designating numbers filled in.
- 4) Project name and building or structure name.

2. Drawings:

- a. Bind into the manual drawings, diagrams, and illustrations up to and including 11 inches by 17 inches in size, with reinforcing.
- b. Documents larger than 11 inches by 17 inches shall be folded and inserted into clear plastic pockets bound into the manual. Mark pockets with printed text indicating content and drawing numbers. Include no more than three drawing sheets per pocket.

3. Copy Quality and Document Clarity:

- a. Contents shall be original-quality copies. Documents in the manual shall be either original manufacturer-printed documents or first-generation photocopies indistinguishable from originals. If original is in color, copies shall be in color.
- b. Clearly mark in ink to indicate all components of materials and equipment on catalog pages for ease of identification. In standard or pre-printed documents, indicate options furnished or cross out inapplicable content.

4. Organization:

- a. Provide table of contents in each volume for each chapter or section.
- b. Use dividers and indexed tabs between major categories of information, such as operating instructions, preventive maintenance instructions, and other major subdivisions of data in each manual.

C. Format of Electronic Copies:

1. Each electronic copy shall include all information included in the corresponding printed copy.
2. Submit electronic copy via transferable method and format acceptable to Engineer.
3. File Format:
 - a. Acceptable formats include Adobe PDF, Microsoft Word, Autodesk DWF, and AutoCAD.
 - b. Files shall be electronically searchable.

- c. Submit separate file for each separate document in the printed copy.
- d. Within each file, provide bookmarks for the following:
 - 1) Each chapter and subsection listed in the corresponding printed copy document's table of contents
 - 2) Each figure
 - 3) Each table
 - 4) Each appendix
- 4. Submit drawings and figures in one of the following formats: ".bmp", ".tif", ".jpg", ".gif", ".dwf", or ".dwg".

D. General Content Requirements:

- 1. Prepare each operations and maintenance manual specifically for the Project. Include in each manual all pertinent instructions, as-built drawings as applicable, bills of materials, technical bulletins, installation and handling requirements, maintenance and repair instructions, and other information required for complete, accurate, and comprehensive data for safe and proper operation, maintenance, and repair of materials and equipment furnished for the Project. Include in manuals specific information required in the Specification Section for the material or equipment, data required by Laws and Regulations, and data required by authorities having jurisdiction.
- 2. Submit complete, detailed written operating instructions for each material or equipment item including: function; operating characteristics; limiting conditions; operating instructions for start-up, normal and emergency conditions; regulation and control; operational troubleshooting; and shutdown. Also include, as applicable, written descriptions of alarms generated by equipment and proper responses to such alarm conditions.
- 3. Submit written explanations of all safety considerations relating to operation and maintenance procedures.
- 4. Submit complete, detailed, written preventive maintenance instructions including all information and instructions to keep materials, equipment, and systems properly lubricated, adjusted, and maintained so that materials, equipment, and systems function economically throughout their expected service life. Instructions shall include:
 - a. Written explanations with illustrations for each preventive maintenance task such as inspection, adjustment, lubrication, calibration, and cleaning. Include pre-startup checklists for each equipment item and maintenance requirements for long-term shutdowns.

- b. Recommended schedule for each preventive maintenance task.
 - c. Lubrication charts indicating recommended types of lubricants, frequency of application or change, and where each lubricant is to be used or applied.
 - d. Table of alternative lubricants.
 - e. Troubleshooting instructions.
 - f. List of required maintenance tools and equipment.
5. Submit complete bills of material or parts lists for materials and equipment furnished. Lists or bills of material may be furnished on a per-drawing or per-equipment assembly basis. Bills of material shall indicate:
- a. Manufacturer's name, address, telephone number, fax number, and Internet website address.
 - b. Manufacturer's local service representative's or local parts supplier's name, address, telephone number, fax number, Internet website address, and e-mail addresses, when applicable.
 - c. Manufacturer's shop order and serial number(s) for materials, equipment or assembly furnished.
 - d. For each part or piece include the following information:
 - 1) Parts cross-reference number. Cross-reference number shall be used to identify the part on assembly drawings, Shop Drawings, or other type of graphic illustration where the part is clearly shown or indicated.
 - 2) Part name or description.
 - 3) Manufacturer's part number.
 - 4) Quantity of each part used in each assembly.
 - 5) Current unit price of the part at the time the operations and maintenance manual is submitted. Price list shall be dated.
6. Submit complete instructions for ordering replaceable parts, including reference numbers (such as shop order number or serial number).
7. Submit manufacturer's recommended inventory levels for spare parts, extra stock materials, and consumable supplies for the initial two years of operation. Consumable supplies are items consumed or worn by operation of materials or equipment, and items used in maintaining the operation of material or equipment, including items such as lubricants, seals, reagents, and testing chemicals used for

calibrating or operating the equipment. Include estimated delivery times, shelf life limitations, and special storage requirements.

8. Submit manufacturer's installation and operation bulletins, diagrams, schematics, and equipment cutaways. Where materials pertain to multiple models or types, mark the literature to indicate specific material or equipment supplied. Marking may be in the form of checking, arrows, or underlining to indicate pertinent information, or by crossing out or other means of obliterating information that does not apply to the materials and equipment furnished.
9. Submit original-quality copies of each approved and accepted Shop Drawing, product data, and other submittal, updated to indicate as-installed condition. Reduced drawings are acceptable only if reduction is to not less than one-half original size and all lines, dimensions, lettering, and text are completely legible on the reduction.
10. Submit complete electrical schematics and wiring diagrams, including complete point-to-point wiring and wiring numbers or colors between all terminal points.
11. Submit copy of warranty bond and service contract as applicable.
12. When copyrighted material is used in operations and maintenance manuals, obtain copyright holder's written permission to use such material in the operation and maintenance manual.
13. Submit all manufacturer's field startup reports, signed by the manufacturer's installer certifying proper installation.

1.03 SUBMITTALS

- A. Action/Informational Submittals: Submit preliminary schedule (listing) of operations and maintenance data for Engineer's review. Preliminary operations and maintenance data shall be grouped as major equipment and material systems and divided into sub-systems as required for clarity, subject to Engineer's approval.
- B. Closeout Submittals:
 1. Operation and maintenance data: Submit the operations and maintenance data indicated in the Contract Documents, grouped into submittals as approved by Engineer.

PART 2 – PRODUCTS (NOT USED)

PART 3 – EXECUTION (NOT USED)

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SECTION 01 78 39
PROJECT RECORD DOCUMENTS

PART 1 – GENERAL

1.01 SUMMARY

- A. Section Includes:
 - 1. Requirements for recording changes to record documents.
 - 2. Requirements for electronic files furnished by Engineer.
- B. Contractor shall maintain and submit to Engineer with record documents in accordance with the Specifications, General Conditions, and Supplementary Conditions.

1.02 ADMINISTRATIVE REQUIREMENTS

- A. Maintenance of Record Documents:
 - 1. The following record documents shall be maintained in the Contractor's field office:
 - a. Drawings, Specifications, and Addenda.
 - b. Shop Drawings, Samples, and other Contractor submittals, including records of test results, approved or accepted as applicable, by Engineer.
 - c. Change Orders, Work Change Directives, Field Orders, photographic documentation, survey data, and all other documents pertinent to the Work.
 - 2. Update record documents on a monthly basis, minimum.
 - 3. Provide files and racks for proper storage and easy access to record documents.
 - 4. Make record documents available for inspection upon request of Engineer or Owner.
 - 5. Do not use record documents for purpose other than serving as Project record. Do not remove record documents from Contractor's field office without Engineer's approval.
- B. Submittal of Record Documents:
 - 1. Submit to Engineer the following record documents: Drawings.

2. Prior to readiness for final payment, submit to Engineer one copy of final record documents. Submit complete record documents; do not make partial submittals.
3. Submit record documents with transmittal letter on contractor letterhead complying with letter of transmittal requirements in Section 01 33 00 – Submittal Procedures.
4. Record documents submittal shall include certification, with original signature of official authorized to execute legal agreements on behalf of Contractor.

C. Electronic Files Furnished by Engineer:

1. CADD files will be furnished by Engineer upon the following conditions:
 - a. Contractor shall submit to Engineer a letter on Contractor letterhead requesting CADD files and providing specific definition(s) or description(s) of how files will be used, and specific description of benefits to Owner (including credit proposal, if applicable) if the request is granted.
 - b. Contractor shall execute Engineer's standard agreement for release of electronic files and shall abide by all provisions of the agreement for release of electronic files.
 - c. Layering system incorporated in CADD files shall be maintained as transmitted by Engineer. CADD files transmitted by Engineer containing cross-referenced files shall not be bound by Contractor. Drawing cross-references and paths shall be maintained. If Contractor alters layers or cross-reference files, Contractor shall restore all layers and cross-references prior to submitting record documents to Engineer.
 - d. Contractor shall submit record drawings to Engineer in same CADD format that files were furnished to Contractor.

1.03 SUBMITTALS

- A. Closeout Submittals: Provide record documentation as specified in this Section.

PART 2 – PRODUCTS (NOT USED)

PART 3 – EXECUTION

3.01 GENERAL REQUIREMENTS:

- A. At the start of the Project, label each record document to be submitted as, "PROJECT RECORD" using legible, printed letters. Letters on record copy of the Drawings shall be two inches high.

- B. Keep record documents current. Make entries on record documents within two working days of receipt of information required to record the change.
- C. Do not permanently conceal the Work until required information has been recorded.
- D. Accuracy of record documents shall be such that future searches for items shown on the record documents may rely reasonably on information obtained from Engineer-accepted record documents.
- E. Marking of Entries:
 - 1. Use erasable, colored pencils (not ink or indelible pencil) for marking changes, revisions, additions, and deletions to record documents.
 - 2. Clearly describe the change by graphic line and make notations as required. Use straight-edge to mark straight lines. Writing shall be legible and sufficiently dark to allow scanning of record documents into legible electronic files.
 - 3. Date all entries on record documents.
 - 4. Call attention to changes by drawing a “cloud” around the change(s) indicated.
 - 5. Mark initial revisions in red. In the event of overlapping changes, use different colors for subsequent changes.

3.02 RECORDING CHANGES TO DRAWINGS:

- A. Record changes on copy of the Drawings. Submittal of Contractor-originated or -produced drawings as a substitute for recording changes on the Drawings is unacceptable.
- B. Record changes on plans, sections, schematics, and details as required for clarity, making reference dimensions and elevations (to Project datum) for complete record documentation.
- C. Record actual construction including:
 - 1. Depths of various elements of foundation relative to Project datum.
 - 2. Field changes of dimensions, arrangements, and details.
 - 3. Changes made in accordance with Change Orders, Work Change Directives, and Field Orders.
 - 4. Changes in details on the Drawings. Submit additional details prepared by Contractor when required to document changes.

3.03 RECORDING CHANGES FOR SCHEMATIC LAYOUTS:

- A. In some cases, on the Drawings, arrangements of conduits, circuits, piping, ducts, and similar items are shown schematically and are not intended to portray physical layout. For such cases, the final physical arrangement shall be determined by Contractor subject to acceptance by Engineer.
- B. Record on record documents all revisions to schematics on Drawings, including: piping schematics, ducting schematics, process and instrumentation diagrams, control and circuitry diagrams, electrical one-line diagrams, motor control center layouts, and other schematics when included in the Contract. Record actual locations of equipment, lighting fixtures, in-place grounding system, and other pertinent data.
- C. When dimensioned plans and dimensioned sections on the Drawings show the Work schematically, indicate on the record documents, by dimensions accurate to within one inch in the field, centerline location of items of Work such as conduit, piping, ducts, and similar items
 - 1. Clearly identify the Work item by accurate notations such as “cast iron drain”, “rigid electrical conduit”, “copper waterline”, and similar descriptions.
 - 2. Show by symbol or note the vertical location of Work item; for example, “embedded in slab”, “under slab”, “in ceiling plenum”, “exposed”, and similar designations. For piping not embedded, also provide elevation dimension relative to Project datum.
 - 3. Descriptions shall be sufficiently detailed to be related to Specifications.
- D. Engineer may furnish written waiver of requirements relative to schematic layouts shown on plans and sections when, in Engineer’s judgment, dimensioned layouts of Work shown schematically will serve no useful purpose. Do not rely on waiver(s) being issued.

3.04 REQUIREMENTS FOR SUPPLEMENTAL DRAWINGS:

- A. In some cases, drawings produced during construction by Engineer or Contractor supplement the Drawings and shall be included with record documents submitted by Contractor. Supplemental record drawings shall include drawings provided with Change Orders, Work Change Directives, and Field Orders and that cannot be incorporated into the Drawings due to space limitations.
- B. Supplemental drawings provided with record drawings shall be integrated with the Drawings and include necessary cross-references between drawings. Supplemental record drawings shall be on sheets the same size as the Drawings.

- C. When supplemental drawings developed by Contractor using computer-aided drafting/design (CADD) software are to be included in record drawings, submit electronic files for such drawings in AutoCAD (latest version) as part of record drawing submittal.

3.05 RECORDING CHANGES TO SPECIFICATIONS AND ADDENDA:

- A. Mark each Section to record:
 - 1. Manufacturer, trade name, catalog number, and Supplier of each product and item of equipment actually provided.
 - 2. Changes made by Addendum, Change Orders, Work Change Directives, and Field Orders.

END OF SECTION

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SECTION 01 78 43
SPARE PARTS AND EXTRA MATERIAL

PART 1 – GENERAL

1.01 SUMMARY

- A. Contractor shall furnish spare parts data and extra materials for materials and equipment in accordance with the Contract Documents.
- B. Spare Parts and Extra Materials:
 - 1. Provide spare parts, extra stock materials, maintenance supplies, and special tools required for maintenance (“spare parts and extra materials”) for one year of operation (unless otherwise specified in the individual Specification Section).
 - a. Provide Supplier recommended lubricating oil and grease in accordance with this Section and the Contract Documents.
 - 2. Provide list of Supplier recommended spare parts and extra material.
 - a. Include list of four standard lubricants, minimum, that shall be interchangeable for each type of lubricant required in the Contract Documents.
 - b. Include unit prices in current United States funds
 - c. Source(s) of supply for each.
- C. Packaging and Labeling:
 - 1. Furnish spare parts and extra materials in manufacturer’s unopened cartons, boxes, crates, or other original, protective covering suitable for preventing corrosion and deterioration for maximum length of storage normally anticipated by manufacturer.
 - 2. Packaging of spare parts and extra materials shall be clearly marked and identified with name of manufacturer, applicable equipment, part number, part description, and part location in the equipment.
 - 3. Protect and package spare parts and extra materials for maximum shelf life normally anticipated by manufacturer.
- D. Finishes: Spare parts and extra material shall have painting, protective coating, and finishes identical to original installed equipment and material. Where painting, protective

coating, or finishes are not specified, suitable provisions shall be furnished to protect from corrosion.

- E. Special Tools: Contractor shall provide special tools necessary to operate, disassemble, service, repair, and adjust equipment and material in accordance with the manufacturer's operation and maintenance manual. Special tool requirements shall be the same as spare parts and extra material specified in this Section.
- F. Storage Prior to Delivery to Owner: Prior to furnishing spare parts and extra materials to Owner, store spare parts and extra materials in accordance with the Contract Documents and manufacturers' recommendations.
- G. Delivery Time and Eligibility for Payment:
 - 1. Deliver to Owner spare parts and extra materials prior to date of Substantial Completion for equipment or system associated with the spare parts and extra materials. Do not deliver spare parts and extra materials before commencing start-up for associated equipment or system.
 - 2. Spare parts and extra materials are not eligible for payment until delivered to Owner and Contractor's receipt of Owner's countersignature on letter of transmittal.
- H. Procedure for Delivery to Owner:
 - 1. Deliver spare parts and extra materials to Owner's permanent storage rooms at the Site or area(s) at the Site designated by Owner.
 - 2. When spare parts and extra materials are delivered, Engineer and Owner will mutually inventory the spare parts and extra materials delivered to verify compliance with the Contract Documents regarding quantity and part numbers.
 - 3. Additional procedures for delivering spare parts and extra materials to Owner, if required, will be developed by Engineer and complied with by Contractor.
- I. Transfer Documentation:
 - 1. Furnish on Contractor letterhead a letter of transmittal for spare parts and extra materials furnished under each Specification Section. Letter of transmittal shall accompany spare parts and extra materials. Do not furnish letter of transmittal separate from associated spare parts and extra materials.
 - 2. Furnish three original, identical, signed letters of transmittal for each Specification Section. Upon delivery of specified quantities and types of spare parts and extra materials to Owner, designated person from Owner will countersign each original letter of transmittal indicating Owner's receipt of spare parts and extra materials.

- a. Owner will retain one fully signed original.
 - b. Contractor shall submit one fully signed original to Engineer.
 - c. Contractor shall retain one fully signed original for Contractor's file.
3. Letter of transmittal shall include the following:
- a. Information required for letters of transmittal in Section 01 33 00 – Submittal Procedures.
 - b. Transmittal shall list spare parts and extra materials furnished under each Specification Section. List each individual part or product and quantity furnished.
 - c. Provide space for countersignature by Owner as follows: space for signature, space for printed name, and date.
- J. Contractor shall be fully responsible for loss or damage to spare parts and extra materials until spare parts and extra materials are received by Owner.

1.02 SUBMITTALS

- A. Action/Informational Submittals: Individual Specification Sections that require spare parts, extra material, or tools, Contractor shall submit inventory checklist for each individual Specification Section that includes the following information:
- 1. Specification Section number and title.
 - 2. Name of spare parts, extra material, or tools.
 - 3. Manufacturer, part number and description.
 - 4. Quantity specified and furnished.

PART 2 – PRODUCTS (NOT USED)

PART 3 – EXECUTION (NOT USED)

END OF SECTION

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SECTION 01 79 00
INSTRUCTION OF OWNER'S PERSONNEL

PART 1 – GENERAL

1.01 SUMMARY

- A. Contractor shall furnish services of operation and maintenance training specialists to instruct Owner's personnel in recommended operation and maintenance procedures for materials and equipment furnished, in accordance with the Contract Documents.
- B. Contractor shall provide a combination of classroom and field training at the Site, unless otherwise required elsewhere in the Contract Documents.
- C. Owner reserves the right to record training sessions on video for Owner's later use in instructing Owner's personnel.

1.02 ADMINISTRATIVE REQUIREMENTS

- A. Definitions:
 - 1. Training – Manufacturer's verbal, visual, and written presentation of materials to Owner's staff to ensure that any Owner personnel undergoing training understand the Manufacturer's recommended procedures to properly operate and maintain the equipment and systems for the expected service life.
- B. Qualifications:
 - 1. Contractor's instructors shall be factory-trained by Manufacturer of material or equipment.
 - 2. Contractor's instructors shall be proficient and experienced in conducting training of type required.
 - 3. Qualifications of instructors are subject to acceptance by Engineer. If Engineer does not accept qualifications of proposed instructor, furnish services of replacement instructor with acceptable qualifications.
- C. Scheduling:
 - 1. General:
 - a. Contractor shall coordinate training services with start-up and initial operation of materials and equipment on days and times, and in manner, acceptable to Owner, in accordance with the Contract Documents.

- b. Training may be required outside of normal business hours to accommodate schedules of operations and maintenance personnel. Furnish training services at the required days and times at no additional cost to Owner.
 - c. Prerequisites to Training: Training of Owner's personnel shall commence after acceptable preliminary operation and maintenance data has been submitted and work required in Section 01 75 00 – Checkout and Startup Procedures is complete.
- 2. Training Schedule Submittal:
 - a. Training Schedule Required: Contractor shall prepare and submit proposed training schedule for review and acceptance by Engineer and Owner. Proposed training schedule shall show all training required in the Contract Documents, and shall demonstrate compliance with specified training requirements relative to number of hours of training, number of training sessions, and scheduling.
 - b. Timing of Training Schedule Submittal: Submit initial training schedule at least thirty days before scheduled start of first training session. Submit final training schedule, incorporating revisions in accordance with Engineer's comments, no later than seven days prior to starting the first training session.
 - c. Owner reserved the right to modify personnel availability for training in accordance with process or emergency needs at the Site.

D. Video Recording

- 1. Contractor shall provide a training specialist for a minimum of three (3) days, for each item of equipment specified, to meet with the Engineer to prepare training scripts and to participate in video recording of training. Video recorded training sessions shall be conducted separately from training sessions held for the Owner's personnel.
- 2. Manufacturer shall be the ownership rights to one unedited and one edited copy of the video recorded training.
- 3. As an alternative to video recording training at the Site, the Manufacturer may submit pre-recorded digital media covering the equipment supplied for approval. Submitted pre-recorded digital media shall meet the intent of this Section for approval consideration. If approved, Owner shall have the right to permanent ownership and use of at least one complete copy.

1.03 TRAINING REQUIREMENTS

A. General Lesson Plan Requirements:

1. Contractor's lesson plan shall describe specific instruction topics, system components for which training will be furnished, and training procedures. Handouts, if any, to be used in training shall be included with the lesson plan. Describe in lesson plan "hands-on" demonstrations planned for training sessions.
2. Submit acceptable lesson plan 60 days prior to starting associated training.
3. Lesson plan shall include estimated duration of each training segment.

B. Specific Lesson Plans Requirements:

1. Equipment overview shall cover the following:
 - a. Equipment's operating (process) function, performance objectives, and fundamental operating principles.
 - b. Equipment's mechanical, electrical, and electronic components and features. Group related components into subsystems and describe function of subsystem and subsystem's interaction with other subsystems.
 - c. Support equipment and appurtenances.
 - d. Safety and potential hazards.
 - e. Safety and control interlocks.
2. Operations personnel training shall cover the following:
 - a. Equipment overview: As described in this Section.
 - b. Operation:
 - 1) Principles, operating, start-up, and shutdown procedures.
 - 2) Abnormal or emergency start-up, operating, and shutdown procedures.
 - 3) Alarm conditions and responses.
 - 4) Monitoring and recordkeeping.
 - 5) Housekeeping.

- c. Troubleshooting: Required corrective maintenance or an operating parameter adjustment.
- 3. Maintenance personnel training:
 - a. Equipment overview: As described in this Section.
 - b. Equipment preventive maintenance:
 - 1) Inspection procedures:
 - a) Operation.
 - b) Trouble symptoms and anticipate breakdowns.
 - c) Predictive maintenance.
 - 2) Preventative maintenance intervals.
 - 3) Lubricant and replacement parts.
 - 4) Cleaning practices and intervals.
 - 5) Special tools required.
 - 6) Removal, installation, and disassembly and assembly procedures.
 - 7) "Hands-on" demonstrations of preventive maintenance procedures.
 - 8) Measuring instruments and procedures
 - 9) Torquing, mounting, calibrating, and aligning procedures and settings requirements.
 - 10) Check and test equipment following corrective maintenance.
- 4. Equipment Troubleshooting:
 - a. Systematic troubleshooting procedures.
 - b. Checklists.
 - c. Testing and diagnostic procedures.
 - d. Corrective maintenance procedures with "hands on" demonstrations.

C. Training Aids:

1. Contractor's instructor shall incorporate training aids as appropriate to assist in the instruction. Provide handouts of text, tables, graphs, and illustrations as required. Other appropriate training aids include:
 - a. Audio-visual aids
 - b. Equipment cutaways and samples
 - c. Tools, including special tools
2. Podium presentation aids: Presentation shall cover equipment, products and materials provided. Provide electronic version of presentation material to Engineer.
 - a. Electronic version of presentation aids shall be Microsoft PowerPoint or equivalent format.
 - b. Presentation shall include the following sections:
 - 1) Complete system overview including, but not limited to, related and associated equipment specific to the system.
 - 2) Specific equipment requirements and how equipment functions within the overall system.
 - 3) Site specific system and equipment requirements.
 - c. Hardcopy handouts of the electronic presentation aids shall be provided prior to each training section for review during podium presentation.
 - d. As an alternative to the Electronic presentation, Manufacturer may submit, for approval by the Engineer and the Owner, prerecorded DVD(s) or digital media covering the equipment supplied. Approval of such DVD(s) or digital media shall be contingent upon their content meeting the lesson plan requirement of this Section. If prerecorded DVD(s) or digital media are approved by the Engineer and the Owner, the Owner shall have the right to permanent ownership and use.
3. Handouts:
 - a. Contractor's instructor shall distribute and use descriptive handouts during training.
 - b. Handouts should be coordinated with the instruction
 - c. Provide at least ten copies of handouts for each training session

4. Audio-visual Equipment: Training provider shall provide audio-visual equipment required for training sessions.

1.04 SUBMITTALS

A. Action/Informational Submittals:

1. Training Schedule: Detailed schedule of training sessions, demonstrating compliance with number of training sessions, hours required in the Contract Documents, and complying with the Contract Times. Submit training schedule submittals in accordance with timeframes specified in this Section.
2. Lesson Plan: Acceptable lesson plan for training on each material or equipment item, in accordance with the Contract Documents. Lesson plan shall comply with requirements of this Section. Include with lesson plan copy of handouts that will be used during training sessions. Provide lesson plan submittals in accordance with timeframes specified in this Section.
3. Podium presentation material, electronic version.
4. Qualifications: Credentials of Contractor's proposed operations and maintenance instructor(s). Credentials shall demonstrate compliance with requirements of this Section and shall include brief resume and specific details of instructor's operating, maintenance, and training experience relative to the specific material and equipment for which instructor will provide training.

B. Closeout Submittals:

1. Trainee sign-in sheet for each training session. Submit to Owner's training coordinator.

C. Quality Assurance Submittals:

1. Qualifications: Credentials of Contractor's proposed operations and maintenance instructor(s). Credentials shall demonstrate compliance with requirements of this Section and shall include brief resume' and specific details of instructor's operating, maintenance, and training experience relative to the specific material and equipment for which instructor will provide training.

PART 2 – PRODUCTS (NOT USED)

PART 3 – EXECUTION

3.01 “HANDS-ON” DEMONSTRATIONS

- A. Contractor's instructor shall provide “hands-on” demonstration of operations and maintenance of equipment and materials for each training session.
- B. Contractor shall furnish tools and appurtenances required for demonstrations.

3.02 SCHEDULE

- A. Contractor shall furnish the hours of training and number of sessions indicated, at a minimum. Travel time and expenses are the responsibility of the Manufacturer and are excluded from required training time indicated in the Contract Documents.
- B. Owner's operations at the Site occur 24 hours per day, divided into three shifts. Training shall be scheduled during day shift, normal working hours unless otherwise approved by Engineer.
- C. Training shall be provided for a minimum of two identical sessions, unless otherwise specified, with each session scheduled for different weeks.
- D. Training Schedule: refer to individual equipment Specifications.

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SECTION 01 88 16
WATERTIGHTNESS TESTING OF CONCRETE STRUCTURES

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. All concrete work and sealing work around built-in items and penetrations shall be performed as required to ensure that groundwater, surface water, and water or liquids in tanks, channels, and containers will not intrude into any equipment rooms, pipe galleries, habitable areas, or other generally dry areas.
- B. The required watertightness shall be achieved by quality concrete construction and proper sealing of all joints and penetrations.
- C. Each unit shall be tested separately, and the leakage tests shall be made prior to backfilling and before equipment is installed. Testing water shall be from any potable, non-potable, or natural moving source such as a river or stream, but not from any still water source such as a lake or pond, and not from any wastewater source.
- D. All water holding structures shall be tested for leakage by the Contractor. The Contractor shall provide at their own expense all labor, material, temporary bulkheads, pumps, water measuring devices, etc., necessary to perform the required tests.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 01 45 23 – Testing Services Furnished by Contractor
- B. Section 03 30 00 – Cast-in-Place Concrete

1.03 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

- A. ACI 350.1-10 - Specification for Tightness Testing of Environmental Engineering Concrete Structures

1.04 SUBMITTALS

- A. Testing procedures shall be submitted for approval prior to the test.
- B. Testing Report: Prior to placing the structure in service, submit for review and approval a detailed bound report summarizing the watertightness test data, describing the testing procedure, and showing the calculations confirming the test data.

PART 2 – PRODUCTS (NOT USED)

PART 3 – EXECUTION

3.01 TEST PREPARATION

- A. The design capability of the structure to withstand testing shall be verified for the pressures to be applied. Another type of test shall not be substituted for hydrostatic tightness testing without approval of the Engineer.
- B. The structure shall not be tested before all elements of the structure which resist any portion of the retained liquid pressure are in place and the concrete has attained its specified compressive strength.
- C. Unless otherwise specified, coatings shall not be applied until after the hydrostatic tightness testing is complete. Liners that are mechanically locked to the surface during the placement of the concrete shall be installed before the hydrostatic tightness testing. Interior liners shall be visually examined for deficiencies (pinholes, tears, and partially fused splices) and must pass integrity testing. Deficiencies shall be repaired.
- D. Clean the exposed concrete surfaces of the structure, including the floor, of all foreign material and debris. Prior to testing, standing water in or outside of the structure that would interfere with the inspection of the exposed concrete surfaces of the structure shall be removed.
- E. The concrete surfaces and concrete joints shall be thoroughly inspected for potential leakage points. Areas of potential leakage shall be repaired before filling the containment structure with water.
- F. All openings, fittings, and pipe penetrations in the structure shall be inspected at both faces of the concrete, if practical. Defective or cracked concrete shall be repaired prior to testing. All structural penetrations and inlet/outlets shall be securely sealed to prevent the loss of water from the structure during the test. All structural penetrations shall be monitored before and during the test to determine the watertightness of these appurtenances. If the structure will be filled using the inlet/outlet pipe, positive means shall be provided to check that water is not entering or leaving through this pipe once the structure is filled to the test level. Leakage at these inlet/outlets shall be repaired prior to testing. No allowance shall be made in test measurements for uncorrected known points of leakage.
- G. The flow from any underdrain system, if a system is provided, shall be monitored during this same period, and any increase in flow shall be recorded and considered for information as a part of the hydrostatic tightness testing.

- H. The ground water level shall be brought to a level below the top of the base slab and kept at that elevation or at a lower elevation during the test.
- I. No backfill shall be placed against the walls or on the wall footings of the structure to be tested unless otherwise specified.

3.02 PROCEDURE

- A. The initial filling of a new structure should not exceed a rate of 4 ft/hour. Filling shall be continued until the water surface is at the design maximum liquid level, or either 1 in. below any fixed overflow level in covered containment structures or 4 in. in open structures, whichever is lower.
- B. The exterior surfaces of the structure shall be inspected during the period of filling the structure. If any flow of water is observed from the structure exterior surfaces, including joints or cracks, the defect causing the leakage shall be repaired prior to testing.
- C. Watertightness Test - Part 1: Qualitative Criteria
 - 1. The water shall be kept at the test level for at least 3 days prior to Part 2 of the testing.
 - 2. The exterior surfaces of the structure shall be observed in both the early mornings and later afternoons during the 3-day period before Part 2 of the test. If any water is observed on the structure exterior surfaces, including joints, repaired honeycombed areas and cracks, where water droplets can be picked up on a dry hand, the containment structure shall be considered to have failed Part 1 of the test.
 - 3. Wet areas on top of wall footing shall not indicate a failure of Part 1 of the test unless the water can be observed to be flowing.
 - 4. Part 2 of the test may begin prior to completion of repairs for Part 1. However, all defects causing the failure of Part 1 shall be repaired before the structure is accepted. The 3-day period of keeping water at the test level shall be observed again after completion of all repairs and prior to acceptance of structure.
- D. Watertightness Test - Part 2: Quantitative Criteria
 - 1. The test measurements shall not be scheduled when the weather forecast predicts a difference of more than 35°F between the ambient temperature readings at the times of the initial and final level measurements of the water surface. The test shall also not be scheduled when the weather forecast indicates the water surface could be frozen before the test is completed.

2. The vertical distance to the water surface shall be measured to within 1/16 in. from a fixed point on the structure above the water surface. Measurements shall be recorded at 24-hour intervals. Measurements taken at the same time of day will reduce the probability of temperature difference.
3. Measurements shall be taken at two locations, 180° apart, to minimize the possible effect of differential settlement. Measurements shall be taken at the same locations to reduce the probability of measurement differences.
4. The test period shall be at least the theoretical time required to lower the water surface 3/8 in. assuming a loss of water at 0.050% of the water volume per 24-hour period. The test period shall not be longer than five days.
5. The water temperature shall be recorded at a depth of 18 in. below the water surface at the start and end of the test.
6. A floating, restrained, partially filled, calibrated, open container for evaporation and precipitation measurement should be positioned in open structures and the water level in the container recorded at 24-hour intervals. Determination of evaporation by a shallow pan-type measuring device is not acceptable due to possible heating of the bottom of the shallow pan resulting in accelerated evaporation.

3.03 EVALUATION

- A. The containment structure shall continue to be observed in both the early mornings and late afternoons to verify compliance with Part 1 of the test during Part 2.
- B. At the end of the test period, the water surface shall be recorded to within 1/16-in at the location of original measurements. The water temperature and the evaporation and precipitation measurements shall be recorded.
- C. The allowable loss of water for tightness tests shall not exceed 0.050% of the test water volume in 24 hours.
- D. The change in water volume in the structure shall be calculated and corrected, if necessary, for evaporation, precipitation, and temperature based on the change recorded in the water level from the open container. If the loss exceeds the allowable loss, the structure shall be considered to have failed the test.
- E. During Part 2 of the test, observed flow or seepage of water from the exterior surface, including that from cracks and joints, should be considered as a failed test. Excessive wetness resulting in water droplets on dry hand after contact will also be considered a failed test. Slight dampness with only slight wetting of dry hand will not necessarily qualify as a failed test, depending on application, location, and visibility. Dampness or wetness on top of a footing shall not be considered as a failed test.

3.04 RETESTING

- A. A restart of the test shall be required when test measurements become unreliable due to unusual precipitation or other external factors.
- B. The Contractor shall be permitted to immediately retest when no visible leakage is exhibited. If the structure fails the second test or if the Contractor does not exercise the option of immediately retesting after the first test failure, the interior of the structure shall be inspected by a diver or by other means to determine probable areas of leakage. The structure shall only be retested after the most probable areas of leakage are repaired.
- C. If the leakage exceeds the allowable limit, the work shall be corrected by methods approved by the Engineer.
- D. Upon completion of the necessary remedial work, the leakage test shall be repeated until it is successfully passed. A minimum of three days shall occur between completion of any repairs with water level remaining at required test level without further issues prior to structure being deemed as satisfying all requirements of testing.

3.05 NOTIFICATION BY ENGINEER

- A. If any leaks greater than the specified amount are not remedied by the Contractor within four (4) weeks of notification by the Engineer, regardless of whether the cause of these leaks is or is not determined, the Engineer shall have the authority to have these leaks repaired by others. The cost of repairs, by others, shall be deducted from monies due or to become due to the General Contractor.

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**SECTION 02 41 00
SITE DEMOLITION**

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. The Contractor shall furnish all labor, materials, and equipment in accordance with the requirements of applicable sections of Divisions 1 and 2.
- B. In addition, the Contractor shall demolish and remove all concrete and asphalt paving, curbs, sidewalk, and miscellaneous yard piping, utilities, and structures as required and shown on the Contract Drawings during the construction work.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 01 14 00 – Coordination with Owner's Operations
- B. Section 01 42 00 – References
- C. Section 01 73 00 – Demolition and Execution of Work

1.03 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

- A. References shall be in accordance with reference standards, codes, and specifications as set forth herein and in Section 31 10 00 – Clearing, Grubbing, and Site Preparation.

1.04 SUBMITTALS

- A. In accordance with the procedures and requirements set forth in Section 01 33 00 – Submittal Procedures, the Contractor shall submit the following:
 - 1. Copies of all photographs and other records from the joint existing conditions surveys.

PART 2 – PRODUCTS (NOT USED)

PART 3 – EXECUTION

3.01 DEMOLITION

- A. Existing concrete and asphalt paving, curbs, sidewalk and miscellaneous yard piping, utilities, and structures within the areas designated for new construction work shall be completely demolished and all debris removed from the site.

- B. Excavation caused by demolition shall be backfilled with fill free from rubbish and debris. Select fill or structural fill shall be used where specifically required on Contract Drawings.
- C. Work shall be performed in such manner as not to endanger the safety of the workmen or the public or cause damage to nearby structures.
- D. Provide all barriers and precautionary measures in accordance with Owner's requirements and other authorities having jurisdiction.
- E. Where parts of existing pavements or structures are to remain in service, demolish the portions to be removed, repair damage, and leave the pavement or structure in proper condition for the intended use. Remove asphalt or concrete pavement, concrete, and masonry to the lines designated by saw-cutting, drilling, chipping, or other suitable methods. Leave the resulting surfaces reasonably true and even, with sharp straight corners that will result in neat joints with new construction and be satisfactory for the purpose intended. Where existing reinforcement extends into new construction, remove the concrete so that the reinforcing is clean and undamaged. Cut off other reinforcing 1/2-inch below the surface and fill with epoxy resin binder flush with the surface.
- F. Prior to the execution of the work, the Contractor, Owner and Engineer shall jointly survey the condition of the adjoining and/or nearby pavements and structures. Photographs and records shall be made of any prior settlement or cracking of structures, pavements, and the like, that may become the subject of possible damage claims. Contractor shall provide Owner a copy of all records of the joint survey of conditions before demolition activities may begin.

3.02 DISPOSAL OF MATERIAL

- A. All debris resulting from the demolition and removal work shall be disposed of by the Contractor at a properly permitted facility as part of the work of this Contract. All regulations covering material handling and disposal shall be followed. Material designated by the Engineer to be salvaged shall be stored on the construction site as directed. All other material shall be disposed of off-site by the Contractor at the Contractor's expense.
- B. Burning of any debris resulting from the demolition will not be permitted at the site.

END OF SECTION

SECTION 03 01 30
CONCRETE REPAIRS

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. The Contractor shall furnish all materials, labor, equipment, tools, etc., required for the pH testing, repair, renovation, and replacement of concrete and/or reinforcing steel as indicated on the Drawings, specified herein, and determined by field survey.
- B.

The Contractor, in conjunction with the Engineer, shall determine the extent of cracked or deteriorated concrete to be rehabilitated and/or resurfaced. A summary of the work to be performed shall be submitted to the Engineer for review, and such summary shall be approved by the Engineer prior to commencement of the Work. The extent of damaged concrete material to be removed prior to installation of repair material shall be determined by parent material soundness as well as surface pH levels. Prepared surfaces to receive repair materials or coatings shall have a minimum surface pH level of 11. Removal of materials shall continue until the exposed surface pH level is 11 or higher.
- C. Concrete repair work to be paid from the Contingency Allowance. Reference Bid Form. Concrete repairs include the following:
 - 1. Concrete repairs for Filter Effluent Flume, Filter Serpentine Flume, and Filter 16.
 - 2. Concrete repairs for Clearwell Influent and Effluent Channels.
 - 3. Concrete repairs identified by the Contractor and submitted to the Resident Project Representative of Record, who will review and provide recommended repair directions.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Division 01 – General Requirements
- B. Section 01 20 00 – Measurement and Payment
- C. Division 03 – Concrete

1.03 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

- A. Shall be as specified in Section 01 42 00 – References.

- B. ICRI CSP – International Concrete Repair Institute Concrete Surface Profile.

1.04 SUBCONTRACTOR/APPLICATOR QUALIFICATIONS

- A. The Contractor shall furnish the name of all subcontractors/applicators which they proposes to use for this work, including necessary evidence and/or experience records to ascertain their qualifications in the application of epoxy, urethane, and polymer-modified and silica fume enhanced repair materials.
- B. Approved applicator qualifications shall include a minimum of 5 years of experience in applying epoxy, urethane, and polymer-modified and silica fume enhanced cement-based repair materials like those materials specified in this Section.
- C. A letter from the manufacturer of the specified materials, on the manufacturer's letterhead, signed by an officer of the company, stating that the subcontractor/applicator has been trained in the proper techniques for applying the product, including surface preparation and mixing, placing, curing, and caring for the manufacturer's products shall be submitted. This letter shall further state that the subcontractor/applicator is on the manufacturer's approved list of contractors.

1.05 SUBMITTALS

- A. Material certifications and technical data sheets on all grouts, mortars, epoxy resins, aggregates and repair products specified in this Section.
- B. Subcontractor/Applicator qualifications as specified in Section 1.04.
- C. Shop Drawings detailing any planned deviation from the proposed construction sequence and/or method of repair.
- D. The Contractor, based on their experience in their profession, and/or recommendation from product manufacturers, may submit to the Engineer for approval, alternative materials and/or methods of work to assure the durability and watertight integrity of the repair work performed.
- E. Detailed repair procedures for each repair type.
- F. Letter from repair material manufacturer(s) certifying that all repair materials to be used to create single repairs are compatible for use together

1.06 ADDITIONAL GUARANTEE

- A. The Contractor shall guarantee all repair work performed under this Contract against defects in workmanship resulting in leakage and/or failure of concrete bond for a period of three (3) years from the date of the Certificate of Substantial Completion.

PART 2 – MATERIALS

2.01 GENERAL

- A. All concrete repair materials shall conform to NSF Standards for contact with potable water supplies.
- B. All concrete repair materials, when used in combination to create a single repair, shall be compatible.

2.02 WATER

- A. The water used for mixing concrete repair products shall be clear, potable, and free of deleterious substances.

2.03 AGGREGATE

- A. All aggregate shall conform to ASTM C-33. The aggregate supplier shall submit to the Engineer documentation that the proposed aggregates comply with ASTM C-33 and the requirements listed below:
- B. Pea Gravel - Pea gravel shall meet the gradation and material requirements of Standard Size 14 as defined by ASTM C-33. Pea gravel shall be clean and free from deleterious matter and shall contain no limestone.

2.04 EPOXY BONDING AGENT

- A. Epoxy bonding agent shall conform to ASTM C-881 Type I, II, IV or V; Grade 2 for epoxy resin adhesives, depending on the application. The class of epoxy bonding agent shall be suitable for all ambient and substrate temperatures. The epoxy resin shall be "Sikadur Hi-Mod Series" as manufactured by the Sika Corp, Lyndhurst, NJ, "Duralbond" as manufactured by Euclid Chemical Company, Cleveland, OH, "Euco #452 Series" by the Euclid Chemical Company, or "MasterEmaco ADH series" by Master Builders Solutions.

2.05 ANTI-CORROSION REBAR COATING

- A. Anti-corrosive coating shall be a polymer-modified cementitious material such as "Sika Armatec 110 EpoCem " manufactured by Sika Corp., Lyndhurst, NJ, Atlanta, GA, "Duralprep A.C." by the Euclid Chemical Company, or "MasterEmaco P 124" by Master Builders Solutions.

2.06 TYPE I CRACK REPAIR - CEMENTITIOUS SURFACE SEAL

- A. Type I Crack Repair - Cementitious Surface Seal shall be a polymer-modified or silica fume enhanced trowel grade cementitious mortar and shall conform to EPA/USPHS standards for surface contact with potable water supplies. Type I Crack Repair material shall be "Sikatop 123 Plus" manufactured by Sika Corp., Lyndhurst, NJ, "Verticoat" or "Verticoat Supreme" by Euclid Chemical Company; or "Emaco S88 CI" or by Master Builders Solutions.

2.07 TYPE II CRACK REPAIR – EPOXY INJECTION CRACK REPAIR

- A. Type II Crack Repair – Epoxy Injection Crack Repair shall be a 100% solids, high-modulus, low viscosity, moisture insensitive epoxy adhesive designed for structural repair. The epoxy adhesive shall be "Sikadur 52" manufactured by Sika Corp., Lyndhurst, NJ, "Dural 452 LV" manufactured by Euclid Chemical Company, Cleveland, OH, "Eucopoxy Injection Resin" by the Euclid Chemical Company, or "MasterInject 1500" by Master Builders Solutions.

2.08 TYPE III CRACK REPAIR - WATERPROOF INJECTION GROUT

- A. Type III Crack Repair - Waterproof Injection Grout shall be a one-component, water-activated, extra-low viscosity polyurethane or methacrylic acrylate hydrophilic or hydrophobic injection grout capable of 400% expansion. Injection grout shall form a tough flexible or rigid foam seal that is impenetrable to water. Hydrophilic injection grout shall be "MasterInject 1210" manufactured by Master Builders Solutions, "Prime Flex 900 XLV" manufactured by Prime Resins, Conyers, GA, "AV-330 Safeguard" manufactured by Avanti International, Webster, TX, or "DeNeef Sealfoam PUR" or "Gelacryl Superflex" manufactured by Grace Construction Products/GCP Applied Technologies or "SikaFix HH Hydrophilic" manufactured by Sika Corp., Lyndhurst, NJ,. Hydrophobic injection grout shall be "MasterInject 1230" manufactured by Master Builders Solutions, "Prime Flex 940" manufactured by Prime Resins, Conyers, GA, "Sikafix HHLV or "Sikafix HH+" manufactured by Sika Corp., Lyndhurst, NJ, "AV-248-LV Flexseal LV" manufactured by Avanti International, Webster, TX, or "DeNeef Flex SLV one or PUR" manufactured by Grace Construction Products.

2.09 SPALL REPAIR PATCHING MATERIAL

- A. All spall repairs not requiring formwork shall be repaired using a polymer-modified cementitious mortar and shall have a minimum 28-day compressive strength of 7,000

psi. Spall repair mortar for use in horizontal applications shall be "Sikatop 122 Plus" manufactured by Sika Corp., Lyndhurst, NJ, "Eucocrete Supreme" or "Duraltop Flowable Mortar" by the Euclid Chemical Company, or "MasterEmaco T-302" or "MasterEmaco T310CI" by Master Builders Solutions. Spall repair mortar for use in vertical and overhead applications shall be "Sikatop 123 Plus" manufactured by Sika Corp., Lyndhurst, NJ, "Verticoat or Verticoat Supreme" by the Euclid Chemical Company, or "MasterEmaco N 425" or "MasterEmaco N 400" by Master Builders Solutions.

- B. All spall repairs requiring formwork shall be repaired using a polymer-modified cementitious mortar/pea gravel mixture and shall have a minimum 28-day compressive strength of 7,000 psi. Spall repair mortar shall be "SikaTop 111 PLUS" manufactured by Sika Corp., Lyndhurst, NJ, "Eucocrete Supreme" manufactured by Euclid Chemical Company, Cleveland, OH, or "MasterEmaco T 310 CI" by Master Builders Solutions.
- C. All spall repair materials shall conform to EPA/USPHS standards for surface contact with potable water supplies.

2.10 EXPANSION JOINT MEMBRANE REPAIR SYSTEM

- A. Expansion joint repair system shall be a flexible rubber sealing strip secured to the concrete substrate with an epoxy adhesive. System shall be provided by a single manufacturer, installed per manufacturer's recommendations and shall be "Sikadur Combiflex" manufactured by Sika Corp., Lyndhurst, NJ or Engineer approved equal. Minimum width of waterproof membrane patch shall be twelve (12) inches unless shown otherwise on Contract Drawings.

2.11 WATERSTOP REPAIR SYSTEM

- A. Waterstop repair system shall consist of a continuous, watertight, structural sealing compression joint system capable of withstanding 25% tension, 50% compression and 2-inches total movement while functioning as a watertight seal between concrete substrate headers. Waterstop Repair System shall be provided by a single manufacturer and shall be either:
 - 1. Preformed, impermeable, closed cell, low-density, UV stable foam sealing strip system secured to concrete with a bonding agent. System shall be "CEVA 100 System" as manufactured by Chase Construction Products, "Wabo Evazote System", or approved equal. Foam sealing strip and epoxy bonding agent shall be provided by the same manufacturer as a system and shall consist of "Phyzite 380" foam sealing strip with either "EVA-POX BONDER #1", "EVA-POX

UNDERWATER BONDER #47", or "EVA-POX COLD CURE #41" bonding agent, or Evazote UV foam sealing strip with "Wabo Evazote Bonder" or "Wabo Evazote Cold Cure Bonder. Bonding agent shall be as recommended by the manufacturer based on substrate conditions at the time of installation.

2. Preformed flexible neoprene profile system secured to concrete with a bonding agent. System shall be "JP-Series Profile" by D.S. Brown Company, "Jeene Bridge Series Seal" or "Wabo Compression Seal" by Watson Bowman Acme/BASF.

2.12 CEMENT BASED TEXTURED COATING

- A. Cement based textured coating shall be "SikaTop 144" manufactured by Sika Corp., Lyndhurst, NJ, "MasterSeal 581" manufactured by Master Builders Solutions, "Duraltop Coating" manufactured by Euclid Chemical Company, Cleveland, OH, "Eucoseal or Tamoseal" by the Euclid Chemical Company. Cement based textured coating shall have a minimum durability of 10 years and be able to seal cracks with a width up to 1/8 inch.

2.13 OTHER MATERIALS

- A. OAKUM ROPE – Oakum rope shall be dry type oakum or jute intended for use with polyurethane grouts for sealing cracks and gaps in concrete and shall be "DeNeef Dry Oakum" as manufactured by Grace Construction Products/GCP Technologies, or approved equal.

2.14 STORAGE OF MATERIALS

- A. The Contractor shall provide an area for repair material storage free from exposure to moisture in any form, before, during, and after delivery to the site. Manufactured materials shall be delivered in unbroken containers labeled with the manufacturer's name and product type. All mortar products shall be stored on raised platforms. Materials susceptible to damage by freezing shall be stored in a dry, heated, insulated area. Any material that has hardened, partially set, become caked and/or has been contaminated or deteriorated shall be rejected. All aggregates shall be stored in clean bins, scows or platforms.

PART 3 – INSTALLATION

3.01 GENERAL REQUIREMENTS

- A. No repair work shall be undertaken when ambient temperatures are below manufacturer's safe recommendations. No admixtures, except those required by the manufacturer, shall be used in the repairs specified herein.

- B. All products shall be applied in strict accordance with manufacturer's recommendations. The Contractor shall furnish and install safe scaffolding and ladders for the Engineer's prework inspection, the repair work activities, and the Engineer's final inspection.
- C. Sandblast or waterblast (3000-5000 psi waterjet) or use low impact hand chipping tools to clean deteriorated areas to remove all loose concrete, existing coatings, unsound material, debris, and laitance. All surfaces shall be clean, free of dirt, grease, loose particles, and deleterious substances and shall be prepared according to manufacturer's requirements.

3.02 EPOXY BONDING AGENT

- A. An epoxy bonding agent shall be used when applying fresh concrete to previously placed concrete unless otherwise recommended by the manufacturer.
- B. Existing concrete surfaces shall be roughened (1/16" or CSP 5 minimum profile) unless otherwise recommended by the manufacturer prior to application of bonding agent. Concrete surface shall be clean and sound, free of all foreign particles and laitance. Repair material shall be placed while bonding agent is still tacky. If bonding agent cures prior to placement of repair material, bonding agent shall be reapplied.
- C. Repairing concrete with epoxy mortars shall conform to all the requirements of ACI 503.4 "Standard Specification for Repairing Concrete with Epoxy Mortars" (latest edition), except as modified herein.

3.03 ANTI-CORROSION REBAR COATING

- A. Reinforcing steel cut or exposed during demolition and/or repair operations shall be sandblasted and cleaned prior to coating with an anti-corrosive coating. Anti-corrosive coating shall be applied as soon as the reinforcement is exposed and cleaned. Coating shall thoroughly cover all exposed parts of the steel and shall be applied according to manufacturer's recommendations.

3.04 TYPE I CRACK REPAIR – CEMENTITIOUS SURFACE SEAL

- A. Where indicated on the Drawings, or as directed by the Engineer, existing nonstructural cracks 1/16" and wider in vertical and overhead surfaces or existing cracks between 1/16" and 1/4" wide in horizontal surfaces shall be repaired with Type I Crack Repair Material. Rout crack to 3/4" wide by 3/4" deep V-notch to expose sound concrete. Provide a 3/8" high vertical shoulder at the top of notch on each side. Where rebar has

deteriorated, or where deteriorated concrete extends below the top of rebar, crack shall be routed to expose 3/4" all around rebar. The resulting void in concrete shall be patched flush with the existing concrete surface using Type I Crack Repair material.

3.05 TYPE II CRACK REPAIR – EPOXY INJECTION

A. Vertical and Overhead Surfaces

1. Where indicated on the Drawings, or as directed by the Engineer, existing structural cracks 1/4" wide or narrower shall be repaired by pressure injecting Type II Crack Repair material into the prepared crack. Seal crack surface using epoxy resin binder and install injection ports per manufacturer's recommendations. Holes drilled for injection ports shall not cut rebar. If rebar is encountered during drilling, the hole shall be abandoned and relocated, and the abandoned hole shall be patched immediately with non-shrink grout flush with the surface of the existing concrete. Once the surface sealing material has fully cured, inject crack with Type II Crack Repair material using standard pressure injection equipment as directed by the manufacturer.

B. Horizontal Surfaces

1. Where indicated on the Drawings, or as directed by the Engineer, existing structural cracks 1/4" wide or narrower shall be repaired using Type II Crack Repair by pressure injecting Type II Crack Repair material into the prepared crack. Seal crack surface using epoxy resin binder and install injection ports per manufacturer's recommendations. Holes drilled for injection ports shall not cut rebar. If rebar is encountered during drilling, the hole shall be abandoned and relocated, and the abandoned hole shall be patched immediately with non-shrink grout flush with the surface of the existing concrete. Once the surface sealing material has fully cured, inject crack with Type II Crack Repair material using standard pressure injection equipment as directed by the manufacturer.
2. Where indicated on the Drawings, or as directed by the Engineer, existing structural cracks wider than 1/4" shall be repaired by gravity feeding Type II Crack Repair material into the prepared crack. First rout the concrete surface to form a 1/4" wide by 1/4" deep v-notch and clean the crack to remove all loose and foreign particles. Fill the crack with clean, dry sand and then pour structural crack repair binder into V-notch, completely filling crack. As binder penetrates crack, additional binder shall be applied to the V-notch.

3.06 TYPE III CRACK REPAIR – WATERPROOF INJECTION GROUT

- A. Existing, leaking cracks 1/4" or smaller, identified as nonstructural by the Engineer, shall be repaired by pressure injecting a Type III Crack Repair material into the prepared crack. Seal crack surface with epoxy binder and install injection ports per manufacturer's recommendations. Holes drilled for injection ports shall not cut rebar. If rebar is

encountered during drilling, the hole shall be abandoned and relocated, and the abandoned hole shall be patched immediately with non-shrink grout flush with the surface of the existing concrete. Once the surface sealing material has cured, clean, potable water shall be injected into the ports to flush the crack and provide the water necessary for chemical reaction of the grout. Immediately following injection of water, inject the crack with Type III Crack Repair material using standard pressure injection equipment as directed by the manufacturer.

- B. All existing, leaking cracks larger than 1/4", not identified as structural by the Engineer, shall be repaired by first soaking oakum rope or open cell backer rod in waterproof injection grout, and then tightly packing the soaked oakum into the crack so as to completely fill the crack.

3.07 SPALL REPAIR PATCHING MATERIAL

- A. All voids or spalled areas to be repaired shall be chipped back to sound concrete a minimum 1/8" deep, with a minimum surface profile of CSP-5, cleaned and repaired with spall repair patching material according to manufacturer's recommendations. All patching shall provide a final finished surface which is flat, level and even with the existing concrete surface. Repair mortar shall not be feathered to meet existing concrete surface. Prior to commencing repair surface preparation, saw cut or grind a 1/2" deep groove around the perimeter around the repair area, perpendicular to the finished concrete surface to provide a square shoulder to the repair area. Repair areas shall be formed using clean, straight rectangular edges where possible. Final patching on horizontal surfaces shall receive a broom finish consistent with the finish on the existing structure.

3.08 EXPANSION JOINT REPAIR SYSTEM

- A. Thoroughly clean the concrete substrate and apply Expansion Joint Repair System according to the manufacturer's recommendations.

3.09 WATERSTOP REPAIR SYSTEM

- A. Remove all existing expansion joint sealant, backer rod, and expansion joint filler material as required to install the waterstop repair system.
- B. Prepare existing concrete surfaces as required by the manufacturer.
- C. Apply bonding agent to existing concrete and foam sealing strip or neoprene profile, and insert into expansion joint, as required by the manufacturer.

3.10 CEMENT BASED TEXTURED COATING

- A. Thoroughly clean the concrete substrate and apply cement based textured coating according to manufacturer's recommendations. All necessary concrete repairs as detailed on the Contract Drawings shall be completed prior to applying coating.

3.11 CURING

- A. All repair products shall be cured in strict accordance with manufacturer recommendations. Wet curing is preferred where possible.

3.12 WORK IN CONFINED SPACES

- A. The Contractor shall provide and maintain safe working conditions for all employees and subcontractors. Fresh air shall be supplied continuously to confined spaces through the combined use of existing openings, forced-draft fans and temporary ducts to the outside, or by direct air supply to individual workers. Fumes shall be exhausted to the outside from the lowest level of the confined space. Electrical fan motors shall be explosion-proof if in contact with fumes. No smoking or open fires shall be permitted in or near areas where volatile fumes may accumulate.

END OF SECTION

SECTION 03 11 00
CONCRETE FORMWORK

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. Provide materials, labor, and equipment required for the design and construction of all concrete formwork, bracing, shoring and supports in accordance with the provisions of the Contract Documents.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 03 21 00 – Reinforcing Steel
- B. Section 03 15 00 – Concrete Accessories
- C. Section 03 15 16 – Joints in Concrete
- D. Section 03 30 00 – Cast-in-Place Concrete

1.03 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

- A. Without limiting the generality of the other requirements of the specifications, all work herein shall conform to the applicable requirements of the following documents. All referenced specifications, codes, and standards refer to the most current issue available at the time of Bid.
 - 1. Building Code for the State or Commonwealth in which the project is located.
 - 2. ACI 318 – Building Code Requirements for Structural Concrete
 - 3. ACI 301 – Specifications for Structural Concrete
 - 4. ACI 347 – Recommended Practice for Concrete Formwork
 - 5. U.S. Product Standard for Concrete Forms, Class I, PS 1
 - 6. ACI 117 – Specification for Tolerances for Concrete Construction and Materials and Commentary

1.04 SUBMITTALS

- A. Submit the following in accordance with Section 01 33 00 – Submittal Procedures.
 - 1. Manufacturer's data on proposed form release agent

2. Manufacturer's data on proposed formwork system including form ties

1.05 QUALITY ASSURANCE

- A. Concrete formwork shall be in accordance with ACI 301, ACI 318, and ACI 347.

PART 2 – PRODUCTS

2.01 FORMS AND FALSEWORK

- A. All forms shall be smooth surface forms unless otherwise specified.
- B. Wood materials for concrete forms and falsework shall conform to the following requirements:
 1. Lumber for bracing, shoring, or supporting forms shall be Douglas Fir or Southern Pine, construction grade or better, in conformance with U.S. Product Standard PS20. All lumber used for forms, shoring or bracing shall be new material.
 2. Plywood for concrete formwork shall be new, waterproof, synthetic resin bonded, exterior type Douglas Fir or Southern Pine high density overlaid (HDO) plywood manufactured especially for concrete formwork and shall conform to the requirements of PS1 for Concrete Forms, Class I, and shall be edge sealed. Thickness shall be as required to support concrete at the rate it is placed, but not less than 5/8-inch thick.
- C. Other form materials such as metal, fiberglass, or other acceptable material that will not adversely affect the concrete and will facilitate placement of concrete to the shape, form, line and grade indicated may be submitted to the Engineer for approval, but only materials that will produce a smooth form finish equal or better than the wood materials specified will be considered.

2.02 FORMWORK ACCESSORIES

- A. Form ties shall be provided with a plastic cone or other suitable means for forming a conical hole to ensure that the form tie may be broken off back of the face of the concrete. The maximum diameter of removable cones for rod ties, or of other removable form-tie fasteners having a circular cross-section, shall not exceed 7/8-inch, and all such fasteners shall be such as to leave holes of regular shape for reaming.
- B. Form ties for water-retaining structures shall have integral waterstops. Removable taper ties may be used when acceptable to the Engineer. A preformed mechanical EPDM rubber plug shall be used to seal the hole left after the removal of the taper tie. Plug shall be X-Plug by the Sika Corporation or approved equal. Friction fit plugs shall not be used.

- C. Form release agent shall be a blend of natural and synthetic chemicals that employs a chemical reaction to provide quick, easy and clean release of concrete from forms. It shall not stain the concrete and shall leave the concrete with a paintable surface. Formulation of the form release agent shall be such that it would minimize formation of "bug holes" in cast-in-place concrete.

PART 3 – EXECUTION

3.01 FORM DESIGN

- A. Forms and falsework shall be designed for total dead load, plus all construction live load as outlined in ACI 347. Design and engineering of formwork and safety considerations during construction shall be the responsibility of the Contractor.
- B. Forms shall be of sufficient strength and rigidity to maintain their position and shape under the loads and operations incident to placing and vibrating the concrete. The maximum deflection of facing materials reflected in concrete surfaces exposed to view shall be 1/240 of the span between structural members.
- C. All forms shall be designed for predetermined placing rates per hour, considering expected air temperatures and setting rates.

3.02 CONSTRUCTION

- A. The type, size, quality, and strength of all materials from which forms are made shall be subject to the approval of the Engineer. No falsework or forms shall be used which are not clean and suitable. Deformed, broken or defective falsework and forms shall be removed from the work.
- B. Forms shall be smooth and free from surface irregularities. Suitable and effective means shall be provided on all forms for holding adjacent edges and ends of panels and sections tightly together and in accurate alignment so as to prevent the formation of ridges, fins, offsets, or similar surface defects in the finished concrete. Joints between the forms shall be sealed to eliminate any irregularities. The arrangement of the facing material shall be orderly and symmetrical, with the number of seams kept to a practical minimum.
- C. Forms shall be true to line and grade and shall be sufficiently rigid to prevent displacement and sagging between supports. Curved forms shall be used for curved and circular structures. Straight panels joined at angles will not be acceptable for forming curved structures. Forms shall be properly braced or tied together to maintain their position and shape under a load of freshly placed concrete. Facing material shall be supported with studs or other backing which shall prevent both visible deflection marks in the concrete and deflections beyond the tolerances specified.

- D. Forms shall be mortar tight to prevent the loss of water, cement and fines during placing and vibrating of the concrete. Specifically, the bottom of wall forms that rest on concrete footings or slabs shall be provided with a gasket to prevent loss of fines and paste during placement and vibration of concrete. Such gasket may be a 1 to 1-1/2-inch diameter polyethylene rod held in position to the underside of the wall form.
- E. All vertical surfaces of concrete members shall be formed, and side forms shall be provided for all footings, slab edges and grade beams, except where placement of the concrete against the ground is called for on the Drawings. Not less than 1-inch of concrete shall be added to the thickness of the concrete member as shown where concrete is permitted to be placed against trimmed ground in lieu of forms. Such permission will be granted only for members of comparatively limited height and where the character of the ground is such that it can be trimmed to the required lines and will stand securely without caving or sloughing until the concrete has been placed.
- F. All forms shall be constructed in such a manner that they can be removed without hammering or prying against the concrete. Wood forms shall be constructed for wall openings to facilitate loosening and to counteract swelling of the forms.
- G. Adequate clean-out holes shall be provided at the bottom of each lift of forms. Temporary openings shall be provided at the base of column forms and wall forms and at other points to facilitate cleaning and observation immediately before the concrete is deposited. The size, number and location of such clean-outs shall be as acceptable to the Engineer.
- H. Construction joints shall not be permitted at locations other than those shown or specified, except as may be acceptable to the Engineer. When a second lift is placed on hardened concrete, special precautions shall be taken in the way of the number, location and tightening of ties at the top of the old lift and bottom of the new to prevent any unsatisfactory effect whatsoever on the concrete. For flush surfaces at construction joints exposed to view, the contact surface of the form sheathing over the hardened concrete in the previous placement shall be lapped by not more than 1 inch. Forms shall be held against hardened concrete to prevent offset or loss of mortar at construction joints and to maintain a true surface.
- I. The formwork shall be cambered to compensate for anticipated deflections in the formwork due to the weight and pressure of the fresh concrete and due to construction loads. Set forms and intermediate screed strips for slabs accurately to produce the designated elevations and contours of the finished surface. Ensure that edge forms and screed strips are sufficiently strong to support vibrating screeds or roller pipe screeds if the nature of the finish specified requires the use of such equipment. When formwork is cambered, set screeds to a like camber to maintain the proper concrete thickness.
- J. Positive means of adjustment (wedges or jacks) for shores and struts shall be provided and all settlement shall be taken up during concrete placing operation. Shores and struts

shall be securely braced against lateral deflections. Wedges shall be fastened firmly in place after final adjustment of forms prior to concrete placement. Formwork shall be anchored to shores or other supporting surfaces or members to prevent upward or lateral movement of any part of the formwork system during concrete placement. If adequate foundation for shores cannot be secured, trussed supports shall be provided.

- K. Runways shall be provided for moving equipment with struts or legs. Runways shall be supported directly on the formwork or structural member without resting on the reinforcing steel.

3.03 TOLERANCES

- A. Unless otherwise indicated in the Contract Documents, formwork shall be constructed so that the concrete surfaces will conform to the tolerance limits listed in ACI 117.
- B. Structural framing of reinforced concrete around elevators and stairways shall be accurately plumbed and located within 1/4 in. tolerance from established dimensions.
- C. The Contractor shall establish and maintain in an undisturbed condition and until final completion and acceptance of the project, sufficient control points and benchmarks to be used for reference purposes to check tolerances. Plumb and string lines shall be installed before concrete placement and shall be maintained during placement. Such lines shall be used by Contractor's personnel and by the Engineer and shall be in sufficient number and properly installed. During concrete placement, the Contractor shall continually monitor plumb and string line form positions and immediately correct deficiencies.
- D. Regardless of the tolerances specified, no portion of the structure shall extend beyond the legal boundary of the structure.

3.04 FORM ACCESSORIES

- A. Suitable moldings shall be placed to bevel or round all exposed corners and edges of beams, columns, walls, slabs, and equipment pads. Chamfers shall be 3/4 inch unless otherwise noted.
- B. Form ties shall be so constructed that the ends, or end fasteners, can be removed without causing appreciable spalling at the faces of the concrete. After ends, or end fasteners of form ties have been removed, the embedded portion of the ties shall terminate not less than 2 inches from the formed face of the concrete that is exposed to water or enclosed surfaces above the water surface, and not less than 1 inch from the formed face of all other concrete. Holes left by the removal of form tie cones shall be reamed with suitable toothed reamers to leave the surface of the holes clean and rough before being filled with mortar as specified in Section 03 35 00 – Concrete Finishes. No form-tying device or part thereof, other than metal, shall be left embedded in the concrete. Ties shall not be removed in such manner as to leave a hole extending

through the interior of the concrete member. The use of snap-ties which cause spalling of the concrete upon form stripping or tie removal will not be permitted. No snap ties shall be broken off until the concrete is at least three days old. If steel panel forms are used, rubber grommets shall be provided where the ties pass through the form in order to prevent loss of cement paste.

3.05 APPLICATION – FORM RELEASE AGENT

- A. Forms for concrete surfaces that will not be subsequently waterproofed shall be coated with a form release agent. Form release agent shall be applied on formwork in accordance with manufacturer's recommendations.

3.06 INSERTS AND EMBEDDED ITEMS

- A. Sleeves, pipe stubs, inserts, anchors, expansion joint material, waterstops, and other embedded items shall be positioned accurately and supported against displacement prior to concreting. Voids in sleeves, inserts, and anchor slots shall be filled temporarily with readily removable material to prevent the entry of concrete into the voids.

3.07 FORM CLEANING AND REUSE

- A. The inner faces of all forms shall be thoroughly cleaned prior to concreting. Forms may be reused only if in good condition and only if acceptable to the Engineer. Light sanding between uses will be required wherever necessary to obtain uniform surface texture. Unused tie rod holes in forms shall be covered with metal caps or shall be filled by other methods acceptable to the Engineer.

3.08 FORM REMOVAL AND SHORING

- A. Forms shall not be disturbed until the concrete has attained sufficient strength. Sufficient strength shall be demonstrated by structural analysis considering proposed loads, strength of forming and shoring system, and concrete strength data. Shoring shall not be removed until the supported member has acquired sufficient strength to support its weight and the load upon it. Members subject to additional loads during construction shall be adequately shored to sustain all resulting stresses. Forms shall be removed in such manner as not to impair safety and serviceability of the structure. All concrete to be exposed by form removal shall have sufficient strength not to be damaged thereby.
- B. Provided the strength requirements specified above have been met and subject to the Engineer's approval, forms may be removed at the following minimum times. The Contractor shall assume full responsibility for the strength of all such components from which forms are removed prior to the concrete attaining its full design compressive strength. Shoring may be required at the option of the Engineer beyond these periods.

Ambient Temperature (°F.) During Concrete Placement

	Over 95°	70°-95°	60°-70°	50°-60°	Below 50°
Edge Forms for Slabs on Grade	1 day	1 day	1 day	1 day	
Walls	5 days	2 days	2 days	3 days	Do not remove until directed by Engineer (7 days minimum)
Columns	7 days	2 days	3 days	4 days	
Beam Soffits	10 days	7 days	7 days	7 days	
Elevated Slabs	12 days	7 days	7 days	7 days	

- C. When, in the opinion of the Engineer, conditions of the work or weather justify, forms may be required to remain in place for longer periods of time.
- D. An accurate record shall be maintained by the Contractor of the dates of concrete placings and the exact location thereof and the dates of removal of forms. These records shall always be available for inspection at the site, and two copies shall be furnished the Engineer upon completion of the concrete work.

3.09 RESHORING

- A. When reshoring is permitted or required the operations shall be planned and subjected to approval by the Engineer.
- B. Reshores shall be placed after stripping operations are complete but in no case later than the end of the working day on which stripping occurs.
- C. Reshoring for the purpose of early form removal shall be performed so that at no time will large areas of new construction be required to support their own weight. While reshoring is under way, no construction or live loads shall be permitted on the new construction. Reshores shall be tightened to carry their required loads but they shall not be overtightened so that the new construction is overstressed. Reshores shall remain in place until the concrete has reached its specified 28-day strength, unless otherwise specified.
- D. For floors supporting shores under newly placed concrete, the original supporting shores shall remain in place or reshores shall be placed. The shoring or reshoring system shall have a capacity sufficient to resist the anticipated loads and, in all cases, shall have a capacity equal to at least one-half of the capacity of the shoring system above. Reshores shall be located directly under a reshore position above unless other locations are permitted.

- E. In multi-story buildings, reshoring shall extend over a sufficient number of stories to distribute the weight of newly placed concrete, forms, and construction live loads so the design superimposed loads of the floors supporting shores are not exceeded.

END OF SECTION

SECTION 03 15 00
CONCRETE ACCESSORIES

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. Furnish all materials, labor and equipment required to provide all concrete accessories including waterstops, expansion joint material, joint sealants, expansion joint seals, crack inducing joint inserts, epoxy bonding agent, and neoprene bearing pads.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 03 11 00 – Concrete Formwork
- B. Section 03 15 16 – Joints in Concrete
- C. Section 03 30 00 – Cast-in-Place Concrete
- D. Section 07 90 00 – Joint Fillers, Sealants, and Caulking

1.03 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

- A. Without limiting the generality of the other requirements of the specifications, all work herein shall conform to the applicable requirements of the following documents. All referenced specifications, codes, and standards refer to the most current issue available at the time of Bid.
 - 1. ASTM C881 – Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete
 - 2. ASTM D412 – Standard Tests for Rubber Properties in Tension
 - 3. ASTM D471 - Standard Test Method for Rubber Properties
 - 4. ASTM D624 – Standard Test method for Rubber Property - Tear Resistance
 - 5. ASTM D638 – Standard Test Method for Tensile Properties of Plastics
 - 6. ASTM D1171 – Standard Test Method for Ozone Resistance at 500 pphm
 - 7. ASTM D1751 – Standard Specifications for Preformed Expansion Joint fillers for Concrete Paving and Structural Construction (non-extruding and resilient bituminous types)

8. ASTM D1752 – Standard Specification for Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction
9. ASTM D2240 – Standard Test for Rubber Property – Durometer Hardness

1.04 SUBMITTALS

- A. Submit the following in accordance with Section 01 33 00 – Submittal Procedures.
 1. Manufacturer's literature on all products specified herein including material certifications.
 2. Proposed system for supporting PVC waterstops in position during concrete placement.
 3. Samples of products if requested by the Engineer.

PART 2 – PRODUCTS

2.01 POLYVINYL CHLORIDE (PVC) WATERSTOPS

- A. PVC waterstops for construction joints shall be flat ribbed type, 6 inches wide with a minimum thickness at any point of 3/8 inches.
- B. Waterstops for expansion joints shall be ribbed with a center bulb. They shall be 9 inches wide with a minimum thickness at any point of 3/8 inch unless shown or specified otherwise. The center bulb shall have a minimum outside diameter of 1 inch and a minimum inside diameter of 1/2 inch.
- C. The waterstops shall be manufactured from virgin polyvinyl chloride plastic compound and shall not contain any scrap or reclaimed material or pigment whatsoever. The properties of the polyvinyl chloride compound used, as well as the physical properties of the waterstops, shall exceed the requirements of the U.S. Army Corps. of Engineers' Specification CRD-C572. The waterstop material shall have an off-white, milky color.
- D. The required minimum physical characteristics for this material are:
 1. Tensile strength – 1,750 psi (ASTM D638).
 2. Ultimate elongation – not less than 280% (ASTM D638).
- E. No reclaimed PVC shall be used for the manufacturing of the waterstops. The Contractor shall furnish certification that the proposed waterstops meet the above requirements.
- F. PVC waterstops shall be as manufactured by BoMetals, Inc., DuraJoint Concrete Accessories, or Sika Greenstreak.

- G. All waterstop intersections, both vertical and horizontal, shall be made from factory fabricated corners and transitions. Only straight butt joint splices shall be made in field.

2.02 RETROFIT WATERSTOPS

- A. Retrofit waterstops shall be used where specifically shown on Drawings for sealing joints between existing concrete construction and new construction.
- B. Retrofit waterstops shall be PVC waterstops fabricated from material as described in Section 2.01 of this Specification.
- C. Retrofit waterstop shall be attached to existing concrete surface as shown on Drawings.
- D. Use of split waterstop in lieu of specially fabricated retrofit waterstop will not be acceptable.
- E. Retrofit Waterstop manufacturer must provide a complete system including all Waterstop, stainless steel anchoring hardware, and epoxy for installation.
- F. For construction joints, retrofit waterstop shall be style number 609 by Sika Greenstreak, RF-638 by BoMetals, Inc., or approved equal. For expansion joints, retrofit waterstop shall be style number 667 by Sika Greenstreak, RF-912 by BoMetals, Inc., Type 36RT Retrofit Kit by DuraJoint Concrete Accessories, or approved equal.

2.03 WATERPROOF MEMBRANE PATCH

- A. Waterproof membrane patch shall be Sikadur Combiflex by Sika Corporation or approved equal. Minimum width of waterstop material shall be twelve (12) inches unless shown otherwise on Contract Drawings.

2.04 HYDROPHILIC WATERSTOPS

- A. Hydrophilic waterstops shall be designed to expand under hydrostatic conditions. For hydrostatic head pressure greater than 25 feet, waterstops shall be Adeka Ultra Seal MC-2010MN by Adeka Ultra Seal/OCM, Inc., or Hydrotite CJ-1020-2K by Sika Greenstreak. For hydrostatic head pressure 25 feet or less, Adeka Ultra Seal KBA-1510FP or Hydrotite CJ-1020-2K shall be used. Concrete cover and confinement requirements shall be in accordance with the manufacturer's recommendations.
- B. Waterstops shall be fabricated from a chemically modified natural rubber product with a hydrophilic agent. Use of bentonite based waterstop material will not be allowed.
- C. Waterstops shall either contain an interior stainless-steel mesh or an interior coextrusion of non-hydrophilic rubber to ensure expansion occurs along the width and thickness of the waterstop thereby restricting the expansion in the longitudinal direction.

2.05 WATERSTOP ADHESIVE

- A. Adhesive between waterstops and existing concrete shall be Neoprene Adhesive 77-198 by JGF Adhesives, Sikadur 31 Hi-Mod Gel by Sika Corporation, DP-605 NS Urethane Adhesive by 3M Adhesive Systems.
- B. Hydrophilic, non-bentonite water swelling elastic sealant shall be used to bond hydrophilic waterstops to rough surfaces. Hydrophilic elastic sealant shall be P-201 by Adeka Ultra Seal/OCM, Inc., Leakmaster LV-Z by Sika Greenstreak, or approved equal.

2.06 JOINT SEALANTS

- A. Joint sealants shall comply with Section 07 90 00 – Joint Fillers, Sealants, and Caulking.

2.07 EXPANSION JOINT MATERIAL

- A. Preformed expansion joint material shall be non-extruding, and shall be of the following types:
 - 1. Type I – Sponge rubber, conforming to ASTM D1752, Type I.
 - 2. Type II –Cork, conforming to ASTM D1752, Type II.
 - 3. Type III – Self-expanding cork, conforming to ASTM D1752, Type III.
 - 4. Type IV – Bituminous fiber, conforming to ASTM Designation D1751.

2.08 EXPANSION JOINT SEAL

- A. Expansion Joint Seal System shall consist of a preformed neoprene profile, installed using the same dimensions as the joint gap, bonded with a two-component epoxy adhesive, and pressurized during the adhesive cure time.
- B. The expansion joint system shall be Hydrozo/Jeene Structural Sealing joint system by Hydrozo/Jeene, Inc.

2.09 CRACK INDUCING JOINT INSERTS

- A. Crack inducing joint inserts shall be Zip-Cap by Greenstreak Plastic Products, Zip-Joint by BoMetals, Inc.

2.10 EPOXY BONDING AGENT

- A. Epoxy bonding agent shall conform to ASTM C881 and shall be Sikadur 32 Hi-Mod, Sika Corporation, Lyndhurst, N.J.; Euco #452 Epoxy System, Euclid Chemical Company, Cleveland, OH, MasterEmaco ADH Series by Master Builders Solutions.

2.11 EPOXY RESIN BINDER

- A. Epoxy resin binder shall conform to the requirements of ASTM C881, Type III, Grade 3, Class B and C for epoxy resin binder and shall be Sikadur 23, Low-Mod-Gel, manufactured by the Sika Corporation, Lyndhurst, N.J., Flexocrete Gel manufactured by DuraJoint Concrete Accessories or Euco #352 Gel, Euclid Chemical Company, MasterEmaco ADH 327 or 327 RS by Master Builders Solutions.

2.12 BEARING PADS

- A. Neoprene bearing pads shall conform to requirements of A4-F3-T.063-B2, Grade 2, Method B, in accordance with the RMA Rubber Handbook. Pads shall be nonlaminated pads having a nominal Shore A durometer hardness of 70 in accordance with ASTM D2240. Adhesive for use with neoprene pads shall be an epoxy-resin compound compatible with the neoprene having a sufficient shear strength to prevent slippage between pads and adjacent bearing surfaces. Adhesive shall be 20+F Contact Cement by Miracle Adhesives Corporation, Neoprene Adhesive 77-198 by IGI Adhesives, Sikadur 31, Hi-Mod Gel by Sika Corporation, or DP-605 NS Urethane Adhesive by 3M Adhesive Systems.

PART 3 – EXECUTION

3.01 PVC WATERSTOPS

- A. PVC waterstops shall be provided in all construction and expansion joints in water bearing structures and at other such locations as required by the Drawings.
- B. Waterstops shall be carefully positioned so that they are embedded to an equal depth in concrete on both sides of the joint. They shall be kept free from oil, grease, mortar or other foreign matter. To ensure proper placement, all waterstops shall be secured in correct position at 12" on center along the length of the waterstop on each side, prior to placing concrete. Such method of support shall be submitted to the Engineer for review and approval. Grommets or small pre-punched holes as close to the edges as possible will be acceptable for securing waterstops.
- C. Splices in PVC waterstops shall be made with a thermostatically controlled heating element. Only straight butt joint splices will be allowed in the field. Factory fabricated corners and transitions shall be used at all intersections. Splices shall be made in strict accordance with the manufacturer's recommended instructions and procedures. At least

three satisfactory sample splices shall be made on the site. The Engineer may require tests on these splices by an approved laboratory. The splices shall exhibit not less than 80 percent of the strength of the unspliced material.

- D. All splices in waterstops will be subject to rigid review for misalignment, bubbles, inadequate bond, porosity, cracks, offsets, discoloration, charring, and other defects which would reduce the potential resistance of the material to water pressure at any point. All defective joints shall be replaced with material which will pass said review and all faulty material shall be removed from the site and disposed of by the Contractor at no additional cost to the Owner.
- E. Retrofit waterstops shall be installed as shown on Contract Drawings using approved waterstop adhesive and Type 316 stainless steel batten bars and expansion anchors.
- F. Waterstop installation and splicing defects which are unacceptable include, but are not limited to the following:
 - 1. Tensile strength less than 80 percent of parent material.
 - 2. Overlapped (not spliced) Waterstop.
 - 3. Misalignment of waterstop geometry at any point greater than 1/16 inch.
 - 4. Visible porosity or charred or burnt material in weld area.
 - 5. Visible signs of splice separation when splice (24 hours or greater) is bent by hand at sharp angle.

3.02 WATERPROOF MEMBRANE PATCH AND HYDROPHILIC WATERSTOPS

- A. Patches and waterstops shall be installed only where shown on the Drawings.
- B. Patches and waterstops shall be installed in strict accordance with manufacturer's recommendations.

3.03 WATERSTOP ADHESIVE

- A. Adhesive shall be applied to both contact surfaces in strict accordance with manufacturer's recommendations.
- B. Adhesive shall be used where waterstops are attached to existing concrete surfaces.

3.04 INSTALLATION OF EXPANSION JOINT MATERIAL AND SEALANTS

- A. Type I, II, or III shall be used in all expansion joints in structures and concrete pavements unless specifically shown otherwise on the Drawings. Type IV shall be used in sidewalk and curbing and other locations specifically shown on the Drawings.

- B. All expansion joints exposed in the finish work, exterior and interior, shall be sealed with the specified joint sealant. Expansion joint material and sealants shall be installed in accordance with manufacturer's recommended procedures and as shown on the Drawings.
- C. Expansion joint material that will be exposed after removal of forms shall be cut and trimmed to ensure a neat appearance and shall completely fill the joint except for the space required for the sealant. The material shall be held securely in place and no concrete shall be allowed to enter the joint or the space for the sealant and destroy the proper functions of the joint.
- D. A bond breaker shall be used between expansion joint material and sealant. The joint shall be thoroughly clean and free from dirt and debris before the primer and the sealant are applied. Where the finished joint will be visible, masking of the adjoining surfaces shall be carried out to avoid their discoloration. The sealant shall be neatly tooled into place and its finished surfaces shall present a clean and even appearance.
- E. Type 1 joint sealant shall be used in all expansion and crack inducing joints in concrete, except where other specific types are required as stated below, and wherever else specified or shown on the Drawings. Sealant shall be furnished in pour grade or gun grade depending on installation requirements. Primers shall be used as required by the manufacturer. The sealant shall be furnished in colors as directed by the Engineer.
- F. Type 8 joint sealant shall be used in all concrete pavements and floors subject to heavy traffic and wherever else specified or shown on the Drawings.
- G. Type 7 joint sealant shall be used for all joints in chlorine contact tanks and wherever specified or shown on the Drawings.

3.05 EXPANSION JOINT SEAL

- A. The expansion joint seal system shall be installed as shown on the Drawings in strict accordance with the manufacturer's recommendations.

3.06 CRACK INDUCING JOINT INSERTS

- A. For joints in slabs, inserts shall be floated in fresh concrete during finishing.
- B. For joints in walls, inserts shall be secured in place prior to casting wall.
- C. Inserts shall be installed true to line at the locations of all joints as shown on the Drawings.
- D. Inserts shall extend into concrete sufficient depth as indicated on the Drawings or specified in Section 03 15 16 – Joints in Concrete.

- E. Inserts shall not be removed from concrete until concrete has cured sufficiently to prevent chipping or spalling of joint edges due to inadequate concrete strength.

3.07 EPOXY BONDING AGENT

- A. The Contractor shall use an epoxy bonding agent for bonding fresh concrete to existing concrete as shown on the Drawings.
- B. Bonding surface shall be clean, sound, and free of all dust, laitance, grease, form release agents, curing compounds, and any other foreign particles.
- C. Application of bonding agent shall be in strict accordance with manufacturer's recommendations.
- D. Fresh concrete shall not be placed against existing concrete if epoxy bonding agent has lost its tackiness.

3.08 EPOXY RESIN BINDER

- A. Epoxy resin binder shall be used to seal all existing rebar cut and burned off during demolition operations. Exposed rebar shall be burned back 1/2-inch minimum into existing concrete and the resulting void filled with epoxy resin binder.

3.09 BEARING PADS

- A. Care shall be taken in fabricating pads and related metal parts so effects detrimental to the proper performance of the pads, such as uneven bearing and excessive bulging, will not occur.

END OF SECTION

SECTION 03 15 16
JOINTS IN CONCRETE

PART 1 – GENERAL

1.01 THE REQUIREMENTS

- A. Provide all materials, labor and equipment required for the construction of all joints in concrete specified herein and shown on the Drawings.
- B. Types of joints in concrete shall be defined as follows:
 - 1. Construction Joints – Intentionally created formed joints between adjacent concrete placements with 100% of reinforcement continuous through joint.
 - 2. Expansion Joints – Formed joints in concrete which separate adjacent sections to allow movement due to dimensional increases and reduction of adjacent sections (temperature and shrinkage). Reinforcement terminates within concrete on each side of joint. Expansion joints may also be considered isolation joints.
 - 3. Contraction Joints – Formed joints in concrete to create interface between concrete placements to allow movement due to dimensional reduction of adjacent sections (shrinkage).
 - a. Full Contraction Joints – Formed contraction joints with no bonded reinforcement passing through the joint.
 - b. Partial Contraction Joints – Formed contraction joints with no more than 50% of bonded reinforcement passing through the joint.
 - 4. Crack Inducing Joints – Joints formed, tooled, or sawcut in a monolithic placement to create a weakened plane to regulate the location of crack formation due to dimensional reduction of adjacent sections (shrinkage).

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 03 11 00 – Concrete Formwork
- B. Section 03 15 00 – Concrete Accessories
- C. Section 03 30 00 – Cast-in-Place Concrete
- D. Section 07 90 00 – Joint Fillers, Sealants and Caulking

1.03 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

- A. Without limiting the generality of the other requirements of the specifications, all work herein shall conform to the applicable requirements of the following documents. All referenced specifications, codes, and standards refer to the most current issue available at the time of Bid.
 - 1. ACI 301 – Specifications for Structural Concrete for Buildings
 - 2. ACI 318 – Building Code Requirements for Structural Concrete
 - 3. ACI 350 – Code Requirements for Environmental Engineering Concrete Structures
 - 4. ACI 224.3 – Joints in Concrete Construction

1.04 SUBMITTALS

- A. Submit the following in accordance with Section 01 33 00 – Submittal Procedures.
 - 1. Layout drawings showing location and type of all joints to be placed in each structure.
 - 2. Details of proposed joints in each structure.
 - 3. For sawcut crack-inducing joints, submit documentation indicating the following:
 - a. Proposed method of sawcutting indicating early entry or conventional sawing.
 - b. Description of how work is to be performed including equipment to be utilized, size of crew performing the work and curing methods.
 - c. Description of alternate method in case of time constraint issues or failure of equipment.

PART 2 – MATERIALS

2.01 MATERIALS

- A. All materials required for joint construction shall comply with Section 03 15 00 - Concrete Accessories and Section 07 90 00 – Joint Fillers, Sealants and Caulking.

PART 3 – EXECUTION

3.01 CONSTRUCTION JOINTS

- A. Construction joints shall be as shown on the Drawings. Otherwise, Contractor shall submit description of the joint and proposed location to Engineer for approval. All joints shall be construction joints or expansion joints unless otherwise specified on the Drawings or approved by the Engineer on the joint plan submittal.
- B. Unless noted otherwise on the Drawings, construction joints shall be located near the middle of the spans of slabs, beams, and girders unless a beam intersects a girder at this point. In this case, the joints in the girders shall be offset a distance equal to twice the width of the beam. Joints in walls and columns shall be at the underside of floors, slabs, beams, or girders and the top of footings or floor slabs unless noted otherwise on Drawings. Beams, girders, brackets, column capitals, haunches, and drop panels shall be placed at the same time as slabs. Joints shall be perpendicular to the main reinforcement.
- C. Maximum distance between horizontal joints in slabs and vertical joints in walls shall be 50'-0". For exposed walls with fluid or earth on the opposite side, the spacing between vertical and horizontal joints shall be a maximum of 25'-0".
- D. All corners shall be part of a continuous placement, and should a construction joint be required, the joint shall not be located closer than five feet from a corner.
- E. All reinforcing steel and welded wire fabric shall be continued across construction joints. Keys and inclined dowels shall be provided as shown on the Drawings or as directed by the Engineer. Longitudinal keys shall be provided in all joints in walls and between walls and slabs or footings, except as specifically noted otherwise on the Drawings. Size of keys shall be as shown on the Drawings.
- F. All joints in water bearing structures shall have a waterstop. All joints below grade in walls or slabs which enclose an accessible area shall have a waterstop.
- G. Joint plan of walls and slabs shall consider aspect ratio to create placement of sections as close to square as possible. Aspect ratio is defined as the ratio of plan dimensions for slab sections and length to height placement of wall sections. Aspect ratios shall be between 0.65 and 1.5.

3.02 EXPANSION JOINTS

- A. Size and location of expansion joints shall be as shown on the Drawings. All joints shall be construction joints or expansion joints unless otherwise specified on the Drawings or approved by the Engineer on the joint plan submittal.

- B. All expansion joints in water-bearing structures shall have a center-bulb type waterstop. All expansion joints below grade in walls or slabs which enclose an accessible area shall have a center-bulb type waterstop. Waterstop shall be as shown on Drawings and specified in Section 03 15 00 – Concrete Accessories.

3.03 CONTRACTION JOINTS

- A. Contraction joints shall be located as shown on the Drawings or otherwise approved by the Engineer on the joint plan submittal. Contractor shall submit proposed locations and details of all contraction joints concurrent or prior to submission of reinforcement drawings. Use of contraction joints at locations not specifically detailed on the Drawings requires Engineer approval and will only be considered if meeting the stipulations herein.
- B. Full contraction joints may be considered where the structural behavior of the element allows termination of all reinforcement through joint without compromise of structural integrity of element.
- C. Partial contraction joints may be considered where the structural behavior of the element requires partial continuation of reinforcement through joint to ensure structural integrity.
- D. Where full contraction joints are allowed, maximum distance between horizontal contraction joints in slab and vertical contraction joints in walls shall be 50'-0". For exposed walls with fluid or earth on the opposite side, spacing between vertical and horizontal contraction joints shall be a maximum of 25'-0".
- E. Bond breaker shall be provided between sections for all contraction joints.
- F. Joint plan of walls and slabs shall consider aspect ratio to create placement of sections as close to square as possible. Aspect ratio is defined as the ratio of plan dimensions for slab sections and length to height placement of wall sections. Aspect ratios shall be between 0.65 and 1.5.

3.04 CRACK INDUCING JOINTS

- A. Location of crack inducing joints shall be as shown on the Drawings or submitted by Contractor and approved by Engineer.
- B. Crack inducing joints shall be formed either by saw cutting, tooling, or use of approved inserts as specified in Section 03 15 00 – Concrete Accessories.
- C. If approved by the Engineer, saw cutting of crack inducing joints in lieu of forming or tooling shall conform to the following requirements:
 - 1. Joints shall be sawed as soon as the concrete can support foot traffic without leaving any impression, normally the same day as concrete is placed and in no case longer than 24 hours after concrete is placed.

2. Curing shall be performed using wet curing methods as indicated in Section 03 39 00 – Concrete Curing. Curing mats, fabrics or sheeting materials shall remain in place to the extent possible while cutting of joint is being performed. Curing materials shall only be removed as required and shall be immediately reinstalled once cutting of the joint has been completed.
 3. Depth of joint shall be as shown on the drawings or noted in these specifications. At locations where the joint cannot be installed to full depth due to curbs or other stopping points hand tools shall be used to complete joints.
 4. Saw cut joints shall meet the requirements of ACI 224.3, Section 2.8, Jointing Practice.
- D. Unless noted otherwise on Drawings, depth of crack inducing joints shall be 1-1/2 inches in reinforced concrete and 1/3 of concrete thickness in unreinforced concrete.

3.05 JOINT PREPARATION

- A. No concrete shall be allowed to enter the joint or the space for the sealant and destroy the proper functions of the joint.
- B. The surface of the concrete at all joints shall be thoroughly cleaned and all laitance removed by wire brushing, air or light sand blasting.
- C. The joint shall be thoroughly clean and free from dirt and debris before the primer and the sealant are applied. Where the finished joint will be visible, masking of the adjoining surfaces shall be carried out to avoid their discoloration. The sealant shall be neatly tooled into place and its finished surface shall present a clean and even appearance.
- D. All joints shall be sealed as shown on the Drawings and specified in Section 03 15 00 – Concrete Accessories.

END OF SECTION

SECTION 03 21 00
REINFORCING STEEL

PART 1 – GENERAL

1.01 THE REQUIREMENTS

- A. Provide all concrete reinforcing including all cutting, bending, fastening and any special work necessary to hold the reinforcing steel in place and protect it from injury and corrosion in accordance with the requirements of this section.
- B. Provide deformed reinforcing bars to be grouted into reinforced concrete masonry walls.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 03 11 00 – Concrete Formwork
- B. Section 03 15 00 – Concrete Accessories
- C. Section 03 30 00 – Cast-in-Place Concrete
- D. Section 03 40 00 – Precast Concrete
- E. Section 04 20 00 – Unit Masonry

1.03 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

- A. Without limiting the generality of the other requirements of the specifications, all work herein shall conform to the applicable requirements of the following documents. All referenced specifications, codes, and standards refer to the most current issue available at the time of Bid.
 - 1. Building Code for the State or Commonwealth in which the project is located.
 - 2. CRSI - Concrete Reinforcing Institute Manual of Standard Practice
 - 3. ACI MNL-66 - ACI Detailing Manual
 - 4. ACI 315 - Details and Detailing of Concrete Reinforcing
 - 5. ACI 318 - Building Code Requirements for Structural Concrete
 - 6. WRI - Manual of Standard Practice for Welded Wire Fabric
 - 7. ASTM A 615 - Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement

8. ASTM A706 – Standard Specification for Deformed and Plain Low-Alloy Steel Bars for Concrete Reinforcement
9. ASTM A 1064 - Standard Specification for Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete
10. ASTM E 3121 – Standard Test Methods for Field Testing of Anchors in Concrete or Masonry

1.04 SUBMITTALS

A. Submit the following in accordance with Section 01 33 00 – Submittal Procedures.

1. Detailed placing and shop fabricating drawings, prepared in accordance with ACI 315 and ACI Detailing Manual - (MNL-66), shall be furnished for all concrete reinforcing. These drawings shall be made to such a scale as to clearly show joint locations, openings, and the arrangement, spacing and splicing of the bars.
2. Detailed placing and shop fabricating drawings, prepared in accordance with ACI 315 and ACI Detailing Manual - (MNL-66), shall be furnished for all deformed bar reinforcing used in masonry. These drawings shall be made to such a scale as to clearly show joint locations, openings, and the arrangement, locations, spacing and splicing of the bars.
3. Mill test certificates - 3 copies of each.
4. Description of the reinforcing steel manufacturer's marking pattern.
5. Requests to relocate any bars that cause interferences or that cause placing tolerances to be violated.
6. Proposed supports for each type of reinforcing.
7. Request to use splices not shown on the Drawings.
8. Request to weld reinforcement.
9. Request to use mechanical couplers along with manufacturer's literature on mechanical couplers with instructions for installation, and certified test reports on the couplers' performance, including International Code Council–Evaluation Services Report (ICC-ES ESR)..
10. Request for placement of column dowels without the use of templates.
11. Request and procedure to field bend or straighten partially embedded reinforcing.

12. International Code Council–Evaluation Services Report (ICC-ES ESR) for dowel adhesives.
13. Certification that all installers of dowel adhesive systems in horizontal to vertically overhead applications are certified as Adhesive Anchor Installers in accordance with the ACI-CRSI Anchor Installer Certification Program.
14. Adhesive dowel testing plan.

1.05 QUALITY ASSURANCE

- A. If requested by the Engineer, the Contractor shall provide samples from each load of reinforcing steel delivered in a quantity adequate for testing. Costs of initial tests will be paid by the Owner. Costs of additional tests due to material failing initial tests shall be paid by the Contractor.
- B. Provide a list of names of all installers who are trained by the Manufacturer's Field Representative on this jobsite prior to installation of products. Record must include the installer name, date of training, products included in the training and trainer name and contact information.
- C. Provide a copy of the current ACI/CRSI "Adhesive Anchor Installer" certification cards, or equivalent, for all installers who will be installing adhesive anchors in the horizontal to vertically overhead orientation.
- D. Special inspections for adhesive dowels shall be conducted in accordance with the manufacturer's instructions and Specification Section 01 45 33 – Special Inspections. Downward installations require periodic inspection and horizontal and overhead installations require continuous inspection.

PART 2 – PRODUCTS

2.01 REINFORCING STEEL

- A. Bar reinforcing shall conform to the requirements of ASTM A 615 for Grade 60 deformed billet-steel reinforcing unless noted otherwise. All reinforcing steel shall be from domestic mills and shall have the manufacturer's mill marking rolled into the bar which shall indicate the producer, size, type, and grade. All reinforcing bars shall be deformed bars. Smooth reinforcing bars shall not be used unless specifically called for on Drawings.
 1. Reinforcement to be welded shall conform to the requirements of ASTM A706, Grade 60.

- B. Welded wire fabric reinforcing shall conform to the requirements of ASTM A 1064 and the details shown on the Drawings.
- C. A certified copy of the mill test on each load of reinforcing steel delivered showing physical and chemical analysis shall be provided, prior to shipment. The Engineer reserves the right to require the Contractor to obtain separate test results from an independent testing laboratory in the event of any questionable steel. When such tests are necessary because of failure to comply with this Specification, such as improper identification, the cost of such tests shall be borne by the Contractor.
- D. Use of coiled reinforcing steel will not be allowed.

2.02 ACCESSORIES

- A. Accessories shall include all necessary chairs, slab bolsters, concrete blocks, tie wires, dips, supports, spacers, and other devices to position reinforcing during concrete placement. Wire bar supports shall be plastic protected (CRSI Class 1).
- B. Concrete blocks (dobies), used to support and position bottom reinforcing steel, shall have the same or higher compressive strength as specified for the concrete in which it is located.

2.03 MECHANICAL COUPLERS

- A. Mechanical couplers shall comply with ACI 318 Type 2 and develop a tensile strength which exceeds 100 percent of the ultimate tensile strength and 125 percent of the yield strength of the reinforcing bars being spliced. The reinforcing steel and coupler used shall be compatible for obtaining the required strength of the connection.
- B. Where the type of coupler used is composed of more than one component, all components required for a complete splice shall be supplied by the same coupler manufacturer.
- C. Hot forged sleeve type couplers shall not be used. Acceptable mechanical couplers are Dayton Superior Dowel Bar Splicer System by Dayton Superior, Dayton, Ohio, or approved equal. Mechanical couplers shall only be used where shown on the Drawings or where specifically approved by the Engineer.
- D. Tension-compression mechanical splices may only be used where shown on the Drawings or where specifically approved by the Engineer. Tension-compression mechanical splices shall be shear screw coupling sleeve type. Acceptable mechanical couplers are Bar Lock L-series or XL-series couplers by Dayton Superior, Dayton, Ohio, or approved equal.

- E. Dowel bar mechanical splices shall only be used at construction joints where shown on the Drawings or where specifically approved by the Engineer. Acceptable dowel bar mechanical couplers are the DBDI Splicing System by Dayton Superior, Dayton, Ohio, or approved equal.
- F. Where the threaded rebar to be inserted into the coupler reduces the diameter of the bar, the threaded rebar piece and all components of the coupler system shall be provided by the same coupler manufacturer.
- G. Mechanical couplers shall have a valid evaluation report from ICC-ES in accordance with the Building Code.
- H. All mechanical couplers shall be installed in accordance with the manufacturer's recommendations.

2.04 DOWEL ADHESIVE SYSTEM

- A. Where shown on the Drawings, reinforcing bars anchored into hardened concrete with a dowel adhesive system shall use a two-component adhesive mix which shall be injected with a static mixing nozzle following manufacturer's instructions.
- B. All holes shall be drilled in accordance with the manufacturer's instructions except that core drilled holes shall not be permitted unless specifically allowed by the Engineer. Cored holes, if allowed by the manufacturer and approved by the Engineer, shall be roughened in accordance with manufacturer's requirements.
- C. Thoroughly clean drill holes of all debris, drill dust, and water in accordance with manufacturer's instructions prior to installation of adhesive and reinforcing bar.
- D. Degree of hole dampness shall be in strict accordance with manufacturer recommendations. Installation conditions shall be dry, or water saturated unless otherwise permitted by the engineer. If water saturated installation is approved, appropriate reduction factors in accordance with manufacturer's design requirements should be considered. Water filled or submerged holes shall not be permitted unless specifically approved by the Engineer.
- E. Injection of adhesive into the hole shall be performed in a manner to minimize the formation of air pockets in accordance with the manufacturer's instructions.
- F. Embedment Depth:
 - 1. The embedment depth of the bar shall be as shown on the Drawings. Although all manufacturers listed below are permitted, the embedment depth shown on the

Drawings is based on "Pure 110+" by DeWalt" ESR 3298 issued 7/2020. If the Contractor submits one of the other named dowel adhesives from the list below, the Engineer shall evaluate the required embedment and the Contractor shall provide the required embedment depth stipulated by the Engineer specific to the approved dowel adhesive.

2. Where the embedment depth is not shown on the Drawings, the embedment depth shall be determined to provide the minimum allowable bond strength equal to the tensile strength of the rebar according to the manufacturer's ICC-ES ESR.
3. The embedment depth shall be determined using design parameters listed below. In no case shall the embedment depth be less than the minimum, or more than the maximum, embedment depths stated in the manufacturer's ICC-ES ESR.
4. Design of adhesive anchor system shall be based on the following parameters:
 - a. Actual compressive strength of concrete.
 - b. Cracked concrete state.
 - c. Dry or water saturated condition for installation.
 - d. Base material temperature between 40- and 104-degrees Fahrenheit.
 - e. Installation with either a hammer drill with carbide bit or hollow-drill bit system drilling methods.
 - f. Minimum age of concrete of 21 days at time of installation.
- G. Engineer's approval is required for use of this system in locations other than those shown on the Drawings.
- H. The adhesive system shall be IBC compliant for use in both cracked and uncracked concrete in all Seismic Design Categories and shall be "HIT-HY 200 Adhesive Anchoring System" as manufactured by Hilti, Inc. "SET-3G Epoxy Adhesive Anchors" as manufactured by Simpson Strong-Tie Co. or "Pure 110+ Epoxy Adhesive Anchor System" by DeWalt. Fast-set epoxy formulations shall not be acceptable. No or equal products will be considered, unless pre-qualified and approved.
- I. All individuals installing dowel adhesive systems in horizontal to vertically overhead applications shall be certified as an Adhesive Anchor Installer in accordance with the ACI-CRSI Anchor Installation Certification Program, or equivalent.

PART 3 – EXECUTION

3.01 FABRICATION

- A. Reinforcing steel shall be accurately formed to the dimensions and shapes shown on the Drawings and the fabricating details shall be prepared in accordance with ACI 315 and ACI 318, except as modified by the Drawings.
- B. The Contractor shall fabricate reinforcing bars for structures in accordance with the bending diagrams, placing lists and placing Drawings.
- C. No fabrication shall commence until approval of Shop Drawings has been obtained. All reinforcing bars shall be shop fabricated unless approved to be bent in the field. Reinforcing bars shall not be straightened or bent in a manner that will injure the material. Heating of bars will not be permitted.
- D. Welded wire fabric with longitudinal wire of W9.5 size or smaller shall be either furnished in flat sheets or in rolls with a core diameter of not less than 10 inches. Welded wire fabric with longitudinal wires larger than W9.5 size shall be furnished in flat sheets only.

3.02 DELIVERY, STORAGE AND HANDLING

- A. All reinforcing shall be neatly bundled and tagged for placement when delivered to the job site. Bundles shall be properly identified for coordination with mill test reports.
- B. Reinforcing steel shall be stored above ground on platforms or other supports and shall always be protected from the weather by suitable covering. Reinforcing steel shall be stored in an orderly manner and plainly marked to facilitate identification.
- C. Reinforcing steel shall always be protected from conditions conducive to corrosion until concrete is placed around it.
- D. The surfaces of all reinforcing steel and other metalwork to be in contact with concrete shall be thoroughly cleaned of all dirt, grease, loose scale and rust, grout, mortar and other foreign substances immediately before the concrete is placed. Where delay in depositing concrete occurs, reinforcing shall be inspected again and if necessary recleaned.

3.03 PLACING

- A. Reinforcing steel shall be accurately positioned as shown on the Drawings and shall be supported and wired together to prevent displacement, using annealed iron wire ties or suitable clips at intersections. All reinforcing steel shall be supported by concrete, plastic or plastic protected (CRSI Class 1) metal supports, spacers or metal hangers which are strong and rigid enough to prevent any displacement of the reinforcing steel. Where concrete is to be placed on the ground, supporting concrete blocks (or dobies) shall be

used in sufficient numbers to support the reinforcing bars without settlement. In no case shall concrete block supports be continuous.

- B. The portions of all accessories in contact with the formwork shall be made of plastic or steel coated with a 1/8-inch minimum thickness of plastic which extends at least 1/2 inch from the concrete surface. Plastic shall be gray in color.
- C. Tie wires shall be bent away from the forms to provide the specified concrete coverage.
- D. Reinforcing bars additional to those shown on the Drawings, which may be found necessary or desirable by the Contractor for the purpose of securing reinforcing in position, shall be provided by the Contractor at no additional cost to the Owner.
- E. Reinforcing placing, spacing, and protection tolerances shall be within the limits specified in ACI 318 except where in conflict with the Building Code, unless otherwise specified.
- F. Reinforcing bars may be moved within one bar diameter as necessary to avoid interference with other concrete reinforcing, conduits, or embedded items. If bars are moved more than one bar diameter, or enough to exceed placing tolerances, the resulting arrangement of bars shall be as acceptable to the Engineer.
- G. Welded wire fabric shall be supported on slab bolsters spaced not less than 30 inches on centers, extending continuously across the entire width of the reinforcing mat and supporting the reinforcing mat in the plane shown on the Drawings.
- H. Reinforcing shall not be straightened or bent unless specifically shown on the drawings. Bars with kinks or bends not shown on the Drawings shall not be used. Coiled reinforcement shall not be used.
- I. Dowel Adhesive System shall be installed in strict conformance with the manufacturer's recommendations and as required in Article 2.04 above. A representative of the manufacturer must be on site prior to adhesive dowel installation to provide instruction on proper installation procedures for all adhesive dowel installers. Testing of adhesive dowels shall be as indicated below. If the dowels have a hook at the end to be embedded in subsequent work, an approved mechanical coupler shall be provided at a convenient distance from the face of existing concrete to facilitate adhesive dowel testing while maintaining required hook embedment in subsequent work.
- J. All adhesive dowel installations in the horizontal or overhead orientation shall be conducted by a certified Adhesive Anchor Installer as certified by ACI/CSRI Adhesive Anchor Installer Certification program, or equivalent, per ACI 318-19 26.7. Current AAI Certificates must be submitted to the Engineer for approval prior to commencement of any adhesive anchor installations.
- K. Adhesive Dowel Testing

1. At all locations where adhesive dowels are shown on the Drawings, at least 10 percent of all adhesive dowels installed shall be tested to 80% of the yield load of the reinforcing bar, with a minimum of one tested dowel per group.
2. Contractor shall submit a plan and schedule indicating locations of dowels to be tested, load test values, and proposed dowel testing procedure (including a diagram of the testing equipment proposed for use) prior to conducting any testing. Proof testing procedures shall be in accordance with ASTM E 3121 for confined testing.
3. Where Contract Documents indicate adhesive dowel design is the Contractor's responsibility, the Contractor shall submit a plan and schedule indicating locations of dowels to be tested and load test values, sealed by a Professional Engineer currently registered in the State or Commonwealth in which the project is located. The Contractor shall also submit documentation indicating the Contractor's testing procedures have been reviewed and the proposed procedures are acceptable.
4. Adhesive Dowel shall have no visible indications of displacement or damage during or after the load test. Dowels exhibiting damage shall be removed and replaced. If more than 5 percent of tested dowels fail, then 100 percent of dowels shall be load tested.
5. When special inspections are not required for the installation, load testing of adhesive dowels shall be performed by an independent testing laboratory retained directly by the Contractor. The Contractor shall be responsible for costs of all testing, including additional testing required due to previously failed tests. If special inspections are required for installation, the independent testing laboratory shall be retained directly by the Owner.

3.04 SPLICING

- A. Reinforcing bar splices shall only be used at locations shown on the Drawings. When necessary to splice reinforcing at points other than where shown, the splice shall be as acceptable to the Engineer.
- B. The length of lap for reinforcing bars, unless otherwise shown on the Drawings shall be in accordance with ACI 318 for a class B splice.
- C. Laps of welded wire fabric shall be in accordance with ACI 318. Adjoining sheets shall be securely tied together with No. 14 tie wire, one tie for each 2 running feet. Wires shall be staggered and tied in such a manner that they cannot slip.
- D. Mechanical splices shall be used only where shown on the drawings or when approved by the Engineer. Splices shall also meet the requirements of Section 2.03.

- E. Mechanical couplers for dowel bar mechanical splices at construction joints which are located at a joint shall be a type which can be set either flush or recessed from the concrete surface. The couplers shall be sealed during concrete placement to eliminate concrete, or cement paste from entering. After the concrete is placed, couplers intended for future connections shall be plugged and sealed to prevent any contact with water or other corrosive materials. Threaded couplers shall be plugged with plastic plugs which have an O-ring seal.

3.05 WELDING OF REINFORCEMENT

- A. Welding of reinforcement shall only occur where shown on the Drawings or where specifically approved by the Engineer.
- B. Welding shall comply with all requirements of AWS D1.4.
- C. Welding shall be performed by certified welders in conformance with AWS D1.4.
- D. Material of reinforcement to be welded shall be as specified in Section 2.01.A.1.

3.06 INSPECTION

- A. The Contractor shall advise the Engineer of his intentions to place concrete and shall allow him adequate time to inspect all reinforcing steel before concrete is placed.
- B. The Contractor shall advise the Engineer of his intentions to place grout in masonry walls and shall allow him adequate time to inspect all reinforcing steel before grout is placed.

3.07 CUTTING OF EMBEDDED REBAR

- A. The Contractor shall not cut embedded rebar cast into structural concrete without prior approval.

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SECTION 03 30 00
CAST-IN-PLACE CONCRETE

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. Provide all labor, equipment, materials, and services necessary for the manufacture, transportation, and placement of all plain and reinforced concrete work, as shown on the Drawings or as required by the Engineer.
- B. The requirements in this section shall apply to the types of concrete listed below. See Article 2.10 for concrete mix design and properties of concrete.
 - 1. Class A1 Concrete: Normal weight structural concrete to be used in all structures qualifying as environmental concrete structures designed in accordance with ACI 350 including any structures containing water, wastewater or any other fluid, process chemicals, or other materials used in treatment process.
 - 2. Class A2 Concrete: Normal weight structural concrete in all structures other than structures as described above, and for all sidewalks and pavement.
 - 3. Class A3 Concrete: Normal weight structural concrete to be used for interior slabs where a Type “D” Steel Troweled Finish or Type “G” Hardened Finish is required. Class A3 concrete shall not contain entrained air.
 - 4. Class A6 Concrete: Normal weight structural concrete to be used for superstructure frames as specifically required on Contract Drawings. Superstructure frames are concrete moment frame structures and include elevated slabs placed integrally with frames. Where concrete frames are placed monolithic with elevated slabs and a Type “D” Steel Troweled or Type “G” Hardened Finish is required for the slabs, Class A6 concrete shall not contained entrained air.
 - 5. Class B Concrete: Normal weight structural concrete used for duct bank encasements, catch basins, fence and guard post embedment, concrete fill, and other areas where specifically noted on Contract Drawings.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 03 11 00 – Concrete Formwork
- B. Section 03 21 00 – Reinforcing Steel

- C. Section 03 15 00 – Concrete Accessories
- D. Section 03 15 16 – Joints in Concrete
- E. Section 03 35 00 – Concrete Finishes
- F. Section 03 39 00 – Concrete Curing
- G. Section 03 60 00 – Grout

1.03 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

- A. Without limiting the generality of the Specifications, all work herein shall conform to or exceed the applicable requirements of the following documents. All referenced specifications, codes, and standards refer to the most current issue available at the time of Bid.
 - 1. International Building Code
 - 2. ACI 214 – Guide to Evaluation of Strength Test Results of Concrete
 - 3. ACI 301 – Specifications for Structural Concrete
 - 4. ACI 304 – Guide for Measuring, Mixing, Transporting, and Placing Concrete
 - 5. ACI 305 – Specification for Hot Weather Concreting
 - 6. ACI 306 – Standard Specification for Cold Weather Concreting
 - 7. ACI 309R – Guide for Consolidation of Concrete
 - 8. ACI 318 – Building Code Requirements for Structural Concrete and Commentary
 - 9. ACI 350 – Code Requirements for Environmental Engineering Concrete Structures
 - 10. ASTM C 31 – Standard Practice for Making and Curing Concrete Test Specimens in the Field
 - 11. ASTM C 33 – Standard Specification for Concrete Aggregates
 - 12. ASTM C 39 – Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
 - 13. ASTM C42 – Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete

14. ASTM C 88 – Standard Test Method for Soundness of Aggregates by use of Sodium Sulfate or Magnesium Sulfate
15. ASTM C 94 – Standard Specification for Ready-Mixed Concrete
16. ASTM C 114 – Standard Test Method for Chemical Analysis of Hydraulic Cement
17. ASTM C 136 – Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
18. ASTM C 138 – Standard Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete
19. ASTM C 143 – Standard Test Method for Slump of Hydraulic Cement Concrete
20. ASTM C 150 – Standard Specification for Portland Cement
21. ASTM C 157 - Standard Test Method for Length Change of Hardened Hydraulic Cement, Mortar and Concrete
22. ASTM C 172 – Standard Practice for Sampling Freshly Mixed Concrete
23. ASTM C 192 – Standard Practice for Making and Curing Concrete Test Specimens in the Laboratory
24. ASTM C 231 – Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
25. ASTM C 260 – Standard Specification for Air-Entraining Admixtures for Concrete
26. ASTM C 295 – Standard Guide for Petrographic Examination of Aggregates for Concrete
27. ASTM C 457 – Standard Test Method for Microscopical Determination of the Air-Void System in Hardened Concrete
28. ASTM C 494 – Standard Specification for Chemical Admixtures for Concrete
29. ASTM C 595 – Standard Specification for Blended Hydraulic Cements
30. ASTM C 618 – Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
31. ASTM C 989 – Standard Specification for Slag Cement for Use in Concrete and Mortars

32. ASTM C 1012 – Standard Test Method for Length Change of Hydraulic Cement Mortars Exposed to a Sulfate Solution
33. ASTM C 1077 – Standard Practice for Agencies Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Testing Agency Evaluation
34. ASTM C 1157 – Standard Performance Specification for Hydraulic Cement
35. ASTM C 1260 – Test Method for Potential Alkali Reactivity of Aggregates (Mortar Bar Method)
36. ASTM C 1567 – Standard Test Method for Determining the Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials and Aggregate (Accelerated Mortar-Bar Method)
37. ASTM C 1579 – Standard Test Method for Evaluating Plastic Shrinkage Cracking of Restrained Fiber Reinforced Concrete (Using a Steel Form Insert)
38. ASTM C 1602 – Standard Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete
39. ASTM C 1609 – Standard Test Method for Flexural Performance of Fiber Reinforced Concrete (Using Beam with Third-Point Loading)
40. ASTM C 1778 – Standard Guide for Reducing the Risk of Deleterious Alkali – Aggregate Reaction in Concrete

1.04 SUBMITTALS

- A. Submit the following in accordance with Section 01 33 00 – Submittal Procedures.
 1. Sources of all materials and certifications of compliance with specifications for all materials.
 2. Certified current (less than 6 months old) chemical analysis (mill test report) of the Portland Cement or Blended Cement to be used. The chemical analysis must include the equivalent alkali content of the Portland Cement or Blended Cement. For Type IL cement, submit updated cement mill test reports every 6 months while active concrete work is being performed.
 3. Certified current (less than 1 year old) chemical analysis of fly ash or slag cement to be used.
 4. Aggregate test results showing compliance with required standards, i.e., sieve analysis, potential reactivity, aggregate soundness tests, petrographic analysis, mortar bar expansion testing, etc.

5. Manufacturer's data on all admixtures stating compliance with required standards.
6. Concrete mix design for each class of concrete specified herein.
7. Verification that concrete mix and individual constituents in concrete meet requirements for NSF 61 approval for potable water applications where required.
8. Field experience records and/or trial mix data for the proposed concrete mixes for each class of concrete specified herein.
9. Drying shrinkage test results from trial concrete mixes.

1.05 QUALITY ASSURANCE

- A. Tests on materials used in the production of concrete shall be required as specified in Part 2 – Products. These tests shall be performed by an independent testing laboratory approved by the Engineer at no additional cost to the Owner.
- B. Trial concrete mixes shall be tested when required in accordance with Article 3.01 at no additional cost to the Owner. Where historical data is utilized for mix design verification, submit certified cement chemical analysis (mill test report) for the historical concrete.
- C. Field quality control tests, as specified in Article 3.10, unless otherwise stated, will be performed by a materials testing consultant employed by the Owner. However, the Contractor shall be charged for the cost of any additional tests and investigation on work performed which does not meet the Specifications. Any individual who samples and tests concrete to determine if the concrete is being produced in accordance with this Specification shall be certified as a Concrete Field-Testing Technician, Grade I, in accordance with ACI CP-2. Testing laboratory shall conform to requirements of ASTM C-1077.

1.06 CONCRETE COORDINATION CONFERENCE

- A. Unless waived by the Engineer, prior to any concrete submittals and at least 35 days prior to the start of the concrete construction schedule, the Contractor shall conduct a meeting at the site. The purpose of the meeting is to review the proposed concrete mix designs, to discuss the proposed approaches and procedures for mixing, transporting, placing, testing, finishing, and curing of all aspects of concrete work to ensure the concrete construction is performed in accordance with the Specifications, and to clarify roles of the parties involved. The Contractor shall send a concrete coordination conference agenda to all attendees 20 days prior to a mutually agreed upon date for the conference.

- B. As a minimum the agenda shall include:
1. Concrete Materials and Mix Designs
 2. Inspection Responsibilities
 3. Concrete Sampling and Testing Specification Requirements
 4. Cylinder Storage and Transportation
 5. Acceptance/Rejection Responsibility and Authority for Fresh Concrete
 6. Concrete finishing
 7. Concrete Curing
 8. Test Report Distribution
 9. Miscellaneous Items
- C. The Contractor shall require responsible representatives of every party who is concerned with the concrete work to attend the conference, including but not limited to the following:
1. Contractor's superintendent
 2. Engineer
 3. Owner's representative (if they chose to attend)
 4. Laboratory retained for trial batching and construction quality control testing for the concrete.
 5. Any subcontractors involved in placing, finishing, and curing of concrete.
 6. Concrete supplier
 7. Concrete pumping subcontractor (if pumping is being proposed)
- D. Minutes of the meeting shall be recorded, typed, and printed by the Contractor and distributed to all attendees and any other concerned parties within five days of the meeting.

PART 2 – PRODUCTS

2.01 NSF/ANSI STANDARD 61 CERTIFIED CONCRETE

- A. NSF/ANSI Standard 61 certified concrete is required only where the concrete is uncoated and in contact with potable water, the volume of water is less than 350,000 gallons, and the ratio of the concrete surface area in contact with potable water to the volume of water exceeds 0.8 square inches per liter for static water conditions or 0.08 square inches per liter for flowing water conditions. The following structures and utilities require this certification:
 - 1. GAC Facility's flumes and contactors
 - 2. Modifications to the existing Water Treatment Facility structures
- B. Potable water is water at the start of flash mixing in drinking water treatment plants, and at all locations downstream of flash mixing in the water treatment, storage, and distribution system. Concrete surface area in contact with potable water shall include submerged surfaces and surfaces above the water where water can condense and drip back into the water.
- C. Where NSF/ANSI certified concrete is required by the paragraphs above, certification of compliance with NSF/ANSI Standard 61 shall be included with the concrete mix design submittal(s) and shall be provided by either one of the following two options:
 - 1. NSF/ANSI Standard 61 certified testing of concrete aggregates, hydraulic cement, and supplemental cementitious materials shall be provided individually for each constituent showing that each constituent complies with NSF/ANSI Standard 61
 - 2. NSF/ANSI Standard 61 testing of concrete cylinders formed from the trial batch concrete containing all the proposed constituents of the concrete shall be provided showing that the concrete mix complies with NSF/ANSI Standard 61.
- D. Regardless of whether NSF/ANSI Standard 61 certified concrete is required by the paragraphs above, all admixtures used in concrete where the concrete is uncoated and in contact with potable water shall be individually tested and confirm to follow NSF/ANSI Standard 61.

2.02 HYDRAULIC CEMENT

- A. Portland Cement

1. Portland Cement shall be Type II conforming to ASTM C 150. Type I cement may be used provided either fly ash or slag cement is also included in the mix in accordance with Articles 2.03 or 2.04, respectively.
2. The proposed Portland Cement shall not contain more than 8% tricalcium aluminate and more than 12% tetracalcium aluminoferrite.
3. Portland Cement shall also meet performance requirements of ASTM C 1157.

B. Blended Cement

1. Blended cements shall be Type IP (Portland Fly Ash Cement), Type IS (Portland Slag Cement), or Type IL (Portland Limestone Cement) conforming to ASTM C 595.
2. Type IP cement shall be an inter-ground blend of Portland Cement and fly ash in which the fly ash constituent is between 15% and 25% of the weight of the total blend.
3. Type IS cement shall be an inter-ground blend of Portland Cement and slag cement in which the slag cement constituent is between 30% and 40% of the weight of the total blend.
4. Type IL cement shall be an inter-ground blend of Portland Cement and limestone in which the limestone constituent is between 5% and 15% of the weight of the total blend.
5. Fly ash, slag cement, and limestone used in the production of blended cements shall meet the requirements of Articles 2.03, 2.04, and 2.05 respectively.
6. Cements meeting ASTM C 1157 shall not be used in manufacture of blended cements.
7. Blended cement shall meet the Physical Requirements of Tables 2 and 3 of ASTM C 595 including the requirements for high sulfate resistance in Table 3 as tested per ASTM C1012.

- C. Different types of cement shall not be mixed, nor shall they be used alternately except when authorized in writing by the Engineer. For Type IP, Type IS or Type I/II cement, different brands of cement or the same brand from different mills may be used alternately. For Type IL cement, use of a different cement brand or same brand from a different mill requires resubmittal of the mix design with current mill test report for review. A resubmittal will be required if different cements are proposed during the Project.

- D. Cement shall be stored in a suitable weather-tight building to prevent deterioration or contamination. Cement which has become caked, partially hydrated, or otherwise damaged will be rejected.

2.03 FLY ASH

- A. Fly ash shall meet the requirements of ASTM C 618 for Class F, except that the loss on ignition shall not exceed 4%. Fly ash shall also meet the optional physical requirements for uniformity as shown in Table 3 of ASTM C 618. Fly ash shall be considered as a supplemental cementitious material.
- B. For fly ash to be used in the production of Type IP cement, the Pozzolan Activity Index shall be greater than 75% as specified in Table 3 of ASTM C 595.
- C. Where reactive aggregates as defined in Article 2.08 are used in the concrete mix, the fly ash constituent shall be as needed to satisfy the concrete alkali loading requirements stipulated in Section 2.06. The percentage of fly ash shall also be set to meet the mean mortar bar expansion requirements in provisions of Article 2.08.G.2. Where fly ash is used, the minimum fly ash content shall be 15%.
- D. For Type A1 concrete as required for use in environmental concrete structures, i.e., process structures or fluid containing structures, inclusion of fly ash or slag cement in the concrete mix, is mandatory.
- E. Additional fly ash shall not be included in concrete mixed with Type IS or IP cement.

2.04 SLAG CEMENT

- A. Slag cement shall meet the requirements of ASTM C 989 including tests for effectiveness of slag in preventing excessive expansion due to alkali-aggregate reactivity as described in Appendix X-3 of ASTM C 989.
- B. Where reactive aggregates as defined in Article 2.08 are used in concrete mix, the slag cement constituent shall be as needed to satisfy the concrete alkali loading requirements stipulated in Section 2.06. The percentage of slag cement shall also be set to meet the mean mortar bar expansion requirements in provisions of Article 2.08.G.2. Where Slag Cement is used, the minimum Slag Cement content shall be 30%, and the maximum Slag Cement content shall be 40%.
- C. For Type A1 concrete as required for use in environmental concrete structures, i.e., process structures or fluid containing structures, inclusion of fly ash or slag cement in the concrete mix, is mandatory.
- D. Additional slag cement shall not be included in concrete mixed with Type IS or IP cement.

2.05 PORTLAND LESTONE CEMENT (TYPE IL)

- A. Portland Limestone Cement (Type IL) cement shall meet the requirements of ASTM C 595.
- B. Limestone used for blended cement Type IL shall be naturally occurring and meet the requirements of ASTM C 33.
- C. Fly ash or slag cement shall be used with Type IL cement to meet requirements for durability, ASR resistance, sulfate resistance, and use for environmental structures, as specified herein.

2.06 CONCRETE ALKALI LOADING

- A. All concrete mixes containing potentially reactive aggregates shall have a maximum alkali loading of the concrete of 3.0 pounds per cubic yard.
- B. The alkali loading of concrete is the Portland Cement equivalent alkali content multiplied by the Portland Cement content of the mix in pounds per cubic yard divided by 100. The Portland Cement equivalent alkali content shall be included in the certified chemical analysis of the Portland Cement.
- C. Means of evaluating alkali loading of concrete and proportioning constituents of concrete to minimize alkali loading of content shall also conform to the guidelines of ASTM C1778.

2.07 WATER

- A. Water used for mixing concrete shall be clear, potable, and free from deleterious substances such as objectionable quantities of silty organic matter, alkali, salts, and other impurities.
- B. Water shall not contain more than 100 PPM chloride.
- C. Water shall not contain more than 500 PPM dissolved solids.
- D. Water shall have a pH in the range of 4.5 to 8.5.
- E. Water shall meet requirements of ASTM C 1602.

2.08 AGGREGATES

- A. All aggregates used in normal weight concrete shall conform to ASTM C 33.
- B. Fine Aggregate (Sand) in the various concrete mixes shall consist of natural or manufactured siliceous sand, clean and free from deleterious substances, and graded within the limits of ASTM C 33.

- C. Coarse aggregates shall consist of hard, clean, durable gravel, crushed gravel, or crushed rock. Coarse aggregate shall be size #57 or #67 as graded within the limits given in ASTM C 33 unless otherwise specified.
- D. For Class A4 and A7 concrete, coarse aggregate shall be Size #8 in accordance with ASTM C33.
- E. Aggregates shall be tested for gradation by sieve analysis tests in conformance with ASTM C 136.
- F. Aggregates shall be tested for soundness in accordance with ASTM C 88. The loss resulting after five cycles shall not exceed 10 percent for fine or coarse aggregate when using either magnesium sulfate or sodium sulfate.
- G. All aggregates shall be evaluated in accordance with ASTM C 1778 to determine potential reactivity. All aggregates shall be considered reactive unless they meet the requirements below for non-reactive aggregates. Aggregates with a lithology like sources in the same region found to be reactive in service shall be considered reactive regardless of the results of the tests above.
 - 1. Non-reactive aggregates shall meet the following requirements:
 - a. A petrographic analysis in accordance with ASTM C295 shall be performed to identify the constituents of the fine and coarse aggregate. Non-reactive aggregates shall meet the following limitations:
 - 1) Optically strained, micro-fractured, or microcrystalline quartz, 5.0%, maximum.
 - 2) Chert or chalcedony, 3.0%, maximum.
 - 3) Tridymite or cristobalite, 1.0%, maximum.
 - 4) Opal, 0.5%, maximum.
 - 5) Natural volcanic glass in volcanic rocks, 3.0%, maximum.
 - 2. Concrete mixed with reactive aggregates shall meet the following requirements:
 - a. If aggregates are deemed potentially reactive as per ASTM C1778 and fly ash or slag cement is included in proposed concrete mix design, proposed concrete mix including proposed aggregates shall be evaluated by ASTM C-1567. Mean mortar bar expansions at 16 days shall be less than 0.08%. Tests shall be made using exact proportion of all materials proposed for use on the job in design mix submitted.

- b. If aggregates are deemed potentially reactive as per ASTM C-1778 and a straight cement mix without fly ash or slag cement is proposed for concrete mix design, aggregates shall be evaluated by ASTM C-1260. Mean mortar bar expansions at 16 days shall be less than 0.08%.
 - c. If the proposed aggregates are deemed potentially reactive, the concrete mix shall be evaluated and confirmed to meet the requirements for concrete alkali loading as stipulated in Section 2.06.
- H. Contractor shall submit a new trial mix to the Engineer for approval whenever a different aggregate or gradation is proposed.

2.09 ADMIXTURES

- A. Admixtures containing intentionally added chlorides shall not be used.
- B. Admixtures containing 1,4 Dioxane shall not be used.
- C. Air entraining admixture shall be added to all concrete unless noted otherwise. The air entraining admixture shall conform to ASTM C 260. The admixture proposed shall be selected in advance so that adequate samples may be collected, and the required tests made. Air content of concrete, when placed, shall be within the ranges given in the concrete mix design.
- D. The following admixtures are required or used for water reduction, slump increase, and/or adjustment of initial set, and enhancing durability. Admixtures permitted shall confirm to the requirements of ASTM C 494. Admixtures shall be non-toxic after 30 days and shall be compatible with and made by the same manufacturer as the air-entraining admixtures.
 - 1. Water reducing admixture shall conform to ASTM C 494, Type A and shall contain no more than 0.05% chloride ions. Acceptable products are "Eucon Series" by the Euclid Chemical Company, "Master Pozzoloth Series or Master Polyheed Series" by Master Builders Solutions, and "Plastocrete Series" by Sika Corporation.
 - 2. High range water reducer shall conform to ASTM C 494, Type F or G. The high range water reducer shall be added to the concrete at the batch plant and may be used in conjunction with a water reducing admixture. The high range water reducer shall be accurately measured, and pressure injected into the mixer as a single dose by an experienced technician. A standby system shall be provided and tested prior to each day's operation of the job site system. Concrete shall be mixed at

mixing speed for a minimum of 100 mixer revolutions after the addition of the high range water reducer. Acceptable products are "Eucon 37" or Plastol 5000 by the Euclid Chemical Company, "Master Rheobuild 1000 or Master Glenium Series" by Master Builders Solutions, and "Daracem 100 or Advaflow Series" by W.R. Grace.

3. A non-chloride, non-corrosive accelerating admixture may be used where specifically approved by the Engineer. The admixture shall conform to ASTM C 494, Type C or E. The admixture manufacturer must have long-term non-corrosive test data from an independent testing laboratory (of at least a year's duration) using an acceptable accelerated corrosion test method such as that using electrical potential measures. Acceptable products are "MasterSet AC 534 or MasterSet FP 20" by Master Builders Solutions, "Accelguard 80/90 or NCA" by the Euclid Chemical Company and "Daraset" by W.R. Grace.
4. A retarding admixture may be used where specifically approved by the Engineer. The admixture shall conform to ASTM C494, Type B or D. Acceptable products are "Eucon NR or Eucon Retarder 100" by the Euclid Chemical Company, "MasterSet R Series or MasterSet DELVO Series" by Master Builders Solutions, and "Plastiment" by Sika Corporation.
5. Workability Retaining Admixture shall conform to ASTM C 494, Type S. The admixture shall retain concrete workability without affecting time of setting or early-age strength development. Acceptable products are "MasterSure Z 60" by Master Builders Solutions, ViscoFlow-2020 by Sika Corporation, PLASTOL AMP-X3 by Euclid Chemical Company, or equal.
6. A crystalline permeability reducing admixture shall be used where specifically indicated on the Drawings or required herein. The admixture shall conform to ASTM C 494, Type S. The admixture shall be of the crystalline type that chemically controls and permanently establishes a non-soluble crystalline structure throughout the capillary voids and cracks within the concrete. The crystalline structure shall assist in sealing the concrete to minimize both infiltration and exfiltration of liquids from any direction. The admixture shall be capable of sealing hairline cracks and resisting hydrostatic pressure. Acceptable products are "Xypex Admix C-500 NF" by Xypex Chemical Corporation, "MasterLife® 300 Series" by Master Builders Solutions, and "Krystol Internal Membrane (KIM)" by Kryton International Inc. Submit certified letter from manufacturer of crystalline admixture stating required dosage rate for job specific concrete mix. Concrete truck ticket shall confirm crystalline admixture was included in concrete being placed.

7. A shrinkage reducing admixture shall be used where specifically indicated on the drawings. Acceptable products include Tetraguard AS20 by BASF, Eclipse by W. R. Grace, Eucon SRA by Euclid Chemical Company, or equal.
- E. Admixtures containing calcium chloride, thiocyanate or more than 0.05 percent chloride ions are not permitted. The addition of admixtures to prevent freezing is not permitted.
- F. The Contractor shall submit manufacturer's data including the chloride ion content of each admixture and certification from the admixture manufacturer that all admixtures utilized in the design mix are compatible with one another and properly proportioned prior to mix design review.

2.10 CONCRETE MIX DESIGN

- A. The proportions of cement, aggregates, admixtures, and water used in the concrete mixes shall be based on laboratory trial mixes in conformance with ACI 301. Trial mixes shall also conform to Article 3.01 of this Specification. Trial mix data used as the basis for the proposed concrete mix design shall be submitted to the Engineer along with the proposed mix.
- B. Structural concrete shall conform to the following requirements. Cementitious materials refer to the total combined weight of all cement, fly ash, and slag cement contained in the mix.

1. Compressive Strength (28-Day)

Concrete Class A1, A2, A3	4,500 psi (min.)
Concrete Class A6	6,000 psi (min.)
Concrete Class B	3,000 psi (min.)

2. Water/cementitious materials ratio, by weight

	Maximum	Minimum
Concrete Class A1, A2, A3	0.42	0.39
Concrete A6	0.40	0.35
Concrete Class B	0.50	0.39

3. Slump range

- a. 4" nominal unless high range water reducing admixture is used.
- b. 10" max if high range water reducing admixture is used.

4. Air Content

Concrete Class A1, A2, A6, A7	6% $\pm$ 1.5%
Concrete Class A3, B	3% Max (non-air-entrained)

PART 3 – EXECUTION

3.01 TRIAL MIXES

- A. Trial mixes shall be used to confirm the quality of a proposed concrete mix in accordance with ACI 301. An independent qualified testing laboratory designated and retained by the Contractor shall test a trial batch of each of the preliminary concrete mixes submitted by the Contractor. The trial batches shall be prepared using the aggregates, cement, supplementary cementitious materials, and admixtures proposed for the project. The trial batch materials shall be of a quantity such that the testing laboratory can obtain enough samples to satisfy requirements stated below. Tests on individual materials stated in PRODUCTS should already be performed before any trial mix is done. The cost of laboratory trial batch tests for each specified concrete mix will be borne by the Contractor and the Contractor shall furnish and deliver the materials to the testing laboratory at no cost to the Owner.
- B. The independent testing laboratory shall prepare a minimum of fifteen (15) standard test cylinders in accordance with ASTM C 31 in addition to conducting slump (ASTM C 143), air content (C 231) and density (C 138) tests. Compressive strength test on the cylinders shall subsequently be performed by the same laboratory in accordance with ASTM C 39 as follows: Test 3 cylinders at age 7 days; test 3 cylinders at age 21 days; test 3 cylinders at age 28 days and test 3 cylinders at 56 days. The cylinders shall be carefully identified as "Trial Mix, Contract No. ". If the average 28-day compressive strength of the trial mix is less than that specified, or if any single cylinder falls below the required strength by more than 500 psi, the mix shall be corrected, another trial batch prepared, test cylinders taken, and new tests performed as before. Any such additional trial batch testing required shall be performed at no additional cost to the Owner. Adjustments to the mix shall be considered refinements to the mix design and shall not be the basis for extra compensation to the Contractor.

3.02 SHRINKAGE TESTS

- A. Concurrent with the trial batch requirements stated in Article 3.01, the testing laboratory shall perform drying shrinkage tests for the trial batches as specified herein. Shrinkage testing is only required for concrete to be used for environmental concrete structures (Class A1).

- B. Fabricate, cure, dry, and measure specimens in accordance with ASTM C157 modified as follows.
1. Remove specimens from molds at an age of 23 hours $\pm$ 1 hour after trial batching.
 2. Place specimens immediately in water at 70 °F $\pm$ 3 °F for at least 30 minutes.
 3. Measure within 30 minutes thereafter to determine original length, then submerge in saturated lime water at 73 °F $\pm$ 3 °F.
 4. At age seven days, measure to determine expansion, expressed as a percentage of original length. This length at age seven days shall be the base length for drying shrinkage calculations (zero days' drying age).
 5. Store specimens immediately in a humidity-controlled room maintained at 73 °F $\pm$ 3 °F and 50 percent $\pm$ 4 percent relative humidity for the remainder of the test.
 6. Make and report separately measurements to determine shrinkage expressed as base length percentage for 7, 14, 21, and 28 days of drying after 7 days of moist curing.
- C. Compute the drying shrinkage deformation for each specimen as the difference between the base length (at zero days' drying age) and the length after drying at each test age. Compute the average drying shrinkage deformation for the specimens to the nearest 0.0001 inch at each test age. If the drying shrinkage for any specimen departs from the average test age for that test by more than 0.0004 inch, disregard the results obtained from that specimen. Report results from the shrinkage test to the nearest 0.001 percent of shrinkage. Take compression test specimens in each case from the same concrete used for preparing drying shrinkage specimens. These tests shall be considered part of the normal compression tests for the project.
- D. The maximum concrete shrinkage for specimens cast in the laboratory from the trial batch, as measured at 21-day drying age or at 28-day drying age, shall be 0.036 or 0.042 percent, respectively. Use a mix design for construction that has first met the trial batch shrinkage requirements.
- E. If the trial batch specimens do not meet both the strength and shrinkage requirements, revise the mix designs and/or materials and retest.

3.03 PRODUCTION OF CONCRETE

- A. All concrete shall be machine mixed. Hand mixing of concrete will not be permitted. The Contractor may supply concrete from a ready-mix concrete plant or from a site mixed plant. In selecting the source for concrete production, the Contractor shall carefully consider its capability for providing quality concrete at a rate commensurate with the

requirements of the placements so that well bonded, homogenous concrete, free of cold joints, is assured.

B. Ready-Mixed Concrete

1. At the Contractor's option, ready-mixed concrete may be used meeting the requirements for materials, batching, mixing, transporting, and placing as specified herein and in accordance with ASTM C 94.
2. Truck mixers shall be equipped with electrically actuated counters by which the number of revolutions of the drum or blades may be readily verified. The counter shall be of the resettable, recording type, and shall be mounted in the driver's cab. The counters shall be actuated at the time of starting mixers at mixing speeds.
3. Each batch of concrete shall be mixed in a truck mixer for not less than 100 revolutions of the drum or blades at the rate of rotation designated by the manufacturer of equipment. Additional mixing, if any, shall be at the speed designated by the manufacturer of the equipment as agitating speed. All materials including mixing water shall be in the mixer drum before actuating the revolution counter for determining the number of revolutions of mixing.
4. Truck mixers and their operation shall be such that the concrete throughout the mixed batch, as discharged, is within acceptable limits of uniformity with respect to consistency, mix and grading. If slump tests taken at approximately the 1/4 and 3/4 points of the load during discharge give slumps differing by more than one inch when the specified slump is 3 inches or less, or if they differ by more than 2 inches when the specified slump is more than 3 inches, the mixer shall not be used on the work unless the causing condition is corrected and satisfactory performance is verified by additional slump tests. All mechanical details of the mixer, such as water measuring and discharge apparatus, condition of the blades, speed of rotation, general mechanical condition of the unit and clearance of the drum, shall be checked before a further attempt to use the unit will be permitted.
5. Ready-mixed concrete shall be delivered to the site for the work and discharge shall be completed within the time requirements stated in Article 3.04 of this Section.
6. Every concrete delivery shall be accompanied by a delivery ticket containing at least the following information:
 - a. Date and truck number
 - b. Ticket number
 - c. Mix designation of concrete

- d. Cubic yards of concrete
 - e. Cement brand, type, and weight in pounds
 - f. Weight in pounds of fine aggregate (sand)
 - g. Weight in pounds of coarse aggregate (stone)
 - h. Air entraining agent, brand, and weight in pounds and ounces
 - i. Other admixtures, brand, and weight in pounds and ounces
 - j. Water, in gallons, stored in attached tank
 - k. Water, in gallons, maximum that can be added without exceeding design water/cementitious materials ratio
 - l. Water, in gallons, used (by truck driver)
 - m. Time of loading
 - n. Time of delivery to job (by truck driver)
- 7. Any truck delivering concrete to the job site, which is not accompanied by a delivery ticket showing the above information will be rejected and such truck shall immediately depart from the job site.
 - 8. The use of non-agitating equipment for transporting ready-mixed concrete will not be permitted. Combination truck and trailer equipment for transporting ready-mixed concrete will not be permitted. The quality and quantity of materials used in ready-mixed concrete and in batch aggregates shall be subject to inspection at the batching plant by the Engineer.

C. Site Mixed Concrete

- 1. Site Mixed Concrete shall only be used where specifically approved by the Engineer.
- 2. Scales for weighing concrete ingredients shall be accurate when in use within ± 0.4 percent of their total capacities. Standard test weights shall be available to permit checking scale accuracy.
- 3. Operation of batching equipment shall be such that the concrete ingredients are consistently measured within the following tolerances:
 - a. Cement, fly ash, or slag cement ± 1 percent

- b. Water ± 1 percent
 - c. Aggregates ± 2 percent
 - d. Admixtures ± 3 percent
4. Each batch shall be so charged into the mixer that some water will enter in advance of the cement and aggregates. Water shall continue for a period which may extend to the end of the first 25 percent of the specified mixing time. Controls shall be provided to prevent batched ingredients from entering the mixer before the previous batch has been completely discharged.
 5. The concrete shall be mixed in a batch mixer capable of thoroughly combining the aggregates, cement, and water into a uniform mass within the specified mixing time, and of discharging the concrete without harmful segregation. The mixer shall bear a manufacturer's rating plate indicating the rate capacity and the recommended revolutions per minute and shall be operated in accordance therewith.
 6. Mixers with a rated capacity of one cubic yard or larger shall conform to the requirements of the Plant Mixer Manufacturers' Division of the Concrete Plant Manufacturers' Bureau.
 7. Except as provided below, batches of one cubic yard or less shall be mixed for not less than one minute. The mixing time shall be increased 15 seconds for each cubic yard or fraction thereof of additional capacity.
 8. Shorter mixing time may be permitted provided performance tests made in accordance with of ASTM C 94 indicate that the time is sufficient to produce uniform concrete.
 9. Controls shall be provided to ensure that the batch cannot be discharged until the required mixing time has elapsed. At least three-quarters of the required mixing time shall take place after the last of the mixing water has been added.
 10. The interior of the mixer shall be free of accumulations that will interfere with mixing action. Mixer blades shall be replaced when they have lost 10 percent of their original height.
 11. Air-entraining admixtures and other chemical admixtures shall be charged into the mixer as solutions and shall be measured by means of an approved mechanical dispensing device. The liquid shall be considered a part of the mixing water. Admixtures that cannot be added in solution may be weighed or may be measured by volume if recommended by the manufacturer.

12. If two or more admixtures are used in the concrete, they shall be added separately to avoid possible interaction that might interfere with the efficiency of either admixture or adversely affect the concrete.
13. Addition of retarding admixtures shall be completed within one minute after addition of water to the cement has been completed, or prior to the beginning of the last three-quarters of the required mixing, whichever occurs first. Retarding admixtures shall not be used unless approved by the Engineer.
14. Concrete shall be mixed only in quantities for immediate use and within the time and mixing requirements of ASTM C 94.

3.04 CONCRETE PLACEMENT

- A. No concrete shall be placed prior to approval of the concrete mix design. Concrete placement shall conform to the recommendations of ACI 304.
- B. Prior to concrete placement, all reinforcement shall be securely and properly fastened in its correct position. Formwork shall be clean, oiled and form ties at construction joints shall be retightened. All bucks, sleeves, castings, hangers, pipe, conduits, bolts, anchors, wire, and any other fixtures required to be embedded therein shall be in place. Forms for openings to be left in the concrete shall be in place and anchored by the Contractor. All loose debris in bottoms of forms or in keyways shall be removed and all debris, water, snow, ice, and foreign matter shall be removed from the space to be occupied by the concrete. The Contractor shall notify the Engineer in advance of placement, allowing sufficient time for a concurrent inspection and for any corrective measures required.
- C. On horizontal joints where concrete is to be placed on hardened concrete, flowing concrete containing a high range water reducing admixture shall be placed with a slump not less than 8 inches for the initial placement at the base of the wall. Concrete or cement grout shall meet all strength and service requirements specified herein for applicable class of concrete. This concrete shall be worked well into the irregularities of the hard surface.
- D. All concrete shall be placed during the daylight hours except with the consent of the Engineer. If special permission is obtained to carry on work during the night, adequate lighting must be provided.
- E. When concrete arrives at the project with slump below that suitable for placing, as indicated by the Specifications, water may be added to bring the concrete within the specified slump range provided the design water-cementitious materials ratio is not exceeded. The water shall be incorporated by additional mixing equal to at least half of the total mixing required. Water may be added only to full trucks. On-site tempering shall not relieve the Contractor from furnishing a concrete mix meeting all specified requirements.

- F. Concrete shall be conveyed as rapidly as practical to the point of deposit by methods which prevent the separation or loss of the ingredients. The concrete shall be deposited so that additional handling will be unnecessary. Discharge of the concrete to its point of deposit shall be completed within 90 minutes after the addition of the cement to the aggregates unless workability-retaining admixtures are included and approved by the Engineer. In hot weather, or under conditions contributing to quick stiffening of the concrete, the time between the introduction of the cement to the aggregates and discharge shall not exceed the requirements stated in Article 3.09 of this Section.
- G. Where concrete is conveyed to position by chutes, a continuous flow in the chute shall be maintained. The angle and discharge arrangement of the chute shall be such to prevent segregation of the concrete ingredients. The delivery end of the chute shall be as close as possible to the point of deposit and in no case shall the free pour from the delivery end of the chute exceed five feet, unless approved otherwise.
- H. Special care must be exercised to prevent splashing of forms or reinforcement with concrete, and any such splashes or accumulations of hardened or partially hardened concrete on the forms or reinforcement above the general level of the concrete already in place must be removed before the work proceeds.
- I. Placing of concrete shall be regulated so the pressure caused by the wet concrete shall not exceed that used in the design of the forms.
- J. All concrete for walls shall be placed through openings in the form spaced at frequent intervals or through tremies (heavy duct canvas, rubber, etc.), equipped with suitable hopper heads. Tremies shall be of variable lengths so the free fall shall not exceed five (5) feet, and enough tremies shall be placed in the form to ensure the concrete remains level.
- K. When placing concrete which will be exposed, sufficient illumination shall be provided in the interior of the forms so the concrete, at places of deposit, is visible from deck and runways.
- L. Concrete shall be placed to thoroughly embed all reinforcement, inserts, and fixtures.
- M. When forms are removed, surfaces shall be even and dense, free from aggregate pockets or honeycomb. Concrete shall be consolidated using mechanical vibration, supplemented by forking and spading by hand in the corners and angle of forms and along form surfaces while the concrete is plastic under the vibratory action. Consolidation shall conform to ACI 309.
- N. Mechanical vibration shall be applied directly to the concrete, unless otherwise approved by the Engineer. The bottom of vibrators used on floor slabs must not be permitted to ride the form supporting the slab. Vibration shall be applied at the point of deposit and in freshly placed concrete by a vertical penetration of the vibrator. Vibrators shall not be used to move concrete laterally within the forms.

- O. The intensity of vibration shall be sufficient to cause settlement of the concrete into place and to produce monolithic joining with the preceding layer. Vibration shall be of sufficient duration to accomplish thorough compaction and complete embedment of reinforcement and fixtures with a vibrator transmitting not less than 7,500 impulses per minute. Since the duration of vibration per square foot of surface is dependent on the frequency (impulses per minute), size of vibrator, and slump of concrete, the length of time must therefore be determined in the field. Vibration shall not be continued in any one location to the extent that pools of grout are formed.
- P. Care shall be taken to prevent cold joints when placing concrete in any portion of the work. The concrete placing rate shall ensure that each layer is placed while the previous layer is soft or plastic, so the two layers can be made monolithic by penetration of the vibrators. Maximum thickness of concrete layers shall be 18 inches. The surface of the concrete shall be level whenever a run of concrete is stopped.
- Q. To prevent featheredges, construction joints located at the tops of horizontal lifts near sloping exposed concrete surfaces shall be inclined near the exposed surface, so the angle between such inclined surface and the exposed concrete surface will be not less than 50°.
- R. In placing unformed concrete on slopes, the concrete shall be placed ahead of a non-vibrated slip-form screed extending approximately 2-1/2 feet back from its leading edge. The method of placement shall provide a uniform finished surface with the deviation from the straight line less than 1/8 inch in any concrete placement. Concrete ahead of the slip-form screed shall be consolidated by internal vibrators to ensure complete filling under the slip-form. Prior to placement of concrete on sloped walls or slabs, the Contractor shall submit a plan specifically detailing methods and sequence of placements, proposed concrete screed equipment, location of construction joints and water stops, and/or any proposed deviations from the stated requirements to the Engineer for review and approval.
- S. Concrete shall not be placed during rains sufficiently heavy or prolonged to prevent washing of mortar from coarse aggregate on the forward slopes of the placement. Once placement of concrete has commenced in a block, placement shall not be interrupted by diverting the placing equipment to other uses.

3.05 PLACING FLOOR SLABS ON GROUND

- A. The subgrade for slabs on ground shall be well drained and of adequate and uniform loadbearing nature. The in-place density of the subgrade soils shall be at least the minimum required by the specifications. No foundation, slab, or pavement concrete shall be placed until the depth and character of the foundation soils have been inspected and approved by the materials testing consultant.

- B. The subgrade shall be free of frost before concrete placing begins. If the temperature inside a building where concrete is to be placed is below freezing, the temperature shall be raised and maintained above 50° long enough to remove all frost from the subgrade.
- C. The subgrade shall be moist at the time of concreting. If necessary, the subgrade shall be dampened with water in advance of concreting, but no free water shall remain standing on the subgrade nor any muddy or soft spots when the concrete is placed.
- D. Thirty-pound felt-paper shall be provided between edges of slabs-on-ground and vertical and horizontal concrete surfaces, unless otherwise indicated on the Drawings.
- E. Contraction joints shall be provided in slabs-on-ground at locations indicated on the Drawings. Contraction joints shall be installed as per Section 03 15 16 – Joints in Concrete.
- F. Floor slabs shall be screeded level or pitched to drain as indicated on the Drawings. Finishes shall conform with requirements of Section 03 35 00 – Concrete Finishes. Interior floor slabs shall be placed with non-air-entrained concrete (Class A3) if a steel troweled or hardened finish is required.

3.06 PLACING CONCRETE UNDER PRESSURE

- A. Where concrete is conveyed and placed by mechanically applied pressure, the equipment shall have the capacity for the operation. The operation of the pump shall produce a continuous stream of concrete without air pockets. To obtain the least line resistance, the layout of the pipeline system shall contain minimum bends with no change in pipe size. If two sizes of pipe must be used, the smaller diameter should be used at the pump end and the larger at the discharge end. When pumping is completed, the concrete remaining in the pipelines shall be ejected in such a manner that there will be no contamination of the concrete or separation of the ingredients.
- B. Priming of the concrete pumping equipment shall be with cement grout only. Use of specialty mix pump primers or pumping aids will not be allowed.
- C. No aluminum parts shall be in contact with the concrete during the placing of concrete under pressure.
- D. Prior to placing concrete under pressure, the Contractor shall submit the concrete mix design together with test results from a material's testing consultant proving the proposed mix meets all requirements. In addition, an actual pumping test under field conditions is required prior to acceptance of the mix. This test requires a duplication of anticipated site conditions from beginning to end. The batching and truck mixing shall be the same as will be used during construction, and the pipe and pipe layouts will reflect the maximum height and distance contemplated. All submissions shall be subject to approval by the Engineer.

- E. If the pumped concrete does not produce satisfactory end results, the Contractor shall discontinue the pumping operation and proceed with the placing of concrete using conventional methods.
- F. The pumping equipment must have two cylinders and be designed to operate with one cylinder only in case the other one is not functioning. In lieu of this requirement, the Contractor may have a standby pump on the site during pumping.
- G. The minimum diameter of the hose (conduits) shall be four inches.
- H. Pumping equipment and hoses (conduits) that are not functioning properly shall be replaced.
- I. Concrete samples for quality control in accordance with Article 3.10 will be taken at the placement (discharge) end of the line.

3.07 ORDER OF PLACING CONCRETE

- A. To minimize the effects of shrinkage, the concrete shall be placed in units as bounded by construction joints shown on the Drawings and maximum lengths as indicated on Drawings. Where required on the Drawings and wherever else practical, the placing of such units shall be done in a strip pattern in accordance with ACI 302.1. A minimum of 72 hours shall pass prior to placing concrete directly adjacent to previously placed concrete.

3.08 CONCRETE WORK IN COLD WEATHER

- A. Cold weather concreting procedures shall conform to the requirements of ACI 306.1.
- B. The Engineer may prohibit the placing of concrete at any time when air temperature is 40°F. or lower. If concrete work is permitted, the concrete shall have a minimum temperature, as placed, of 55°F. for placements less than 12" thick, 50°F. for placements 12" to 36" thick, and 45°F. for placements greater than 36" thick. The temperature of the concrete as placed shall not exceed these minimum values by more than 20°F, unless otherwise approved by the Engineer.
- C. All aggregate and water shall be preheated. Precautions shall be taken to avoid the possibility of flash set when aggregate or water are heated to a temperature greater than 100°F. to meet concrete temperature requirements. The addition of admixtures to the concrete to prevent freezing is not permitted. All reinforcement, forms, and concrete accessories shall be defrosted by an approved method. No concrete shall be placed on frozen ground.

3.09 CONCRETE WORK IN HOT WEATHER

- A. Hot weather concreting procedures shall conform to the requirements of ACI 305.1.

- B. When air temperatures exceed 85°F., or when extremely dry or high wind conditions exist even at lower temperatures, the Contractor and the Contractor's concrete supplier shall exercise special and precautionary measures in preparing, delivering, placing, finishing, curing, and protecting the concrete mix. The Contractor shall consult with the Engineer regarding such measures prior to each day's placing operation, and the Engineer reserves the right to modify the proposed measures consistent with the requirements herein. All necessary materials and equipment shall be in place prior to each placing operation.
- C. Preparatory work at the job site shall include thorough wetting of all forms, reinforcing steel and, in the case of slab pours on ground or subgrade, spraying the ground surface on the preceding evening and again just prior to placing. No standing puddles of water shall be permitted in those areas which are to receive the concrete.
- D. The temperature of the concrete mix when placed shall not exceed 95°F.
- E. Temperature of mixing water and aggregates shall be carefully controlled and monitored at the supplier's plant, with haul distance to the job site being considered. Stockpiled aggregates shall be shaded from the sun and sprinkled intermittently with water. If ice is used in the mixing water for cooling purposes, the ice must be entirely melted prior to addition of the water to the dry mix.
- F. Delivery schedules shall be carefully considered in advance to ensure concrete is placed as soon as practical after mixing. For hot weather concrete work (air temperature greater than 85°F), discharge of the concrete to its point of deposit shall be completed within 60 minutes from the time the concrete is batched, unless workability-retaining admixtures are included and approved by the Engineer.
- G. The Contractor shall arrange for an ample work force to be on hand to accomplish transporting, vibrating, finishing, and covering of the fresh concrete as rapidly as possible.

3.10 QUALITY CONTROL

- A. Field Testing of Concrete
 - 1. The Contractor shall coordinate with the Engineer's project representative the on-site scheduling of the materials testing consultant personnel as required for concrete testing.
 - 2. Concrete for testing shall be supplied by the Contractor at no additional cost to the Owner, and the Contractor shall assist the materials testing consultant in obtaining samples. The Contractor shall dispose of and clean up all excess material.
- B. Consistency

1. The consistency of the concrete will be checked by the materials testing consultant by standard slump cone tests. The Contractor shall make any necessary adjustments in the mix as the Engineer and/or the materials testing consultant may direct and shall upon written order suspend all placing operations in the event the consistency does not meet the intent of the specifications. No payment shall be made for any delays, material, or labor costs due to such occurrences.
2. Slump tests shall be made in accordance with ASTM C 143. Slump tests will be performed as deemed necessary by the materials testing consultant and each time compressive strength samples are taken.
3. Concrete with a specified nominal slump shall be placed having a slump within 1" (higher or lower) of the specified slump. Concrete with a specified maximum slump shall be placed having a slump less than the specified slump.

C. Density

1. Samples of freshly mixed concrete shall be tested for density by the materials testing consultant in accordance with ASTM C 138.
2. Density tests will be performed as deemed necessary by the Engineer and each time compressive strength samples are taken.

D. Air Content

1. Samples of freshly mixed concrete will be tested for entrained air content by the materials testing consultant in accordance with ASTM C 231.
2. Air content tests will be performed as deemed necessary by the materials testing consultant and each time compressive strength samples are taken.
3. In the event test results are outside the limits specified, additional testing shall occur. Admixture quantity adjustments shall be made immediately upon discovery of incorrect air entrainment.

E. Compressive Strength

1. Samples of freshly mixed concrete will be taken by the materials testing consultant and tested for compressive strength in accordance with ASTM C 172, C 31, and C 39, except as modified herein.
2. In general, one sampling shall be taken for each placement more than five (5) cubic yards, with a minimum of one (1) sampling for each day of concrete placement operations, or for each one hundred (100) cubic yards of concrete, or for each 5,000 square feet of surface area for slabs or walls, whichever is greater.

3. Each sampling shall consist of at least five (5) 6x12 cylinders or (8) 4x8 cylinders. Each cylinder shall be identified by a tag, which shall be hooked or wired to the side of the container. The materials testing consultant will fill out the required information on the tag, and the Contractor shall satisfy themselves that such information shown is correct.
4. The Contractor shall be required to furnish labor to the Owner for assisting in preparing test cylinders. The Contractor shall provide approved curing boxes for storage of cylinders on site. The insulated curing box shall be of sufficient size and strength to contain all the cylinders made in any four consecutive working days and to protect the specimens from falling over, being jarred, or otherwise disturbed during the period of initial curing. The box shall be erected, furnished, and maintained by the Contractor. The box shall be equipped to provide the moisture conditions and to regulate the temperature necessary to maintain the proper curing conditions required by ASTM C 31. The curing box shall be placed in an area free from vibration such as pile driving and traffic of all kinds and such that all cylinders are shielded from direct sunlight and/or radiant heating sources. No concrete requiring testing shall be delivered to the site until the storage curing box has been provided. Cylinders shall remain undisturbed in the curing box until ready for delivery to the testing laboratory, but not less than sixteen hours.
5. The Contractor shall be responsible for maintaining the temperatures of the curing box during the initial curing of cylinders with the temperature preserved between 60°F and 80°F as measured by a maximum-minimum thermometer. The Contractor shall maintain a written record of curing box temperatures for each day the curing box contains cylinders. Temperature shall be recorded a minimum of three times a day with one recording at the start of the day and one recording at the end of the day.
6. When transported, the cylinders shall not be thrown, dropped, allowed to roll, or be damaged in any way.
7. Compression tests shall be performed in accordance with ASTM C 39. For 6x12 cylinders, two test cylinders will be tested at seven days and two at 28 days. For 4x8 cylinders, three test cylinders will be tested at seven days, three at 28 days. The remaining cylinders will be held to verify test results, if needed.

F. Evaluation and Acceptance of Concrete

1. Evaluation and acceptance of the compressive strength of concrete shall be according to the requirements of ACI 214, ACI 318, and ACI 350.
2. The strength level of concrete will be considered satisfactory if the following conditions are satisfied.

- a. Every arithmetic average of any three consecutive strength tests equals or exceeds the minimum specified 28-day compressive strength for the mix (see Article 2.10).
 - b. No individual compressive strength test result falls below the minimum specified strength by more than 500 psi.
 3. If any of the conditions listed above are not met, the mix proportions shall be corrected for the next concrete placing operation.
 4. If condition 3.10.F.2.b is not met, additional tests in accordance with Article 3.10, Paragraph H shall be performed.
 5. When a ratio between 7-day and 28-day strengths has been established by these tests, the 7-day strengths shall subsequently be taken as a preliminary indication of the 28-day strengths. Should the 7-day test strength from any sampling be more than 10% below the established minimum strength, the Contractor shall:
 - a. Immediately provide additional periods of curing in the affected area from which the deficient test cylinders were taken.
 - b. Maintain or add temporary structural support as required.
 - c. Correct the mix for the next concrete placement operation, if required to remedy the situation.
 6. All concrete which fails to meet the ACI requirements, and these specifications is subject to removal and replacement at no additional cost to the Owner.
- G. When non-compliant concrete is identified, test reports shall be sent immediately to the Engineer for review.
- H. Additional Tests
1. When ordered by the Engineer, additional tests on in-place concrete shall be provided and paid for by the Contractor.
 2. If the 28-day test cylinders fail to meet the minimum strength requirements as outlined in Article 3.10, Paragraph F, the Contractor shall have concrete core specimens obtained and tested from the affected area immediately.
 - a. Three cores shall be taken for each sample in which the strength requirements were not met.

- b. The drilled cores shall be obtained and tested in conformance with ASTM C 42. The tests shall be conducted by a materials testing consultant approved by the Engineer.
 - c. The location from which each core is taken shall be approved by the Engineer. Each core specimen shall be located, when possible, so its axis is perpendicular to the concrete surface and not near formed joints or obvious edges of a unit of deposit.
 - d. The core specimens shall be taken, if possible, so no reinforcing steel is within the confines of the core.
 - e. The diameter of core specimens should be at least 3 times the maximum nominal size of the coarse aggregate used in the concrete but must be at least 2-inches in diameter.
 - f. The length of specimen, when capped, shall be at least twice the diameter of the specimen.
 - g. The core specimens shall be taken to the laboratory and when transported, shall not be thrown, dropped, allowed to roll, or damaged in any way.
 - h. Two (2) copies of test results shall be mailed directly to the Engineer. The concrete in question will be considered acceptable if the average compressive strength of a minimum of three test core specimens taken from a given area equal or exceed 85% of the specified 28-day strength and if the lowest core strength is greater than 75% of the specified 28-day strength.
3. If the concrete placed by the Contractor is suspected of not having proper air content, the Contractor shall engage a materials testing consultant approved by the Engineer, to obtain and test samples for air content in accordance with ASTM C 457.

3.11 CARE AND REPAIR OF CONCRETE

- A. The Contractor shall protect all concrete against injury or damage from excessive heat, lack of moisture, overstress, or any other cause until final acceptance by the Owner. Care shall be taken to prevent the drying of concrete and to avoid roughening or otherwise damaging the surface. Care shall be exercised to avoid jarring forms or placing any strain on the ends of projecting reinforcing bars. Any concrete found to be damaged, or which may have been originally defective, or which becomes defective at any time prior to the final acceptance of the completed work, or which departs from the established line or grade, or which, for any other reason, does not conform to the requirements of the Contract Documents, shall be satisfactorily repaired or removed and replaced with acceptable concrete at no additional cost to the Owner.

- B. Areas of honeycomb shall be chipped back to sound concrete and repaired as directed.
- C. Concrete formwork blowouts or unacceptable deviations in tolerances for formed surfaces due to improperly constructed or misaligned formwork shall be repaired as directed. Bulging or protruding areas, which result from slipping or deflecting forms shall be ground flush or chipped out and redressed as directed.
- D. Areas of concrete in which cracking, spalling, or other signs of deterioration develop prior to final acceptance shall be removed and replaced or repaired as directed. This stipulation includes concrete that has experienced cracking due to drying or thermal shrinkage of the concrete. Structural cracks shall be repaired using an approved epoxy injection system. Non-structural cracks shall be repaired using an approved hydrophilic resin pressure injected grout system unless other means of repair are deemed necessary and approved. All repair work shall be performed at no additional cost to the Owner.
- E. Concrete which fails to meet the strength requirements as outlined in Article 3.10, Paragraph F, will be analyzed as to its adequacy based upon loading conditions, resultant stresses, and exposure conditions for the area of concrete in question. If the concrete in question is found unacceptable based upon this analysis, that portion of the structure shall be strengthened or replaced by the Contractor at no additional cost to the Owner. The method of strengthening or extent of replacement shall be as directed by the Engineer.

END OF SECTION

SECTION 03 35 00
CONCRETE FINISHES

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. Furnish all materials, labor, and equipment required to provide finishes of all concrete surfaces specified herein and shown on the Drawings.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 03 11 00 – Concrete Formwork
- B. Section 03 30 00 – Cast-in-Place Concrete
- C. Section 03 60 00 – Grout

1.03 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

- A. Without limiting the generality of the other requirements of the specifications, all work herein shall conform to the applicable requirements of the following documents. All referenced specifications, codes, and standards refer to the most current issue available at the time of Bid.
 - 1. ACI 301 – Specifications for Structural Concrete for Buildings
 - 2. ACI 318 – Building Code Requirements for Structural Concrete

1.04 SUBMITTALS

- A. Submit the following in accordance with Section 01 33 00 – Submittal Procedures.
 - 1. Manufacturer's literature on all products specified herein.

PART 2 – PRODUCTS

2.01 CONCRETE FLOOR SEALER

- A. Floor sealer shall be Diamond Clear VOX or Super Diamond Clear VOX by the Euclid Chemical Company, MasterKure CC 300 SB by Master Builders Solutions.

06/27/2024

2.02 CONCRETE LIQUID DENSIFIER AND SEALANT

- A. Concrete liquid densifier and sealant shall be a high performance, deeply penetrating concrete densifier and sealant. Product shall be odorless, colorless, VOC-compliant, non-yellowing siliconate based solution designed to harden, dustproof, and protect concrete floors subjected to heavy vehicular traffic and to resist black rubber tire marks on concrete surfaces. The product must contain a minimum solids content of 20% of which 50% is siliconate. Acceptable products are Diamond Hard by the Euclid Chemical Company, and Seal Hard by L&M Construction Chemicals, and Masterkure HD 200 WB by Master Builders Solutions.

PART 3 – EXECUTION

3.01 FINISHES ON FORMED CONCRETE SURFACES

- A. After removal of forms, the finishes described below shall be applied in accordance with Article 3.06 - Concrete Finish Schedule. Unless the finish schedule specifies otherwise, all surfaces shall receive at least a Type I finish. See Article 3.05 for surfaces to receive paint or protective coatings. The Engineer shall be the sole judge of acceptability of all concrete finish work.
 - 1. Type I - Rough: All fins, burrs, offsets, marks, and all other projections left by the forms shall be removed. Projections, depressions, etc. below finished grade required to be removed will only be those greater than ¼-inch. All holes left by removal of ends of ties, and all other holes, depressions, bug holes, air/blow holes or voids shall be filled solid with cement grout after first being thoroughly wetted and then struck off flush. The only holes below grade to be filled will be tie holes and any other holes larger than ¼-inch in any dimension. Honeycombs shall be chipped back to solid concrete and repaired as directed by the Engineer. All holes shall be filled with tools, such as sponge floats and trowels, that will permit packing the hole solidly with cement grout. Cement grout shall consist of one-part cement to three parts sand, epoxy bonding agent (for tie holes only) and the amount of mixing water shall be as little as consistent with the requirements of handling and placing. Color of cement grout shall match the adjacent wall surface.
 - 2. Type II - Grout Cleaned: Where this finish is required, it shall be applied after completion of Type I finish. After the concrete has been pre-dampened over an extended amount of time to reach the condition of saturated surface dry (SSD), a slurry consisting of one part cement (including an appropriate quantity of white cement to produce a color matching the surrounding concrete) and 1-1/2 parts sand passing the No. 16 sieve, by damp loose volume, shall be spread over the surface with clean burlap pads or sponge rubber floats. Mix proportions shall be submitted to the Engineer after a sample of the work is established and accepted. Any surplus shall be removed by scraping and then rubbing with clean burlap.

3. Type III - Smooth Rubbed: Where this finish is required, it shall be applied after the completion of the Type II finish. No rubbing shall be done before the concrete is thoroughly hardened and the mortar used for patching is firmly set. A smooth, uniform surface shall be obtained by wetting the surface and rubbing with a carborundum stone to eliminate irregularities. Unless the nature of the irregularities requires it, the general surface of the concrete shall not be cut into. Corners and edges shall be slightly rounded using a carborundum stone. Brush finishing or painting with grout or neat cement will not be permitted. A 100 square foot example shall be established at the beginning of the project to establish acceptability.

3.02 SLAB AND FLOOR FINISHES

- A. The finishes described below shall be applied to floors, slabs, flow channels and top of walls in accordance with Article 3.05 - Concrete Finish Schedule. The Engineer shall be the sole judge of acceptability of all such finish work.
 1. Type "A" - Screeded: This finish shall be obtained by placing screeds at frequent intervals and striking off to the surface elevation required. When a Type "F" finish is subsequently to be applied, the surface of the screeded concrete shall be roughened with a concrete rake to 1/2" minimum deep grooves prior to final set.
 2. Type "B" - Wood or Magnesium Floated: This finish shall be obtained after completion of a Type "A" finish by working a previously screeded surface with a wood or magnesium float or until the desired texture is reached. Floating shall begin when the water sheen has disappeared and when the concrete has sufficiently hardened so that a person's foot leaves only a slight imprint. If wet spots occur, water shall be removed with a squeegee. Care shall be taken to prevent the formation of laitance and excess water on the finished surface. All edges shall be edged with an 1/8-inch tool as directed by the Engineer. The finished surface shall be true, even, and free from blemishes and any other irregularities.
 3. Type "C" - Cork Floated: This finish shall be similar to Type "B" but slightly smoother than the finish obtained with a wood float. The finish shall be obtained by power or band floating with cork floats.
 4. Type "D" - Steel Troweled: This finish shall be obtained after completion of a Type "B" finish. When the concrete has hardened sufficiently to prevent excess fine material from working to the surface, the surface shall be compacted and smoothed with not less than two thorough and complete steel troweling operations. In areas which are to receive a floor covering such as tile, resilient flooring, or carpeting, the applicable Specification Sections and Contract Drawings shall be reviewed for the required finishes and degree of flatness. In areas that are intermittently wet such as pump rooms, only one troweling operation is required to

provide some trowel marks for slip resistance. All edges shall be edged with an 1/8-inch tool as directed by the Engineer. The finish shall be brought to a smooth, dense surface, free from defects and blemishes.

5. Type "E" - Broom or Belt: This finish shall provide the surface with a transverse scored texture by drawing a broom or burlap belt across the surface immediately after completion of a Type "B" finish. All edges shall be edged with an 1/8-inch tool as directed by the Engineer.

3.03 CONCRETE SEALERS

- A. Concrete sealers shall be applied where specifically required on the Contract Drawings or specified herein. Concrete sealers and densifiers shall not be used as concrete curing compounds. Curing compounds, when allowed, shall be in accordance with Section 03 39 00 – Concrete Curing.
- B. Sealers shall be applied after installation of all equipment, piping, etc. and after completion of any other related construction activities. Application of sealers shall be in strict accordance with manufacturer's requirements.
- C. Sealers shall be applied to all floor slabs not painted and not intended to be immersed.
- D. Floor slabs subjected to vehicular traffic shall be sealed with the concrete liquid densifier and sealer.
- E. All other floor slabs to receive sealer shall be sealed with concrete floor sealer.

3.04 FINISHES ON EQUIPMENT PADS

- A. Formed surfaces of equipment pads shall receive a Type III finish.
- B. Top surfaces of equipment pads, except those surfaces subsequently required to receive grout and support equipment bases, shall receive a Type "D" finish, unless otherwise noted. Surfaces which will later receive grout shall, before the concrete takes its final set, be made rough by removing the sand and cement that accumulates on the top to the extent that the aggregate will be exposed with irregular indentations in the surface up to 1/2 inch deep.

3.05 FINISHES FOR SURFACES TO RECEIVE PAINT OR COATINGS

- A. Surfaces indicated or specified to receive paint or special coatings shall be prepared per specifications in Division 09. All products applied to the concrete surfaces during the placement, finishing, and curing process shall be compatible with the painting or coating system as required by the manufacturer.

3.06 CONCRETE FINISH SCHEDULE

Item	Type of Finish
Concrete surfaces indicated to receive textured coating (as noted on Drawings and in Section 09 97 00 – Special Coatings)	I
Inner face of walls of tanks, flow channels, wet wells, perimeter walls, and miscellaneous concrete structures:	
From 1 feet below water surface to bottom of wall	I
From top of wall to 1 feet below water surface	II
Exterior concrete walls below grade	I
Exterior exposed concrete walls, ceilings, beams, manholes, hand holes, miscellaneous structures, and columns (including top of wall) to one foot below grade. All other exposed concrete surfaces not specified elsewhere	II
All interior exposed concrete walls and vertical surfaces	III
Interior exposed ceiling, including beams	III
Floors of process equipment tanks or basins, wetwells, flow channels and slabs to receive roofing material or waterproof membranes	B
All interior finish floors of buildings and structures and walking surfaces	D
Exterior concrete sidewalks, steps, ramps, decks, slabs on grade and landings exposed to weather	E

END OF SECTION

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SECTION 03 39 00
CONCRETE CURING

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. Protect all freshly deposited concrete from premature drying and from the weather elements. The concrete shall be maintained with minimal moisture loss at a relatively constant temperature for a period necessary for the hydration of the cement and proper hardening of the concrete in accordance with the requirements specified herein.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 03 11 00 – Concrete Formwork
- B. Section 03 30 00 – Cast-In-Place Concrete
- C. Section 03 35 00 – Concrete Finishes

1.03 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

- A. Without limiting the generality of the other requirements of the specifications, all work herein shall conform to the applicable requirements of the following documents. All referenced specifications, codes, and standards refer to the most current issue available at the time of Bid.
 - 1. ACI 301 – Specifications for Structural Concrete
 - 2. ACI 304 – Guide for Measuring, Mixing, Transporting, and Placing Concrete
 - 3. ACI 305.1 – Specification for Hot Weather Concreting
 - 4. ACI 306.1 – Standard Specification for Cold Weather Concreting
 - 5. ACI 308.1 – Specification for Curing Concrete
 - 6. ASTM C171 – Standard Specifications for Sheet Materials for Curing Concrete
 - 7. ASTM C309 – Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete
 - 8. ASTM C1315 – Standard Specification for Liquid Membrane-Forming Compounds Having Special Properties for Curing and Sealing Concrete

1.04 SUBMITTALS

- A. Submit the following in accordance with Section 01 33 00 – Submittal Procedures.
 - 1. Proposed procedures for protection of concrete under wet weather placement conditions.
 - 2. Proposed normal procedures for protection and curing of concrete.
 - 3. Proposed special procedures for protection and curing of concrete under hot and cold weather conditions.
 - 4. Proposed method of measuring concrete surface temperature changes.
 - 5. Manufacturer's literature and material certification for proposed curing compounds.

PART 2 – PRODUCTS

2.01 LIQUID MEMBRANE-FORMING CURING COMPOUND

- A. Clear curing and sealing compound shall be a clear styrene acrylate type complying with ASTM C 1315, Type 1, Class A with a minimum solids content of 30%. Moisture loss shall not be greater than 0.40 kg/m² when applied at manufacturer's recommended volume for square feet of area. Manufacturer's certification is required. Acceptable products are Super Diamond Clear VOX by the Euclid Chemical Company.
- B. Where specifically approved by Engineer, on slabs to receive subsequent applied finishes, compound shall conform to ASTM C 309. Acceptable products are "Kurez DR VOX" or "Kurez W VOX" by the Euclid Chemical Company. Install in strict accordance with manufacturer's requirements.

2.02 EVAPORATION REDUCER

- A. Evaporation reducer shall be "MasterKure ER 50" by Master Builders Solutions, or "Euco-Bar" by Euclid Chemical Company.

PART 3 – EXECUTION

3.01 PROTECTION AND CURING

- A. All freshly placed concrete shall be protected from the elements, flowing water and from defacement of any nature during construction operations.
- B. As soon as the concrete has been placed and horizontal top surfaces have received their required finish, provisions shall be made for maintaining the concrete in a moist

condition for at least a 7-day period thereafter, except for high early strength concrete, for which the period shall be at least the first three days after placement. Horizontal surfaces shall be kept covered, and intermittent, and localized drying will not be permitted.

- C. Walls that will be exposed on one side with either fluid or earth backfill on the opposite side shall be continuously wet cured for a minimum of seven days. Use of a curing compound will not be acceptable for applications of this type.
- D. The Contractor shall use one of the following methods to ensure that the concrete remains in a moist condition for the minimum period stated above.
 - 1. Ponding or continuous fogging or sprinkling.
 - 2. Application of mats or fabric kept continuously wet.
 - 3. Continuous application of steam (under 150°F).
 - 4. Application of sheet materials conforming to ASTM C171.
 - 5. If approved by the Engineer, application of a curing compound in accordance with Article 3.04.
- E. The Contractor shall keep absorbent wood forms wet until they are removed. After form removal, the concrete shall be cured by one of the methods in paragraph D.
- F. Any of the curing procedures used in Paragraph 3.01-D may be replaced by one of the other curing procedures listed in Paragraph 3.01-D after the concrete is one-day old. However, the concrete surface shall not be permitted to become dry at any time.

3.02 CURING CONCRETE UNDER COLD WEATHER CONDITIONS

- A. Suitable means shall be provided for a minimum of 72 hours after placing concrete to maintain it at or above the minimum as placed temperatures specified in Section 03 30 00 – Cast-In-Place Concrete, for concrete work in cold weather. During the 72-hour period, the concrete surface shall not be exposed to air more than 20°F above the minimum as placed temperatures.
- B. Stripping time for forms and supports shall be increased as necessary to allow for retardation in concrete strength caused by colder temperatures. This retardation is magnified when using concrete made with blended cements or containing fly ash or slag cement. Therefore, curing times and stripping times shall be further increased as necessary when using these types of concrete.
- C. The methods of protecting the concrete shall be approved by the Engineer and shall be such as will prevent local drying. Equipment and materials approved for this purpose

shall be on the site in sufficient quantity before the work begins. The Contractor shall assist the Engineer by providing holes in the forms and the concrete in which thermometers can be placed to determine the adequacy of heating and protection. All such thermometers shall be furnished by the Contractor in quantity and type which the Engineer directs.

- D. Curing procedures during cold weather conditions shall conform to the requirements of ACI 306.

3.03 CURING CONCRETE UNDER HOT WEATHER CONDITIONS

- A. When air temperatures exceed 85°F, the Contractor shall take extra care in placing and finishing techniques to avoid formation of cold joints and plastic shrinkage cracking. If ordered by the Engineer, temporary sunshades and/or windbreakers shall be erected to guard against such developments, including generous use of wet burlap coverings and fog sprays to prevent drying out of the exposed concrete surfaces.
- B. Immediately after screeding, horizontal surfaces shall receive an application of evaporation reducer. Apply in accordance with manufacturer's instructions. Final finish work shall begin as soon as the mix has stiffened sufficiently to support the workmen.
- C. Curing and protection of the concrete shall begin immediately after completion of the finishing operation. Continuous moist-curing consisting of method 1 or 2 listed in paragraph 3.01D is mandatory for at least the first 24 hours. Method 2 may be used only if the finished surface is not marred or blemished during contact with the coverings.
- D. At the end of the initial 24-hour period, curing and protection of the concrete shall continue for at least six (6) additional days using one of the methods listed in paragraph 3.01D.
- E. Curing procedures during hot weather conditions shall conform to the requirements of ACI 305.

3.04 USE OF CURING COMPOUND

- A. Curing compound shall be used only where specifically approved by the Engineer. Curing compound shall never be used for curing exposed walls with fluid or earth backfill on the opposite side. A continuous wet cure for a minimum of seven days is required for these applications. Curing compound shall not be used on surfaces exposed to water in potable water storage tanks and treatment plants unless curing compound is certified in accordance with ANSI/NSF Standard 61.
- B. When permitted, the curing compound shall maintain the concrete in a moist condition for the required time, and the subsequent appearance of the concrete surface shall not be affected.

- C. The compound shall be applied in strict accordance with the manufacturer's recommendations after water sheen has disappeared from the concrete surface and after finishing operations. Coverage rates for the curing and sealing compound shall be in strict accordance with manufacturer's requirements for the specific type of finish required. For rough surfaces, apply in two directions at right angles to each other.

END OF SECTION

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SECTION 03 40 00
PRECAST CONCRETE

PART 1 – GENERAL

1.01 REQUIREMENTS

- A. The Contractor shall construct all precast concrete items as required in the Contract Documents, including all appurtenances necessary to make a complete installation.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 33 05 61 – Utility Structures
- B. Section 03 21 00 – Reinforcing Steel
- C. Section 03 30 00 – Cast-in-Place Concrete
- D. Section 03 35 00 – Concrete Finishes
- E. Section 03 39 00 – Concrete Curing
- F. Section 03 60 00 – Grout
- G. Section 05 10 00 – Metal Materials
- H. Section 05 05 13 – Galvanizing
- I. Section 05 05 23 – Metal Fastening

1.03 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

- A. Without limiting the generality of other requirements of these Specifications, all work specified herein shall conform to the applicable requirements of the following documents. All referenced specifications, codes, and standards refer to the most current issue available at the time of the Bid.
 - 1. North Carolina Building Code
 - 2. ACI 301 – Structural Concrete for Buildings
 - 3. ACI 318 – Building Code Requirements for Structural Concrete
 - 4. ASTM D2240 – Standard Test for Rubber Property – Durometer Hardness

5. PCI Standard MNL-116 – Manual for Quality Control for Plants and Production of Precast and Prestressed Concrete Products
6. PCI Standard MNL-120 - Design Handbook Precast and Prestressed Concrete
7. PCI Standard MNL-123 – Manual on Design of Connections for Precast Prestressed Concrete
8. PCI Standard MNL-124 – PCI Design for Fire Resistance of Precast Prestressed Concrete

1.04 SUBMITTALS

- A. The Contractor shall submit the following for review in accordance with Section 01 33 00 – Submittal Procedures.
 1. Shop Drawings for all precast members including layout and dimensions, unit locations, unit identification marks, reinforcement connection details, support items, dimensions, openings, temporary supports, and relationship to adjacent materials. Indicate design loads, deflections, cambers, bearing requirements, and special conditions. The submittal shall be sealed by a Professional Engineer currently registered in the State or Commonwealth in which the project is located.
 2. A list of the design criteria used by the manufacturer for all manufactured, precast items.
 3. Design calculations, showing at least the design loads and stresses on the item and assumptions, shall be submitted. Calculations shall be sealed by a Professional Engineer currently registered in the in the State or Commonwealth in which the project is located.
 4. Certified reports for all lifting inserts, indicating allowable design loads.
 5. Information on lifting and erection procedures.

1.05 QUALITY ASSURANCE

- A. All manufactured precast concrete units shall be produced by an experienced manufacturer regularly engaged in the production of such items. All manufactured precast concrete and site-cast units shall be free of defects, spalls, and cracks. Care shall be taken in the mixing of materials, casting, curing, and shipping to avoid any of the above. The Engineer may elect to examine the units at the casting yard or upon arrival of the same at the site. The Engineer shall have the option of rejecting any or all the precast work if it does not meet with the requirements specified herein or on the Drawings. All rejected work shall be replaced at no additional cost to the Owner.

- B. Manufacturer Qualifications: The precast concrete manufacturing plant shall be certified by the Prestressed Concrete Institute, Plant Certification Program, prior to the start of production. Certification is required for plants providing prestressed structural members such as hollow core planks, double-T members, etc.
- C. Plant production and engineering must be under direct supervision and control of an Engineer who possesses a minimum of five years' experience in precast concrete work.
- D. Erector of precast and prestressed items shall be a company specializing in erecting members specified with a minimum of three years documented experience and specifically approved by the fabricator of precast and prestressed members specified.

PART 2 – PRODUCTS

2.01 DESIGN REQUIREMENTS

- A. Precast and prestressed members shall be designed to support superimposed loads indicated on the Drawings and as required by current Building Code of the State or Commonwealth in which the project is located. Design shall also consider loads and stresses due to handling, transporting, and erecting of units.
- B. Maximum live load deflections for members shall be $L/240$ for roof members and $L/360$ for floor members.
- C. Members shall be designed to accommodate construction tolerances, and clearances of intended openings.
- D. Design shall be performed by a qualified professional engineer registered in the State or Commonwealth in which the project is located.
- E. Fire Rating shall be established in accordance with PCI MNL 124 to achieve the fire ratings required on the Drawings for floor, wall, and roof assemblies.

2.02 CONCRETE

- A. Concrete materials including Portland cement, aggregates, water, and admixtures shall conform to Section 03 30 00 – Cast-in-Place Concrete. Precast concrete manufacturer has option of using Type III cement for prestressed concrete members to expedite release of prestressing and erection.
- B. For prestressed concrete items, minimum compressive strength of concrete at 28 days shall be 5,000 psi unless otherwise specified. Minimum compressive strength of concrete at transfer of prestressing force shall be 3,500 psi unless otherwise specified.

- C. For non-prestressed concrete items, minimum compressive strength of concrete at 28 days shall be 4,500 psi for fluid containing and other environmental concrete structures and 4,000 for other structural concrete structures, unless otherwise specified.

2.03 GROUT

- A. Grout for joints between members shall be a cement grout in conformance with Section 03 60 00 – Grout.
- B. Minimum compressive strength of grout at 7 days shall be 3,000 psi.

2.04 REINFORCING STEEL

- A. Reinforcing steel used for precast concrete construction shall conform to Section 03 21 00 – Reinforcing Steel.

2.05 STEEL INSERTS

- A. Steel inserts shall be in accordance with Section 05 10 00 – Metal Materials.
- B. All steel inserts protruding from or occurring at the surface of precast units shall be galvanized in accordance with Section 05 05 13 – Galvanizing.

2.06 WELDING

- A. Welding shall conform to Section 05 05 23 – Metal Fastening.

2.07 BEARING PADS

- A. Neoprene bearing pads shall conform to the requirements of A4-F3-T.063-B2, Grade 2, Method B, in accordance with the RMA Rubber Handbook. Pads shall be nonlaminated pads having a nominal Shore A durometer hardness of 70 in accordance with ASTM D2240. Adhesive for use with neoprene pads shall be an epoxy-resin compound compatible with the neoprene having a sufficient shear strength to prevent slippage between pads and adjacent bearing surfaces. Adhesive shall be 20+F Contact Cement by Miracle Adhesives Corporation, Neoprene Adhesive 77-198 by IGI Adhesives, Sikadur 31, Hi-Mod Gel by Sika Corporation, or DP-605 NS Urethane Adhesive by 3M Adhesive Systems.
- B. Plastic bearing pads shall be multi-monomer plastic strips which are non-leaching and support construction loads with no visible overall expansion, manufactured specifically for the purpose of bearing precast concrete.

PART 3 – EXECUTION

3.01 FABRICATION AND CASTING

- A. All precast members shall be fabricated and cast to the shapes, dimensions and lengths shown on the Drawings and in compliance with PCI MNL-116. Precast members shall be straight, true, and free from dimensional distortions, except for camber and tolerances permitted later in this clause. All integral appurtenances, reinforcing, openings, etc., shall be accurately located and secured in position. Form materials shall be steel and the systems free from leakage during the casting operation.
- B. Manufacturer shall maintain plant records and quality control program during production of precast members.
- C. Ensure reinforcing steel anchors, inserts, plates, angles, and other cast-in items are embedded and located as indicated on shop drawings.
- D. Openings with a 10-inch minimum dimension in either direction shall be cast in place. Smaller openings shall be considered in the design and arrangement of reinforcement and strands. These openings may be field cut, but only in the size and location approved by the precast manufacturer.
- E. All cover of reinforcing shall be the same as detailed on the Drawings.
- F. Because of the critical nature of the bond development length in prestressed concrete panel construction, if the transfer of stress is by burning of the fully tensioned strands at the ends of the member, each strand shall first be burned at the ends of the bed and then at each end of each member before proceeding to the next strand in the burning pattern.
- G. The Contractor shall coordinate the communication of all necessary information concerning openings, sleeves, or inserts to the manufacturer of the precast members.
- H. Concrete shall be finished in accordance with Section 03 35 00 – Concrete Finishes. Grout all recesses due to cut tendons which will not otherwise be grouted during erection.
- I. Curing of precast members shall be in accordance with Section 03 39 00 – Concrete Curing. Use of a membrane curing compound will not be allowed.
- J. The manufacturer shall provide lifting inserts or other approved means of lifting members.

3.02 HANDLING, TRANSPORTING AND STORING

- A. Precast members shall not be transported away from the casting yard until the concrete has reached the minimum required 28-day compressive strength and a period of at least 5 days has elapsed since casting.
- B. No precast member shall be transported from the plant to the job site prior to approval of that member by the plant inspector. This approval will be stamped on the member by the plant inspector.
- C. During handling, transporting, and storing, precast concrete members shall be lifted and supported only at the lifting or supporting points as indicated on the shop drawings.
- D. All precast members shall be stored on solid, unyielding, storage blocks in a manner to prevent torsion, objectionable bending, and contact with the ground.
- E. Precast concrete members shall not be used as storage areas for other materials or equipment.
- F. Precast members damaged while being handled or transported will be rejected or shall be repaired in a manner approved by the Engineer.

3.03 ERECTION

- A. Erection shall be carried out by the manufacturer or under the manufacturer's supervision using labor, equipment, tools, and materials required for proper execution of the work.
- B. Contractor shall prepare all bearing surfaces to a true and level line prior to erection. All supports of the precast members shall be accurately located and of required size and bearing materials.
- C. Installation of the precast members shall be made by leveling the top surface of the assembled units keeping the units tight and at right angles to the bearing surface.
- D. Connections which require welding shall be properly made in accordance with Section 05 05 23 – Metal Fastening.
- E. Grouting between adjacent precast members and along the edges of the assembled precast members shall be accomplished as indicated on the drawings, care being taken to solidly pack such spaces and to prevent leakage or droppings of grout through the assembled precast members. Any grout which seeps through the precast members shall be removed before it hardens.
- F. In no case shall concentrated construction loads, or construction loads exceeding the design loads, be placed on the precast members. In no case shall loads be placed on

the precast members prior to the welding operations associated with erection, and prior to placing of topping (if required).

- G. No Contractor, Subcontractor or any of their employees shall arbitrarily cut, drill, punch or otherwise tamper with the precast members.
- H. Precast members damaged while being erected will be rejected or shall be repaired in a manner approved by the Engineer.

END OF SECTION

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SECTION 03 41 13
PRECAST PRESTRESSED CONCRETE
HOLLOW CORE PLANKS

PART 1 – GENERAL

1.01 REQUIREMENTS

- A. The Contractor shall furnish all materials, labor, equipment, tools, etc., required for the design, fabrication, delivery and erection of precast, prestressed concrete hollow core planks in accordance with the Drawings and as specified herein.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 03 40 00 – Precast Concrete

1.03 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

- A. Without limiting the generality of other requirements of these Specifications, all work herein shall conform to the applicable requirements of the following documents. All referenced specifications, codes, and standards refer to the most current issue available at the time of Bid.
 - 1. ACI 423 – Recommendations for Concrete Members Prestressed with Unbonded Tendons
 - 2. PCI Design Handbook

1.04 SUBMITTALS

- A. Submittals shall comply with Section 03 40 00 – Precast Concrete.

1.05 QUALITY ASSURANCE

- A. Quality assurance shall comply with Section 03 40 00 – Precast Concrete.

PART 2 – PRODUCTS

2.01 MATERIALS

- A. Materials shall comply with Section 03 40 00 – Precast Concrete, except as stated below.

- B. Minimum compressive strength of concrete at transfer of prestressing force shall be 3,500 psi.

PART 3 – EXECUTION

3.01 DESIGN CRITERIA

- A. All units shall be designed in accordance with the applicable provisions of ACI 318 and PCI Design Handbook, prestressed to sustain the superimposed dead and live loads indicated herein and on the Drawings. Design and subsequent fabrication shall provide for a camber in each unit to eliminate total dead load deflection.
- B. Superimposed Roof Loads
1. Dead Loads - Uniform load shall be that resulting from weight of member and weights of insulation material, built-up roofing, ballast, and lightweight concrete, as shown on the Drawings. Concentrated load at crane rail hanger-support shall be that resulting from contributing weight of crane rail and its support-assembly.
 2. Live Loads - Uniform live load shall be 20 psf unless noted otherwise on the Drawings. Concentrated hoist loads shall consist of the rated capacity plus 33% impact loading and shall occur where crane rails are shown on the Drawings.
 3. Other applicable loads per the International Building Code as indicated on the Drawings.

3.02 FABRICATION AND CASTING

- A. All hollow core planks shall comply with Section 03 40 00 – Precast Concrete.
- B. Hollow core plank dimensions shall comply with PCI Design Handbook and as indicated on the Drawings.
- C. Curing of hollow core planks shall be equivalent to three days moist curing at 70°F.
- D. Unless otherwise noted on the Drawings, permitted dimensional tolerances are as follows:

Length	±1/2"
Width	±1/4" Max.
Depth	±1/4" Max.
Differential Camber Between Adjacent Units	1/4" Max.

Horizontal Alignment	±1/8" per 10' ±1/2" Max.
Location of openings, blockouts, anchors, plates and inserts	±1/2" Max.
Square Ends	±1/8" per 12" of Height

3.03 HANDLING, TRANSPORTING, AND STORING

- A. Handling, transporting, and storing shall comply with Section 03 40 00 – Precast Concrete.

3.04 ERECTION

- A. Erection shall comply with Section 03 40 00 – Precast Concrete.
- B. All hollow core planks shall bear on bearing pads at each end.
 - 1. All hollow core planks shall bear on plastic or neoprene bearing pads at each end in accordance with Section 03 40 00 – Precast Concrete. Pads shall be the size shown on the Contract Drawings.
 - 2. Where neoprene pads are shown on the Drawings, hollow core planks shall bear on neoprene bearing pads at each end in accordance with Section 03 40 00 – Precast Concrete. Pads shall be the size shown on the Contract Drawings and shall be adhered to the supporting concrete surface below with an approved adhesive.
- C. The top of all hollow core planks which receive concrete topping shall be cleaned of all contaminants and thoroughly wetted just prior to placing the topping.

3.05 ANCHORS FOR ITEMS SUSPENDED FROM PLANKS

- A. Anchors for hangers attached to the bottom of hollow core planks shall be designed by the Contractor and coordinated with the hollow core plank manufacturer to support the loads imposed on the anchors.
- B. The anchors shall be designed for the forces indicated on the Contract Drawings. Where forces are not indicated, the Contractor shall determine the applied forces.
- C. The anchor design for all anchors with applied forces over 400 pounds shall be sealed and signed by a Professional Engineer currently registered in the State or Commonwealth where the Project is located. All anchor forces and anchor designs shall be submitted to the Engineer for record purposes.

- D. Prior to installing anchors, the Contractor shall consult with the manufacturer of the hollow core planks to determine locations of prestressing strands and interior voids in planks. Prestressing strands shall not be cut or damaged under any circumstances.
- E. Anchors shall be embedded and installed as directed by the anchor manufacturer.

END OF SECTION

SECTION 03 60 00

GROUT

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. Furnish all materials, labor, and equipment required to provide all grout used in concrete work and as bearing surfaces for base plates, in accordance with the Contract Documents.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Requirements of related work are included in Division 01 and Division 02 of these Specifications.

1.03 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

- A. Without limiting the generality of the other requirements of the specifications, all work herein shall conform to the applicable requirements of the following documents. All referenced specifications, codes, and standards refer to the most current issue available at the time of Bid.
 - 1. CRD-C 621 – Corps of Engineers Specification for Non-shrink Grout
 - 2. ASTM C 33 – Standard Specification for Concrete Aggregates
 - 3. ASTM C 109 – Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2 inch or 50 mm cube Specimens)
 - 4. ASTM C 531 – Standard Test Method for Linear Shrinkage and Coefficient of Thermal Expansion of Chemical-Resistant Mortars, Grouts and Monolithic Surfacing
 - 5. ASTM C 579 – Test Method for Compressive Strength of Chemical-Resistant Mortars and Monolithic Surfacing
 - 6. ASTM C 827 – Standard Test Method for Early Volume Change of Cementitious Mixtures
 - 7. ASTM C 1107 – Standard Specification for Packaged Dry, Hydraulic Cement Grout (Nonshrink)

1.04 SUBMITTALS

- A. Submit the following in accordance with Section 01 33 00 – Submittal Procedures.
 - 1. Certified test results verifying the compressive strength and shrinkage and expansion requirements specified herein.
 - 2. Manufacturer's literature containing instructions and recommendations on the mixing, handling, placement, and appropriate uses for each type of grout used in the work.

1.05 QUALITY ASSURANCE

- A. Field Tests
 - 1. Compression test specimens will be taken during construction from the first placement of each type of grout and at intervals thereafter as selected by the Engineer to ensure continued compliance with these Specifications. The specimens will be made by the Engineer or its representative.
 - a. Compression tests and fabrication of specimens for cement grout and non-shrink grout will be performed as specified in ASTM C 109 at intervals during construction as selected by the Engineer. A set of three specimens will be made for testing at seven days, 28 days, and any additional times as appropriate.
 - b. Compression tests and fabrication of specimens for epoxy grout will be performed as specified in ASTM C 579, Method B, at intervals during construction as selected by the Engineer. A set of three specimens will be made for testing at seven days and any other time as appropriate.
 - 2. The cost of all laboratory tests on grout will be borne by the Owner, but the Contractor shall assist the Engineer in obtaining specimens for testing. The Contractor shall be charged for the cost of any additional tests and investigation on work performed which does not meet the specifications. The Contractor shall supply all materials necessary for fabricating the test specimens, at no additional cost to the Owner.
 - 3. All grout, already placed, which fails to meet the requirements of these Specifications, is subject to removal and replacement at no additional cost to the Owner.

PART 2 – PRODUCTS

2.01 MATERIALS

A. Cement Grout

1. Cement grout shall be composed of Portland Cement and sand in the proportion specified in the Contract Documents and the minimum amount of water necessary to obtain the desired consistency. If no proportion is indicated, cement grout shall consist of one-part Portland Cement to three parts sand. Water amount shall be as required to achieve desired consistency without compromising strength requirements. White Portland Cement shall be mixed with the Portland Cement as required to match color of adjacent concrete.
2. The minimum compressive strength at 28 days shall be 4000 psi.
3. For beds thicker than 1-1/2 inch and/or where free passage of grout will not be obstructed by coarse aggregate, 1-1/2 parts of coarse aggregate having a top size of 3/8 inch should be added. This stipulation does not apply for grout being swept in by a mechanism. These applications shall use a plain cement grout without coarse aggregate regardless of bed thickness. Cement grout used for surfaces swept in by a mechanism shall also contain macro-synthetic fibers in accordance with Section 03 30 00.
4. Sand shall conform to the requirements of ASTM C33.

B. Non-Shrink Grout

1. Non-shrink grout shall conform to CRD-C 621 and ASTM C 1107, Grade B or C when tested at a max. fluid consistency of 30 seconds per CDC 611/ASTM C939 at temperature extremes of 45°F and 90°F and an extended working time of 15 minutes. Grout shall have a min. 28-day strength of 7,000 psi. Non-shrink grout shall be, "NS Grout" by the Euclid Chemical Company, "SikagROUT 212" by Sika Corporation, "Conspec 100 Non-Shrink Non-Metallic Grout" by Conspec, "MasterFlow 928" by Master Builders Solutions.

C. Epoxy Grout

1. Epoxy grout shall be "Sikadur 32 Hi-Mod" by Sika Corporation, "Duralcrete LV" by Tamms Industries, or "E3 Series" by Euclid Chemical, "MasterEmaco ADH 1090 RS" by Master Builders Solutions.
2. Epoxy grout shall be modified as required for each application with aggregate per manufacturer's instructions.

D. Epoxy Base Plate Grout

1. Epoxy base plate grout shall be "Sikadur 42, Grout-Pak" by Sika Corporation, or "MasterFlow 648" by Master Builders Solutions.

2.02 CURING MATERIALS

- A. Curing materials shall be as specified in Section 03 39 00 – Concrete Curing for cement grout and as recommended by the manufacturer for prepackaged grouts.

PART 3 – EXECUTION

3.01 GENERAL

- A. The different types of grout shall be used for the applications stated below unless noted otherwise in the Contract Documents. Where grout is called for in the Contract Documents which does not fall under any of the applications stated below, non-shrink grout shall be used unless another type is specifically referenced.
 1. Cement grout shall be used for grout toppings and for patching of fresh concrete, when approved by the Engineer. Grout toppings swept in by equipment mechanisms shall contain macro-synthetic fibers as specified in Section 03 30 00.
 2. Non-shrink grout shall be used for grouting beneath base plates of structural metal framing.
 3. Epoxy grout shall be used for bonding new concrete to hardened concrete.
 4. Epoxy base plate grout shall be used for precision seating of base plates including base plates for all equipment such as engines, mixers, pumps, vibratory and heavy impact machinery, etc.
- B. New concrete surfaces to receive cement grout shall be as specified in Section 03 35 00 – Concrete Finishes, and shall be cleaned of all dirt, grease, and oil-like films. Existing concrete surfaces shall likewise be cleaned of all similar contamination and debris, including chipping, or roughening the surface if a laitance or poor concrete is evident. The finish of the grout surface shall match that of the adjacent concrete. Curing and protection of cement grout shall be as specified in Section 03 39 00 – Concrete Curing.
- C. All mixing, surface preparation, handling, placing, consolidation, and other means of execution for prepackaged grouts shall be done according to the instructions and recommendations of the manufacturer.
- D. The Contractor, through the manufacturer of a non-shrink grout and epoxy grout, shall provide on-site technical assistance upon request, at no additional cost to the Owner.

3.02 CONSISTENCY

- A. The consistency of grouts shall be that necessary to completely fill the space to be grouted for the application. Dry pack consistency is such that the grout is plastic and moldable but will not flow.

3.03 MEASUREMENT OF INGREDIENTS

- A. Measurements for cement grout shall be made accurately by volume using containers. Shovel measurement shall not be allowed.

- B. Prepackaged grouts shall have ingredients measured by means recommended by the manufacturer.

3.04 GROUT INSTALLATION

- A. Grout shall be placed quickly and continuously, shall completely fill the space to be grouted and be thoroughly compacted and free of air pockets. The grout may be poured in place, pressure grouted by gravity, or pumped. The use of pneumatic pressure or dry-packed grouting requires approval of the Engineer. For grouting beneath base plates, grout shall be placed from one side only and allowed to flow across to the open side to avoid air-entrapment.

END OF SECTION

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SECTION 04 05 13
MORTAR AND MASONRY GROUT

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. Furnish labor, materials, equipment, and appliances required for complete execution of Work shown on Drawings and specified herein.
- B. Principal items of work include:
 - 1. Mortar for unit masonry work.
 - 2. Grout for grouting masonry.
 - 3. Mortar for pointing and touchup.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 04 05 23 – Masonry Accessories
- B. Section 04 20 00 – Unit Masonry

1.03 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

- A. Without limiting the generality of the Specifications, the Work shall conform to the applicable requirements of the following documents:
 - 1. ASTM C91 – Standard Specification for Masonry Cement
 - 2. ASTM C144 – Standard Specification for Aggregate for Masonry Mortar
 - 3. ASTM C150 – Standard Specification for Portland Cement
 - 4. ASTM C207 – Standard Specification for Hydrated Lime for Masonry Purposes
 - 5. ASTM C270 – Standard Specification for Mortar for Unit Masonry
 - 6. ASTM C476 – Standard Specification for Grout for Masonry
 - 7. ASTM C979 – Pigments for Integrally Colored Concrete
 - 8. ASTM C1019 – Standard Methods of Sampling and Testing Grout
 - 9. TMS 602 – Specification for Masonry Structures

1.04 SUBMITTALS

- A. In accordance with the procedures and requirements set forth in Section 01 33 00 – Submittal Procedures, submit the following:
 - 1. Manufacturer's data and mixing instructions for each product.
 - 2. Certificate of compliance with these specifications for each material specified below.
 - 3. Mix Design for Masonry Grout.
 - 4. Test reports.
 - 5. Samples of colored masonry mortar.

1.05 DELIVERY AND STORAGE

- A. Deliver materials in manufacturer's original containers, bearing labels indicating product and manufacturer's name.
- B. Store cementitious materials in waterproof locations to prevent damage by elements. Reject containers showing evidence of damage.
- C. Store aggregates in separate bins to prevent intrusion of foreign particles. Do not use bottom 6 inches of sand or other aggregate stored in contact with the ground.

PART 2 – PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Subject to compliance with the Specifications provide products manufactured by one of the following:
 - 1. LaFarge, Reston, VA
 - 2. Lehigh Cement Company, Allentown, PA
 - 3. Holcim, Inc., Dundee, MI

2.02 MATERIALS

- A. Mortar and Grout Materials

1. Materials used in the production of masonry grout shall meet the requirements of specification 03 33 00, Cast – in – Place Concrete, PART 2 – Products, except coarse and fine aggregate shall meet the requirements of ASTM C 404.
2. Hydrated lime: ASTM C-207, Type "S".
3. Sand: Clean, coarse, free of loam, salt, organic and foreign matter and conforming to ASTM C-144.
4. Masonry Cement: ASTM C 91, Type S and meet the following criteria:
 - a. Prepackaged masonry cement shall contain Portland Cement, hydrated lime and plasticizing admixtures or hydraulic hydrated lime. Masonry cements which contain other materials, including ground limestone, ground slag, or other cementitious and non-cementitious materials, are not acceptable.
5. Water - clean, fresh, potable, and free from injurious amounts of oil, acids, alkalis, salts, organic matter or other deleterious substances.

B. Admixtures

1. Do not use calcium chloride.
2. Provide water repellant admixture in mortar used for architectural concrete masonry units. Admixture shall be compatible with ACMU water repellant admixture.
3. Do not use admixtures, without written approval of Engineer.

C. Mortar pigment

1. Natural or synthetic iron oxide and chromium oxides meeting the requirements of ASTM C979.
2. Pigment shall not exceed 10% of the weight of Portland cement. Carbon black shall not exceed 2% of Portland cement.
3. Color shall be selected by the Owner from the manufacturer's full range of colors.

2.03 GROUT AND MORTAR MIXES

- A.** Masonry mortar shall be Type "S" according to ASTM C-270. Proportions for masonry mortar shall be one of the following:
1. Proportions by volume: 1 part Portland cement to 1/4 - 1/2 parts hydrated lime, and aggregate volume of not less than 2-1/4 or more than 3 times the sum of the volumes of cement and lime.

2. Proportions by volume: 1/2 part Portland cement to 1 part masonry cement, and aggregate volume of not less than 1-1/4 or more than 3 times the sum of the volumes of cement and lime.
- B. Proportions for pointing mortar.
1. Proportions by volume: 1 part Portland cement to 1/4 part hydrated lime and 2 parts extra fine sand.
- C. Masonry Grout shall conform to the requirements of ASTM C 476 and ACI 530.1/ASCE 6, strength of grout, tested in accordance with ASTM C 1019 shall be equal to f'm as specified in Section 04 20 00 – Unit Masonry, but not less than 2,000 psi.
1. Test grout for every 5,000 square feet of masonry, with a minimum of one test per structure.

PART 3 – EXECUTION

3.01 FIELD MORTAR MIXING

- A. Mixing shall be by mechanically operated batch mixer. Entirely discharge before recharging. Mix sand, lime, cement and admixtures dry for two (2) minutes minimum, add water and mix for three (3) minutes minimum. Control batching procedures by measuring materials by volume. Measurement by shovel count shall not be permitted. Mix mortar with less water than the maximum amount, consistent with workability, to provide near maximum tensile bond strength. Mix only quantity that can be used before initial set, or within the first one-half hour.
- B. Mixers, wheel barrows, mortar boards, etc., shall be kept clean.
- C. Retempering of mortar will not be permitted and mortar allowed to stand more than one (1) hour shall not be used.

3.02 INSTALLATION

- A. Install mortar and grout in accordance with TMS 602.

3.03 REPOINTING MORTAR

- A. Prehydrate the mortar by mixing ingredients together dry, and then add only enough water to make a damp, stiff mix that will retain its form when pressed into a ball. After one to two hours, add water to bring it to the proper consistency.

END OF SECTION

SECTION 04 05 23
MASONRY ACCESSORIES

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. Furnish labor, materials, equipment and appliances required for complete execution of Work shown on Drawings and specified herein.
- B. Principal items of work include:
 - 1. Metal joint reinforcement for masonry.
 - 2. Accessories for masonry construction.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 04 05 13 – Mortar and Masonry Grout
- B. Section 04 20 00 – Unit Masonry

1.03 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

- A. Without limiting the generality of these specifications, Work shall conform to the applicable requirements of the following documents:
 - 1. ASTM A1064/1064M – Standard Specification for Carbon Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete
 - 2. ASTM A153 – Standard Specification for Zinc Coating (Hot Dip) on Iron and Steel Hardware
 - 3. ASTM A 951 – Standard Specification for Steel Wire Masonry Joint Reinforcement
 - 4. ASTM D1056 – Standard Specification for Flexible Cellular Materials - Sponge or Extruded Rubber
 - 5. TMS 602 – Specifications for Masonry Structures

1.04 SUBMITTALS

- A. In accordance with the procedures and requirements set forth in Section 01 33 00 – Submittal Procedures, submit the following:
 - 1. Provide manufacturer's complete product data.

2. Provide manufacturer's certification attesting compliance of material and source of each material specified below.

PART 2 – PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS FOR MASONRY REINFORCEMENT

- A. Subject to compliance with the Specifications, provide products manufactured by the following:
 1. AA Wire Products, Company, Chicago, IL
 2. Dur-O-Wal, Inc., Arlington Heights, IL
 3. Heckmann Building Products, Inc., Chicago, IL.
 4. Holman and Barnard, Inc., Hauppauge, NY.

2.02 MATERIALS

- A. Multi Wythe Joint Reinforcement
 1. Steel ladder type reinforcement conforming to ASTM A 951 with adjustable pintel and eye assembly; 3/16 inch side rods and 9 gauge continuous cross rods; manufactured with wire conforming to ASTM A1064/1064M, with widths 2-inches less than nominal wall thickness. Provide seismic clip with 9 gauge continuous wire.
- B. Single Wythe Joint Reinforcement
 1. Steel ladder type reinforcement conforming to ASTM A 951 with 3/16 inch side rods and 9 gauge continuous cross rods; manufactured with wire conforming to ASTM A1064/1064M, with widths 2-inches less than nominal wall thickness.
- C. Anchors: Cast into concrete or weld to steel.
 1. Dovetail Slot shall be 1 inch back by 1 inch deep by 5/8 inch throat, 22 gauge, foam filled.
 2. Dovetail Anchor - accessory for anchoring triangular flexible tie to dovetail slot, shall be 12 gauge by 1 inch wide 1/2 inch long dovetail section.
 3. Wire/Strap Anchor - 1/4 inch wire or 12 gauge x 3/4 inch x length required, welded or mechanically attached to back up structure.
- D. Ties

1. Triangular Flexible Tie: 3/16 inch wire, sized to suit application.
 2. Adjustable Tie: Pintel and eye full tie; properly sized for application, 3/16 inch cold drawn steel.
- E. Seismic Clip and Continuous Wire
1. Seismic clip shall be impact resistant PVC with retaining ridges to accept continuous wire.
 2. Continuous wire shall be 9 gauge galvanized steel.
- F. Top of Wall Anchor
1. Top of wall anchor shall be a 3/8" diameter rod welded to a 3/16" plate with two anchor holes. Provide a plastic tube to allow vertical deflection.
- G. Finish
1. Reinforcements, anchorages and ties shall be hot dipped galvanized, Class B-2, after fabrication in accordance with ASTM A153.

2.03 ACCESSORIES

- A. Expansion and Joint Filler Material
1. Closed cell neoprene material conforming to ASTM D 1056, with a minimum compressibility of 50%. Horizontal joint filler shall be 1/4 inch thick. Expansion joints shall be a minimum 3/8" thick.
- B. Weep and Vent Holes
1. Cellular vent 3/8" wide by 2 1/2" high x 3 5/8" length. CellVent by Mortar Net or equal. Color to closely match mortar.
- C. Control Joint
1. Wide flange rapid preformed neoprene or PVC gasket.
- D. Hardware Cloth
1. 1/2-inch hardware cloth.
- E. Through Wall Flashing

1. Self-sealing, fully adhering composite flashing consisting of 32 mil rubberized asphalt bonded to an 8 mil cross laminated polyethylene film to produce an overall 40 mil thickness.
2. Provide Perm-A-Barrier Wall Flashing by W.R. Grace, Flash-Bond by Wire-Bond or Poly-Barrier Wall Flashing by Polytite Manufacturing Corporation.

F. Cavity Drainage Mat

1. CavClear Masonry Mat by CavClear, Hudson WI. Or approved equal. Description: Fluid conducting, non-absorbent, mold and mildew resistant polymer mesh consisting of 100% recycled polymer with PVC binder. Thickness of actual air space minus tolerances recommended by manufacturer.

PART 3 – EXECUTION

3.01 REINFORCEMENT AND ANCHORAGE

- A. In masonry wall panels, place horizontal joint reinforcement at a vertical spacing of 16 inches on center, unless otherwise noted.
- B. Lap side rods at each end joint a minimum of 6 inches.
- C. Install prefabricated corner and tee assemblies at each wall corner and intersection.
- D. Mitre and butt end joints are prohibited.
- E. Place horizontal joint reinforcement in approximate center of out-to-out wall assembly and assuring a 5/8 inch, minimum, mortar coverage on exterior face and 1/2 inch on interior face.
- F. Veneer ties and wire anchors shall be length required to provide a minimum of 1 ½" engagement into the veneer and assuring a 5/8 inch, minimum, mortar coverage on exterior face and 1/2 inch on interior face.
- G. Adjustable anchor assemblies may be offset no more than that which is stated in manufacturer's published instructions. Pintles may be installed either up or down.
- H. Install horizontal joint reinforcement continuous, terminating only at vertical control joints.
- I. Place masonry joint reinforcement in first and second horizontal joints above and below openings. Extend 24 inches minimum each side of opening.
- J. Place joint reinforcement continuous and at 8 inches on center vertically above roof.

- K. Place reinforcing bars supported and secured against displacement. Maintain position with ½ inch to true dimension.
- L. Coordinate and verify that dowels and anchorages embedded in concrete and attached to structural steel members are properly placed.
- M. Provide wall ties for masonry veneer at maximum 16 inches on center vertically and 16 inches on center horizontally. Place at maximum 8 inches on center each way around perimeter of openings, within 12 inches of openings.
- N. Masonry adjacent to steel and concrete columns to be attached to the column with masonry anchors at 16 inches on center. Anchors to be attached to each face of the column which is adjacent to a masonry wall, unless otherwise noted.

3.02 DOVETAIL SLOTS AND ANCHORS

- A. Provide dovetail slots to concrete contractor for placement into the concrete construction. Dovetail slots shall be placed vertically and spaced 16 inches on center horizontally.
- B. Remove slot filler after forms are removed.
- C. Hook dovetail anchor into slots and set in masonry joints at 16 inches on center.

3.03 BENDING, CUTTING AND SPLICING REINFORCEMENT

- A. Make bends and splices in reinforcement only where indicated, or prior-approval by Engineer. Bend reinforcement only when cold, and prior to any placement in construction, forming around a steel pin of diameter at least 6 times the reinforcement size. Cut bars only by approved sawing, shearing or welding methods. Make ends of reinforcement straight, square, clean and free of defects before splicing. Do not heat or weld bends and splices at points of maximum stress. Clip and bend any tie wires as required to direct the ends away from external surfaces of masonry walls.
- B. Where welding is necessary, provide materials and perform welding in accordance with AWS requirements.
- C. All lap splices to be 48 bar diameters, unless otherwise noted.

3.04 THROUGH WALL FLASHING

- A. Clean areas to receive flashing. Surface shall be free of voids, spalled areas, or sharp protrusions. Concrete surfaces shall be cured a minimum of 7 days.
- B. Apply Primer as recommended by manufacturer.

- C. Apply flashing in strict accordance with manufacturer's instructions and recommendations. Sidelaps shall be a minimum of 2½ inches. End laps shall have a 6" minimum lap. Provide end dams at ends of lintels and other interruptions.
- D. Seal flashing where vertical reinforcing penetrates flashing with a mastic approved for use by manufacturer.

3.05 CAVITY DRAINAGE MAT

- A. Install cavity drainage mat in air-space between insulation and masonry veneer construction full height of cavity.
- B. Cavity drainage mat shall be temporarily fastened in accordance with manufacturer's instructions.

END OF SECTION

SECTION 04 20 00

UNIT MASONRY

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. Furnish labor, materials, equipment, and appliances required for complete execution of Work shown on Drawings and specified work.
 - 1. Principal items of work include:
 - a. Exterior masonry wall construction.
 - b. Interior masonry wall construction.
 - c. Installation of masonry reinforcement and accessories.
 - d. Masonry unit lintels.
 - e. Installing dampproofing, insulation, flashing and work required to be built into masonry work.
 - f. Building into masonry work all anchors, inserts, hangers, and other appurtenances provided under other Sections.
 - g. Pointing and cleaning of exposed masonry surfaces.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 03 21 00 – Reinforcing Steel
- B. Section 04 05 13 – Mortar and Masonry Grout
- C. Section 04 05 23 – Masonry Accessories
- D. Section 07 11 00 – Dampproofing
- E. Section 07 21 00 – Building Insulation
- F. Section 07 60 00 – Flashing and Sheet Metal

1.03 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

- A. Without limiting the generality of the Specifications, the Work shall conform to the applicable requirements of the following documents:

1. TMS 402 – Building Code Requirements for Masonry Structures
2. TMS 602 – Specifications for Masonry Structures
 - a. TMS 602 shall be considered minimum specifications for all materials, workmanship, methods, and techniques for all masonry work.
 - b. Obtain a copy of the above Specifications prior to beginning any work in this Section.
3. ASTM C62 – Standard Specification for Building Brick
4. ASTM C90 – Standard Specification for Load-Bearing Concrete Masonry Units
5. ASTM C140 – Standard Methods for Sampling and Testing Concrete Masonry Units
6. ASTM C216 – Standard Specification for Facing Brick
7. ASTM C744 – Standard Specification for Prefaced Concrete and Calcium Silicate Masonry Units
8. ANSI A41.1 R70 – Code Requirements for Masonry

1.04 TESTING

A. Tests

1. The Owner reserves the right to test materials for compliance with these specifications. Sampling and testing will be done in accordance with the ASTM standard, by an independent testing agency employed by the Owner. Materials that fail to meet requirements are considered defective. Subsequent tests to establish compliance (of the same or new materials) shall be paid for by the Contractor.

1.05 SUBMITTALS

A. In accordance with the procedures and requirements set forth in Section 01 33 00 – Submittal Procedures, submit the following:

1. Samples of each material to be used showing full range of colors.
2. Manufacturer's specifications and certifications of compliance to the Specifications, including results of tests on masonry units showing such compliance, for each type of masonry. Provide handling, storage, and installation instructions along with protection instructions. Indicate by transmittal that installer has received copies of each instruction.

3. Detailed placing and shop fabricating drawings, prepared in accordance with ACI 315 and ACI Detailing Manual - (SP66), shall be furnished for all deformed bar reinforcing. These drawings shall be made to such a scale as to clearly show joint locations, openings, and the arrangement, locations, spacing and splicing of the bars.
4. Cold and/or hot weather construction procedures in accordance with ACI 530.1/ASCE 6 sections 2.3.2.2. and 2.3.2.3.
5. Cleaning procedures and cleaner for each masonry type.

1.06 MOCK-UPS

- A. Build mockups at the site, where directed, full thickness and approximately 4 feet x 4 feet in two directions to create a corner. Incorporate all accessories, insulation, damproofing, weeps, etc. Mock-up shall show the proposed color range, texture, and workmanship for each type of masonry. Mock-up shall have one row of soldier course in the mock-up. Obtain Engineer's acceptance of visual qualities of the mockup before start of masonry work. Do not alter, move, or destroy mockups until Work is completed and removal is directed by the Engineer.

1.07 DELIVERY, STORAGE AND HANDLING

- A. Deliver materials in the manufacturer's original unbroken, undamaged, and unopened packaging with labels bearing the name of the manufacturer and the product. Masonry units and brick shall be factory packaged and strapped, delivered to the site and stored on skids.
- B. Store and handle materials to prevent inclusion of water or foreign matter and to prevent damage of any nature.
- C. Distribute materials on floor slabs to prevent overloading. Designated live loads shown for floor shall not be exceeded.

PART 2 – PRODUCTS

2.01 GENERAL

- A. Provide special shape, type or size indicated or for application requiring a form, size or finish which cannot be produced from standard masonry units by sawing. Provide solid units where masonry unit is exposed.
- B. Masonry units for fire-rated walls shall comply with Underwriter's Laboratory requirements for fire rating shown on the Drawings.

- C. Deformed bar reinforcing steel shall meet the requirements of specification 03 21 00 – Reinforcing Steel.

2.02 MATERIALS

A. Mortar

- 1. In accordance with Section 04 05 13 – Mortar and Masonry Grout

B. Face Brick

- 1. ASTM C216, Type FBS, SW. modular as manufactured and distributed by Belden Brick Company, Glen-Gery Corporation, Cherokee Sanford Group, Inc. or equal. Face brick shall be selected and approved by the Owner from samples submitted. Select color from manufacturer's full color range to match existing buildings. Sand finished brick shall not be accepted.
- 2. Net area compressive strength of brick masonry units shall be a minimum of 3,350 psi when tested in accordance with ASTM C67. Compressive strength of masonry (f'm) shall be a minimum of 1,500 psi in accordance with ACI 530.1 when these units are used with the mortar specified in Section 04 05 13 – Mortar and Masonry Grout.

C. Concrete Masonry Units

- 1. Provide units conforming to ACI 530.1 unless otherwise specified.
- 2. Provide light weight units meeting the requirements of ASTM C90 for hollow and solid load bearing CMU.
- 3. Manufacture units of Portland Cement, conforming to ASTM C-150 and light weight aggregate conforming to ASTM C331 and ASTM C33. Weight of unit shall not exceed 105 lb. per cu. ft. when measured in accordance with provisions of ASTM C140. Units shall be nominally 8 inches x 16 inches x thicknesses shown or as required. Masonry units shall be manufactured not less than 30 days prior to being used and stored under cover until shipment. All units shall have true, sharp edges and corners, free from cracks or other defects. Provide half special sizes and shapes as required by the Drawings or to meet job conditions.
- 4. Net area compressive strength of concrete masonry units shall be a minimum of 2,000 psi when tested in accordance with ASTM C140. Compressive strength of masonry (f'm) shall be a minimum of 2,000 psi in accordance with ACI 530.1 when these units are used with the mortar specified in Section 04 05 13 – Mortar and Masonry Grout.

D. Concrete Masonry Lintels

1. Specially formed units with reinforcing bars and grout fill provided where shown and wherever openings in masonry are indicated without structural steel or other supporting lintels.

E.

PART 3 – EXECUTION

3.01 GENERAL

- A. Examine areas and conditions under which masonry is to be installed and notify the Engineer in writing of conditions detrimental to the proper and timely completion of the work. Do not proceed until unsatisfactory conditions have been corrected.
- B. Do not wet concrete masonry units.
- C. Brick having absorption rates in excess of 0.025 oz. per square inch per minute (as determined per ASTM C 67) shall be wetted sufficiently so that the rate of absorption, when brick is laid, does not exceed this amount.
- D. Clean reinforcing, removing loose rust, ice, or other coatings from bars, before placement.
- E. Thickness of cavity and composite walls, and other masonry construction shall be the full thickness shown. Build single wythe walls to the actual size of masonry units.
- F. Build chases and recesses as shown and as required for the work of other trades.
- G. Build other work into masonry work as shown, fitting masonry units around other work and grouting to assure anchorage.
- H. Cut masonry units with motor driven saw designed to cut masonry with clean, sharp, unchipped edges. Cut units as required to provide pattern shown or specified, and to fit adjoining work neatly.
- I. Cold and hot weather construction.
 1. No masonry shall be erected when ambient temperature has dropped below 45°F unless it is rising and at no time when it has dropped below 40°F. Provisions shall be made for heating and drying of materials, and the complete work shall be protected in accordance with the ACI 530.1/ASCE 6 Section 2.3.2.2. Masonry shall not be laid with ice or frost on its surfaces, and no masonry shall be laid on frozen work. Any work which freezes before the mortar has set shall be removed and

replaced at the Contractor's own expense. Do not use any admixtures or antifreeze in the mortar.

2. When the temperature is above 100°F or 90°F with a wind velocity greater than 8 mph, mortar beds shall be spread no more than 4 feet ahead of masonry and masonry units shall be set within one minute of spreading mortar.

3.02 CONSTRUCTION TOLERANCES

- A. Variation from plumb: For vertical lines and surfaces of columns, walls and arises do not exceed 1/4" in 10', or 3/8" in a story height not to exceed 20', nor 1/2" in 40' or more. For external corners, expansion joints, control joints and other conspicuous lines, do not exceed 1/4" in any story or 20' maximum, nor 1/2" in 40' or more. For vertical alignment of head joints do not exceed plus or minus 1/4" in 10', 1/2" maximum.
- B. Variation from level: For bed joints and lines of exposed lintels, sills, parapets, horizontal grooves, and other conspicuous lines do not exceed 1/4" in any bay or 20' maximum, nor 1/2" in 40' or more. For top surface of bearing walls do not exceed 1/8" between adjacent floor elements in 10' or 1/16" within width of a single unit.
- C. Variation of Linear Building Line: For position shown on plan and related portion of columns, walls, and partitions, do not exceed 1/2" in any bay or 20' maximum, nor 3/4" in 40' or more.
- D. Variation in Cross Sectional Dimensions: For columns and thickness of walls, from dimensions shown, do not exceed minus 1/4" nor plus 1/2".
- E. Variation in Mortar Joint Thickness: Do not exceed bed joint thickness indicated by more than plus or minus 1/8", with a maximum thickness limited to 1/2". Do not exceed head joint thickness indicated by more than plus or minus 1/8".

3.03 LAYING MASONRY WALLS

- A. Layout walls in advance for accurate spacing of surface bond patterns, with uniform joint widths and to properly locate openings, movement-type joints, returns and offsets. Avoid the use of less-than-half size units at corners, jambs, and wherever possible at other locations.
- B. Lay-up walls to comply with specified construction tolerances, with courses accurately spaced and coordinated with other work.
- C. Pattern Bond: Lay exposed masonry in the bond pattern shown or, if not shown, lay in running bond with vertical joint in each course centered on units in courses above and below.

- D. Stopping and Resuming Work: Rack back 1/2 unit length in each course; do not tooth. Clean exposed surfaces of set masonry, wet units lightly, and remove loose masonry units and mortar prior to laying fresh mortar.
- E. Cover top of walls at the end of each day. Protect wall from water infiltration from the top until wall is capped.
- F. Built-In Work: As work progresses, build-in items specified under this and other sections of these Specifications. Fill in solidly with masonry around built-in items.
 - 1. Fill space between hollow metal frames and masonry solidly with mortar, unless otherwise indicated.
 - 2. Where built-in items are to be embedded in cores of hollow masonry units, place a layer of hardware cloth in the joint below and rod grout into core.
 - 3. Fill cores in hollow masonry units with grout 3 courses (24") under bearing plates, beams, lintels, posts and similar items, unless otherwise noted.
 - 4. Seal masonry tight around wall penetrations such as beams, joists, pipes, ducts, and conduit by cutting masonry units to fit as tightly as possible, then closing final gap all around with mortar, or joint filler and caulking as necessary.

3.04 MORTAR BEDDING AND JOINTING

- A. Lay solid masonry units with filled bed and head joints; butter ends with sufficient mortar to fill head joints and shove into place. Do not slush head joints.
- B. Lay hollow concrete masonry units with full mortar coverage on horizontal and vertical face shells; also bed webs with mortar in starting courses on footing or floors, and where adjacent cells are to be reinforced or filled with grout. For starting courses where cells are not grouted, spread full mortar bed including areas under cells.
- C. Maintain joint widths of 3/8", except for minor variations required to maintain bond alignment.
- D. Tooling: Joints shall be tooled to a uniform concave joint. Head joints first and then the bed joints.
- E. Remove masonry units disturbed after laying; clean and reset in fresh mortar. Do not pound corners and jambs to shift adjacent stretcher units which have been set in position. If adjustments are required, remove units, clean, and reset in fresh mortar.

3.05 JOINT REINFORCING

- A. Use continuous horizontal joint reinforcement installed in horizontal mortar joints not more than 16" o.c. vertically.
- B. Parapets: Use continuous horizontal joint reinforcement installed in horizontal joints at 8" o.c. vertically.
- C. Reinforced masonry openings greater than 12" wide, with horizontal joint reinforcing placed in 2 horizontal joints immediately above the lintel and immediately below the sill. Extend reinforcements 2'-0" beyond jambs of the opening except at control joints.
- D. Cut or interrupt joint reinforcement at control and expansion joints, unless otherwise indicated.
- E. Provide continuity at corners and wall intersections by use of prefabricated "L" and "T" sections. Cut and bend reinforcement units as directed by manufacturer for continuity at returns, offsets, pipe enclosures and other special conditions.
- F. Intersecting Load-bearing Walls: Provide rigid steel anchors at not more than 2'-0" o.c. vertically. Embed ends in mortar-filled cores.
- G. Non-loadbearing Interior Partitions: Build full height of story to underside of solid floor or structure above, unless shown otherwise. Fill joint with mortar after dead load deflection of structure above approaches final position.

3.06 CAVITY WALLS

- A. Keep cavity clean of mortar droppings and other materials during construction. Strike joints facing cavity, flush.
- B. Tie exterior wythe to back-up wythe of masonry with horizontal joint reinforcement at 16" o.c. vertically.
- C. Coordinate placement of dampproofing and insulation board with work to ensure there are no gaps or air spaces between pieces of insulation board.
- D. Weep joints shall be placed in exterior wythe of cavity wall, spaced a maximum of 32" o.c. horizontally, immediately above ledges, at lintels over openings, and as shown.

3.07 CAVITY WALL INSULATION

- A. Provide and install insulation as shown and as specified in Section 07 21 00 – Building Insulation.

3.08 CONTROL AND EXPANSION JOINTS

- A. General: Provide vertical and horizontal expansion, control and isolation joints in masonry where shown. Build-in related items as the masonry work progresses.

3.09 LINTELS

- A. Install galvanized steel lintels where indicated.
- B. Provide masonry lintels where shown and wherever openings of more than 8" for brick size units and 1'-4" for block size units are shown without structural steel or other supporting lintels. Provide precast or poured-in-place masonry lintels. Cure precast lintels before handling and installation. Temporarily support formed-in-place lintels.
- C. For hollow concrete masonry unit walls, use specially formed "U"-shaped lintel units with reinforcement bars placed as shown and filled with grout.
- D. Provide minimum bearing of 8" at each jamb.

3.10 FLASHING

- A. Provide flashing as shown and as specified in Section 07 60 00 – Flashing and Sheet Metal.

3.11 REINFORCED UNIT MASONRY

- A. Vertical reinforcement shall be held in place by means of frames or other suitable means. Place horizontal joint reinforcement as masonry work progresses. Provide minimum clear distance between longitudinal bars equal to nominal diameter of bar. Minimum thickness of mortar or grout between masonry and reinforcement shall be 1/4", except 6 gage or smaller wires may be laid in 3/8" mortar joints. Collar joints which contain both horizontal and vertical reinforcement shall have a minimum width of 1/2" larger than the diameter of the horizontal and vertical reinforcement.
- B. Bar splices shall be contact lap splices. Length of splice shall be as shown on Structural Drawings.
- C. Low lift grouting shall be used when grout space is less than 2" in width. Place grout at maximum intervals of 24" in lifts of 6 to 8 inches as the work progresses. Cores to be grouted shall be clean of mortar, mortar dropping and debris. Agitate grout to assure complete filling and coverage of reinforcement. Hold grout 1-1/2 inches below to top of masonry if work is discontinued for more than an hour.
- D. High lift grouting may be used when the grout space is greater than 2". Grout shall not be placed in lifts greater than 4 feet. Grout core shall be kept clean of mortar, mortar dripping and debris. Provide cleanout holes as required for inspection and cleaning.

Replace cleanout plugs after inspection and acceptance. Place grout in accordance with TMS 402 and TMS 602. Hold grout 1-1/2 inches below top of masonry if work is discontinued for more than an hour.

- E. Forms and shoring shall be substantial and tight to prevent leakage of mortar or grout. Brace and shore forms to maintain position and shape. Do not remove forms or shoring until masonry gains enough strength to sufficiently carry its own weight and any other loads, temporary or permanent, placed on it during construction.

3.12 PROTECTION OF WORK

- A. Exposed masonry surfaces shall be protected from staining. Tops of wall shall be covered with nonstaining waterproof coverings when work is not in progress. Installed material shall be secure in high winds.
- B. Protection shall be provided for all openings in the walls to prevent damage to sills, jambs, etc., from all causes. Aluminum or steel frames and other finish materials shall be protected from damage during masonry work.

3.13 REPAIR, POINTING AND CLEANING

- A. Remove and replace masonry units which are loose, chipped, broken, stained or otherwise damaged, or if units do not match adjoining units as intended. Provide new units to match adjoining units and install fresh mortar or grout, pointed to eliminate evidence of replacement.
- B. Pointing of Masonry: At the completion of the masonry work, all holes in exposed masonry shall be pointed. Defective joints shall be cut out and tuckpointed solidly with mortar. Pointing and tuckpointing shall be done with a pre-hydrated mortar. The mortar cement shall be controlled so that, after curing of the mortar, no difference in texture or color exists with that of adjacent masonry.
- C. Masonry Cleaning: While laying masonry units, good workmanship and job housekeeping practices shall be used to minimize the need for cleaning the masonry work. Protect the base of the wall from mud splashes and mortar droppings. The technique for laying masonry shall be such that mortar does not run down the face of the wall or smear onto the face.
 - 1. After the joints are tooled, cut off mortar failings with the trowel and brush excess mortar burrs and dust from the face of the masonry, use a bricklayer's brush made with medium soft hair.
 - 2. Remove all large mortar particles with a hardwood scraper.

3. If, after using the above outlined techniques, additional cleaning of the walls is found necessary, allow the walls to cure one month prior to initiating further cleaning processes.
- D. Clean masonry to comply with the masonry manufacturer's directions and applicable NCMA "Tek" bulletins or BIA technical notes and the following requirements.
1. Saturate the wall with clean water. The wall shall be thoroughly saturated prior to and at the time the cleaning solution is applied.
 2. Clean masonry with an approved cleaning solution for each type of masonry applied with a brush, starting at the top of the wall. Approved cleaners shall be composed primarily of detergents, wetting agents, buffering agents, and a maximum of 10% muriatic acid. Do not use acids on masonry surfaces that will be damaged by use of an acid cleaner. The use of any of the above cleaning agents shall first be approved in writing by the manufacturer of the masonry being cleaned and the Engineer. The concentration, method of application of the cleaning solution, and method of scraping shall be as outlined on the container by the manufacturer.
 3. High pressure water and sandblasting shall not be used for cleaning except with the recommendation of the masonry manufacturer and the written approval of the Engineer.
 4. Immediately after cleaning a small area, the wall shall be rinsed thoroughly with quantities of water.
 5. Protect adjacent surfaces and materials during masonry cleaning operations.
 6. After the walls are cleaned, take the necessary precautions to ensure that other contractors and subcontractors do not damage or soil the walls. Mud protection around the base of walls shall be left in place until the grading work is done.

END OF SECTION

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SECTION 05 05 13

GALVANIZING

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. Where galvanizing is called for in the Contract Documents, the galvanizing shall be performed in accordance with the provisions of this Section unless otherwise noted.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Further requirements for galvanizing specific items may be included in other Sections of the Specifications. See section for the specific item in question.

1.03 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

- A. Without limiting the generality of the other requirements of the specifications, all work herein shall conform to the applicable requirements of the following documents. All referenced specifications, codes, and standards refer to the most current issue available at the time of Bid.
 - 1. International Building Code
 - 2. ASTM A123 – Standard Specification for Zinc (Hot-Galvanized) Coatings on Products Fabricated from Rolled, Pressed, and Forged Steel Shapes, Plates, Bars, and Strip
 - 3. ASTM A153 – Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
 - 4. ASTM A653 – Standard Specification for Steel Sheet, Zinc Coated (Galvanized), or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
 - 5. ASTM A924 – Standard Specification for General Requirements for Steel Sheet, Metallic-Coated by the Hot-Dip Process
 - 6. ASTM A780 – Standard Practice of Repair of Damaged Hot-Dip Galvanized Coatings
 - 7. ASTM F2329 – Standard Specification for Zinc Coating, Hot-Dip, Requirements for Application to Carbon and Alloy Steel Bolts, Screws, Washers, Nuts, and Special Threaded Fasteners

1.04 SUBMITTALS

- A. Submit the following in accordance with Section 01 33 00 – Submittal Procedures.
 - 1. Certification that the item(s) are galvanized in accordance with the applicable ASTM standards specified herein. This certification may be included as part of any material certification that may be required by other Sections of the Specifications.

PART 2 – PRODUCTS

2.01 GALVANIC COATING

- A. Material composition of the galvanic coating shall be in accordance with the applicable ASTM standards specified herein.

PART 3 – EXECUTION

3.01 FABRICATED PRODUCTS

- A. Products fabricated from rolled, pressed, and forged steel shapes, plates, bars, and strips, 1/8 inch thick and heavier which are to be galvanized shall be galvanized in accordance with ASTM A123. Products shall be fabricated into the largest unit which is practicable to galvanize before the galvanizing is done. Fabrication shall include all operations necessary to complete the unit such as shearing, cutting, punching, forming, drilling, milling, bending, and welding. Components of bolted or riveted assemblies shall be galvanized separately before assembly. When it is necessary to straighten any sections after galvanizing, such work shall be performed without damage to the zinc coating. The galvanizer shall be a member of American Galvanizers Association.
- B. Components with partial surface finishes shall be commercial blast cleaned prior to pickling.
- C. Sampling and testing of each lot shall be performed prior to shipment from the galvanizer's facility per ASTM A123.

3.02 HARDWARE

- A. Iron and steel hardware which is to be galvanized shall be galvanized in accordance with ASTM A153 and ASTM F2329.

3.03 ASSEMBLED PRODUCTS

- A. Assembled steel products which are to be galvanized shall be galvanized in accordance with ASTM A123. All edges of tightly contacting surfaces shall be completely sealed by welding before galvanizing.

- B. Assemblies shall be provided with vent and drain holes as required by the fabricator. Vent and drain hole sizes and locations shall be included in the structural steel shop drawings required in Section 05 12 00 – Structural Steel for approval. All vent and drain holes shall be plugged and finished to be flush with and blend in with the surrounding surface. Where water intrusion can occur, the plug shall be carefully melted into the surrounding zinc coating using an appropriate fluxing agent.

3.04 REPAIR OF GALVANIZING

- A. Galvanized surfaces that are abraded or damaged at any time after the application of zinc coating shall be repaired by thoroughly wire brushing the damaged areas and removing all loose and cracked coating, after which the cleaned areas shall be painted with 2 coats of zinc rich paint meeting the requirements of Federal Specification DOD-P-21035A and shall be thoroughly mixed prior to application. Zinc rich paint shall not be tinted. The total thickness of the 2 coats shall not be less than 6 mils. In lieu of repairing by painting with zinc rich paint, other methods of repairing galvanized surfaces in accordance with ASTM A780 may be used provided the proposed method is acceptable to the Engineer.

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SECTION 05 05 23
METAL FASTENING

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. Furnish all materials, labor, and equipment required to provide all metal welds and fasteners not otherwise specified, in accordance with the Contract Documents.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 05 10 00 – Metal Materials
- B. Section 05 05 13 – Galvanizing
- C. Section 05 13 00 – Stainless Steel
- D. Section 05 12 00 – Structural Steel
- E. Section 05 14 00 – Structural Aluminum

1.03 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

- A. Without limiting the generality of the other requirements of the specifications, all work herein shall conform to the applicable requirements of the following documents. All referenced specifications, codes, and standards refer to the most current issue available at the time of Bid.
 - 1. International Building Code
 - 2. AC 193 – Acceptance Criteria for Mechanical Anchors in Concrete Elements
 - 3. AC 308 – Acceptance Criteria for Post-Installed Adhesive Anchors in Concrete Elements
 - 4. ACI 318 – Building Code Requirements for Structural Concrete
 - 5. ACI 355.2 – Qualifications of Post-Installed Mechanical Anchors in Concrete
 - 6. ACI 355.4 – Qualifications of Post-Installed Adhesive Anchors in Concrete
 - 7. AISC – RCSC Specification for Structural Joints Using High Strength Bolts
 - 8. AISC – Code of Standard Practice

9. AWS D1.1 – Structural Welding Code – Steel
10. AWS D1.2 – Structural Welding Code – Aluminum
11. AWS D1.6 – Structural Welding Code – Stainless Steel
12. Aluminum Association – Specifications for Aluminum Structures
13. ASTM A572/A572M-94C – Standard Specification for High Strength Low-Alloy Columbium-Vanadium Structural Steel Grade 50
14. ASTM A36 – Standard Specification for Carbon Structural Steel
15. ASTM A489 – Standard Specification for Eyebolts
16. ASTM A563 – Standard Specifications for Carbon and Alloy Steel Nuts
17. ASTM D1785 – Standard Specification for Polyvinyl Chloride (PVC) Plastic Pipe
18. ASTM E3121 – Standard Test Methods for Field Testing of Anchors in Concrete or Masonry
19. ASTM A572 – Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel
20. ASTM F467 – Standard Specification for Nonferrous Nuts for General Use
21. ASTM F593 – Standard Specification for Stainless Steel Bolts; Hex Cap Screws, and Studs
22. ASTM F594 – Standard Specification for Stainless Steel Nuts
23. ASTM F1554 – Standard Specification for Anchor Bolts, Steel, 36, 55, and 105-ksi Yield Strength
24. ASTM F3125 – Standard Specification for High Strength Structural Bolts, Steel and Alloy Steel, Heat Treated, 120 ksi and 150 ksi Minimum Tensile Strength, Inch and Metric Dimension

1.04 SUBMITTALS

- A. Submit the following in accordance with Section 01 33 00 – Submittal Procedures.
 1. Shop Drawings providing the fastener's manufacturer and type and certification of the fastener's material and capacity.

2. Anchor design calculations sealed by a Professional Engineer currently registered in the State or Commonwealth in which the project is located. Only required if design not shown on Contract Drawings.
3. A current Evaluation Report shall be submitted for all anchors that will be considered for use on this project.
4. Manufacturer's installation instructions.
5. Copy of valid certification for each person who is to perform field welding.
6. Certified weld inspection reports, when required.
7. Welding procedures.
8. Installer qualifications.
9. Certification of Installer Training.
10. Inspection Reports.
11. Results of Anchor Proof Testing.
12. Manufacturer's Literature for Resistance of Adhesive to Appropriate Chemical Exposure, where deemed necessary.

1.05 QUALITY ASSURANCE

- A. Fasteners not manufactured in the United States shall be tested and certification provided with respect to specified quality and strength standards. Certifications of origin shall be submitted for all U.S. fasteners supplied on the project.
- B. Evaluation Report: A current Evaluation Report from an independent testing and evaluation agency (ITEA) shall be submitted for all anchors that will be used on this project. The ITEA producing the evaluation report shall be accredited in accordance with the requirements for ITEA's in ACI 355.2 (mechanical anchors) or 355.4 (adhesive anchors). Acceptable ITEA's include but are not necessarily limited to the International Code Council Evaluation Service (ICC-ES) and the International Association of Plumbing and Mechanical Officials Uniform Evaluation Service (IAPMO-UES).
- C. Installer Qualifications: All concrete anchors shall be installed by an Installer with at least three years of experience performing similar installations. Concrete adhesive anchor installers for anchor installations shall be certified as an Adhesive Anchor Installer in accordance with ACI-CRSI Adhesive Anchor Installation Certification Program.
- D. Installer Training: For concrete anchors, conduct a thorough training with the manufacturer or the manufacturer's representative for the Installer on the project.

Training shall consist of a review of the complete installation process to include but not be limited to the following:

1. Hole drilling procedure.
 2. Hole preparation and cleaning technique.
 3. Adhesive injection technique and dispenser training/maintenance.
 4. Concrete adhesive anchor preparation and installation.
 5. Proof loading/torquing.
 6. Provide a list of names of all installers who are trained by the Manufacturer's Field Representative on this jobsite prior to installation of products. Record must include the installer name, date of training, products included in the training and trainer name and contact information.
 7. Provide a copy of the current ACI/CRSI "Adhesive Anchor Installer" certification cards for all installers.
- E. All steel welding shall be performed by welders certified in accordance with AWS D1.1. All aluminum welding shall be performed by welders certified in accordance with AWS D1.2. All stainless-steel welding shall be performed by welders certified in accordance with AWS D1.6. Certifications of field welders shall be submitted prior to performing any field welds.
- F. Welds and high strength bolts used in connections of structural steel will be visually inspected in accordance with Article 3.04.
- G. The Owner may engage an independent testing agency to perform testing of welded connections and to prepare test reports in accordance with AWS. Inadequate welds shall be corrected or redone and retested to the satisfaction of the Engineer and/or an acceptable independent testing laboratory, at no additional cost to the Owner.
- H. Provide a welding procedure for each type and thickness of weld. For welds that are not prequalified, include a Performance Qualification Report. The welding procedure shall be given to each welder performing the weld. The welding procedure shall follow the format in Annex E of AWS D1.1 with relevant information presented.
- I. Special inspections for concrete adhesive anchors shall be conducted in accordance with the manufacturer's instructions and Section 01 45 33 – Special Inspections. Downward installations require periodic inspection and horizontal and overhead installations require continuous inspection.

PART 2 – PRODUCTS

2.01 ANCHOR RODS

- A. Anchor rods shall conform to ASTM F1554 Grade 55 except where stainless steel or other approved anchor rods are shown on the Drawings or stated herein. Anchor rods shall have hexagonal heads and shall be supplied with hexagonal nuts meeting the requirements of ASTM A563 Grade A. Plate washers shall meet the requirements of ASTM A572, Grade 50.
- B. All anchors rods into concrete shall be cast-in-place anchors unless specifically referenced otherwise on Drawings.
- C. Where anchor rods are used to anchor galvanized steel or are otherwise specified to be galvanized, anchor rods and nuts shall be hot dipped galvanized in accordance with ASTM F1554.
- D. Where pipe sleeves around anchor rods are shown on the Drawings, pipe sleeves shall be cut from Schedule 40 PVC plastic piping meeting the requirements of ASTM D1785.

2.02 HIGH STRENGTH BOLTS

- A. High strength bolts and associated nuts and washers shall be in accordance with ASTM F3125, Grade A325 Type 1 or Grade F1852 Type 1. Bolts, nuts, and washers shall meet the requirements of RCSC "Specification for Structural Joints Using High Strength Bolts".
- B. Where high strength bolts are used to connect galvanized steel or are otherwise specified to be galvanized, bolts, nuts, and washers shall be hot dipped galvanized in accordance with ASTM A325.

2.03 STAINLESS STEEL BOLTS

- A. Stainless steel bolts shall conform to ASTM F-593 for alloy groups 1 and 2, Condition CW1, or ASTM F-3125. All fasteners for aluminum and stainless steel members that are underwater, in confined areas containing fluid, and in corrosive environments shall be Type 316 stainless steel unless noted otherwise. Fasteners for aluminum and stainless-steel members not subject to the above conditions shall be Type 304 stainless steel unless otherwise noted.
- B. Stainless steel bolts shall have hexagonal heads with a raised letter or symbol on the bolts indicating the manufacturer and shall be supplied with hexagonal nuts meeting the requirements of ASTM F594. Nuts, washers, and lock washers shall be of the same alloy as the bolts.

2.04 CONCRETE ANCHORS

A. General

1. Where concrete anchors are called for on the Drawings, one of the types listed below shall be used. Where one of the types listed below is specifically called for on the Drawings, only that type shall be used. The determination of anchors equivalent to those listed below shall be based on test data performed by an approved independent testing laboratory. Two types of anchors shall be used:
 - a. Mechanical anchors include any of the following anchors:
 - 1) Expansion anchors shall be mechanical anchors of the wedge, sleeve, or drop-in type that are set by expanding against the sides of the drilled hole.
 - 2) Screw anchors are mechanical anchors that derive tensile holding strength by the mechanical interlock provided by threads cutting into the concrete during installation. Screw anchors shall be one-piece, heavy duty screw anchors with a finished head.
 - b. Adhesive anchors shall consist of threaded rods anchored with an adhesive system into hardened concrete. Adhesive anchors shall be two-part injection type using the manufacturer's static mixing nozzle and shall be supplied as an entire system.
2. Adhesive anchors shall conform to the requirements of ACI 355.4 or alternately to AC 308. Mechanical anchors shall conform to the requirements of ACI 355.2 or alternately to AC 193.
3. Fire Resistance: All anchors installed within fire resistant construction shall either be enclosed in a fire-resistant envelope, be protected by approved fire-resistive materials, be used to resist wind and earthquake loads only, or be only as anchors for non-structural elements.
4. Engineer's approval is required for use of concrete anchors in locations other than those shown on the Drawings.

B. Wedge Anchors:

- a. Do not use when subjected to vibration.
- b. Do not use in exterior locations or locations subjected to freezing.
- c. Do not use in submerged, intermittently submerged, or buried locations.

- d. Suitable for use in overhead applications.

C. Screw Anchors:

- a. Do not use when subjected to vibration.
- b. Do not use in exterior locations or locations subjected to freezing.
- c. Do not use in submerged, intermittently submerged, or buried locations.
- d. Suitable for use in overhead applications.

D. Sleeve Anchors:

- a. Do not use when subjected to vibration.
- b. Do not use in exterior locations or locations subjected to freezing.
- c. Do not use in submerged, intermittently submerged, or buried locations.
- d. Suitable for use in overhead applications.

E. Undercut Anchors:

- a. Suitable for use where subjected to vibration.
- b. Do not use in exterior locations or locations subjected to freezing.
- c. Do not use in submerged, intermittently submerged, or buried locations.
- d. Suitable for use in overhead applications.

F. Adhesive Anchors in Concrete:

- a. Suitable for use where subjected to vibration.
- b. Suitable for use in exterior locations or locations subjected to freezing.
- c. Suitable for use in submerged, intermittently submerged, or buried locations.
- d. Do not use in overhead applications, unless otherwise shown or approved by Engineer.
- e. Suitable for use in chemical areas provided manufacturer's literature confirms appropriate chemical resistance.
- f. Do not use for pipe hangers, unless otherwise shown or approved by Engineer.

G. Adhesive Anchors in Masonry (where cells have been fully grouted)

- a. Suitable for use where subjected to vibration.
- b. Suitable for use in exterior locations or locations subjected to freezing.
- c. Do not use for pipe hangers, unless otherwise shown or approved by Engineer.
- d. Suitable for use in precast hollow core planks provided cores have been fully grouted.

H. Concrete Anchor Design:

1. Basis of design shall include the following design parameters:
 - a. Actual compressive strength of concrete.
 - b. Cracked concrete conditions.
 - c. Dry or water saturated installation conditions.
 - d. Base material temperature between 40- and 104-degrees Fahrenheit.
 - e. Installation with hammer drill or hollow-drill bit system drilling methods.
 - f. Installation not prior to 21-day minimum age of concrete.
2. An anchor design consists of specifying anchor size, quantity, spacing, edge distance and embedment to resist all applicable loads. Where an anchor design is indicated on the Drawings, the anchors shall be installed to the prescribed size, spacing, embedment depth, and edge distance. If all parts of an anchor design are provided on the Drawings except embedment depth, the Contractor shall provide the embedment depth as indicated in Paragraph B.3 unless otherwise directed by the Engineer. Where an anchor design is not indicated on the Drawings, the Contractor shall provide the anchor design per the requirements listed below.
 - a. The Contractor shall submit design with sealed calculations and drawings performed by an Engineer currently registered in the State or Commonwealth in which the project is located. Anchors shall be of a type recommended by the anchor manufacturer for use in cracked concrete and shall be designed by the Contractor in accordance with ACI 318 Chapter 17.
 - b. Embedment Depth
 - 1) Minimum anchor embedment shall be as indicated on the Drawings unless anchor design is stipulated to be by Contractor or equipment

provider. The provider of equipment including pumps, blowers, etc. shall provide anchor design including size of anchors, pattern, and embedment depth. If the equipment provider is unable to provide design of embedment depth, the design shall be provided by the contractor using the loads furnished by the equipment provider. Although all manufacturers listed are permitted, the embedment depth indicated on the Drawings is based on "Pure 110+ by DeWalt" ESR 3298 issued 7/2017. If the contractor submits one of the other concrete adhesive anchors listed, the Engineer shall evaluate the required embedment and the Contractor shall provide the required embedment depth stipulated by the Engineer specific to the approved dowel adhesive.

- 2) Where the embedment depth is not shown on the Drawings, concrete anchors shall be embedded no less than the manufacturer's standard embedment (mechanical anchors) or to provide a minimum allowable bond strength equal to the allowable yield capacity of the rod according to the manufacturer (adhesive anchors).
- 3) The embedment depth shall be determined using the actual concrete compressive strength, a cracked concrete state, maximum long-term temperature of 110 degrees F, and maximum short-term temperature of 140 degrees F. In no case shall the embedment depth be less than the minimum or more than the maximum stated in the manufacturer's literature.

I. Anchors:

1. Mechanical Anchors:

- a. Wedge Anchors: Wedge anchors shall be "Kwik Bolt TZ" by Hilti, Inc., "Strong-Bolt 2" by Simpson Strong-Tie Co. or "Power-Stud+SD1" or "Power-Stud+ SD-2" by DeWalt.
- b. Screw Anchors: Screw anchors shall be "KWIK HUS-EZ", "KWIK HUS-EZ-I", or "KWIK HUS-EZ CRC" by Hilti, Inc., "Titen HD" or "Stainless Steel Titen HD" by Simpson Strong-Tie Co., or "Screw-Bolt+" by DeWalt.
- c. Sleeve Anchors: Sleeve anchors shall be "HSL-3 Heavy Duty Sleeve Anchor" by Hilti, Inc. or "Power-Bolt +" by DeWalt.
- d. Shallow Embedment Internally Threaded Insert (3/4" max embedment): "Mini-Undercut +Anchor" by DeWalt, "HDI-P-TZ" by Hilti, Inc. or approved equal.

- e. Concrete Undercut Anchors: Concrete undercut anchors shall be “HDA Undercut Anchors” by Hilti, Inc, “DUC Ductile Undercut Anchor”, by USP Structural Connectors, or approved equal.
- f. Mechanical anchor systems shall comply with ACI 355.2 or alternatively the latest revision of AC 193 and shall have a valid evaluation report in accordance with the applicable building code.

2. Adhesive Anchors:

- a. Adhesive anchors shall be “HIT HY-200 Adhesive Anchoring System” by Hilti, Inc., “SET-3G Epoxy Adhesive Anchors” by Simpson Strong-Tie Co., or “Pure 110+ Epoxy Adhesive Anchor System” by DeWalt.
- b. Adhesive anchor systems shall be IBC compliant and capable of resisting short term wind and seismic loads (Seismic Design Categories A through F) as well as long term and short term sustained static loads in both cracked and uncracked concrete in all Seismic Design Categories. Adhesive anchor systems shall comply with ACI 355.4 or alternatively the latest revision of AC308 and shall have a valid evaluation report in accordance with the applicable building code. **No or equal products will be considered unless prequalified and approved by the Engineer and Owner.**

J. Concrete Anchor Materials:

- 1. Concrete anchors used to anchor structural steel shall be a threaded steel rod per anchor manufacturer’s recommendations but shall not have a yield strength (fy) less than 58 ksi nor an ultimate strength (fu) less than 72.5 ksi, unless noted otherwise. Where steel to be anchored is galvanized, concrete anchors shall also be galvanized unless otherwise indicated on the Drawings.
- 2. Concrete anchors used to anchor aluminum, FRP, or stainless steel shall be manufactured from stainless steel unless noted otherwise. All underwater fasteners, fasteners in confined areas containing fluid, and fasteners in corrosive environments shall be Type 316 stainless steel unless noted otherwise. Fasteners for aluminum and stainless-steel members not subject to the above conditions shall be Type 304 stainless steel unless otherwise noted.
- 3. Nuts, washers, lock washers and other hardware shall be of a material to match the anchors.

2.05 MASONRY ANCHORS

- A. Adhesive anchors for fastening to solid or grout-filled masonry shall be anchors consisting of threaded rods anchored with an adhesive system. The adhesive system shall be "HIT HY-270 System" as manufactured by Hilti, Inc., "AC100+ Acrylic Adhesive" by DeWalt, or "SET-3G" as manufactured by Simpson Strong-Tie Co.
- B. Adhesive anchors for fastening to hollow masonry or brick shall be adhesive anchors consisting of threaded rods anchored with an adhesive system dispensed into a screen tube inserted into the masonry. The adhesive system shall use a two-component adhesive mix and shall inject into the screen tube with a static mixing nozzle. Thoroughly clean drill holes of all debris and drill dust prior to installation of adhesive and anchor. Contractor shall follow manufacturer's installation instructions. The adhesive system shall be "HIT HY-270 System" as manufactured by Hilti, Inc., "AC100+ Acrylic Adhesive" by DeWalt, or "SET-3G" as manufactured by Simpson Strong-Tie Co.
- C. Masonry anchors used to anchor steel shall be a threaded steel rod per manufacturer's recommendations for proposed adhesive system but shall not have a yield strength (fy) less than 58 ksi nor an ultimate strength (fu) less than 72.5 ksi, unless noted otherwise. Where steel to be anchored is galvanized, masonry anchors shall also be galvanized.
- D. Masonry anchors used to anchor aluminum, FRP, or stainless steel shall be manufactured from stainless steel unless noted otherwise. All underwater fasteners, fasteners in confined areas containing fluid, and fasteners in corrosive environments shall be Type 316 stainless steel unless noted otherwise. Fasteners for aluminum and stainless-steel members not subject to the above conditions shall be Type 304 stainless steel unless otherwise noted.
- E. Nuts, washers, lock washers and other hardware shall be of a material to match the anchors.
- F. Although all manufacturers listed are permitted, the masonry anchor design is based on "SET-3G by Simpson Strong-Tie ESR 4844 Revised 10-2023. If the contractor submits one of the other concrete adhesive anchors listed, the Engineer shall evaluate the proposed product and the Contractor shall provide the conditions stipulated by the Engineer specific to the approved adhesive anchor.
- G. If the masonry cells are fully grouted and the application is not an exterior application where freezing is a concern, a submerged or below grade application, or an application where vibrations could occur, screw anchors may be considered for anchoring items to masonry walls.

2.06 WELDS

- A. Electrodes for welding structural steel and all ferrous steel shall comply with AWS Code, using E70 series electrodes for shielded metal arc welding (SMAW), or F7 series electrodes for submerged arc welding (SAW).
- B. Electrodes for welding aluminum shall comply with the Aluminum Association Specifications and AWS D1.2.
- C. Electrodes for welding stainless steel and other metals shall comply with AWS D1.6.

2.07 WELDED STUD CONNECTORS

- A. Welded stud connectors shall conform to the requirements of AWS D1.1 Type C.

2.08 EYEBOLTS

- A. Eyebolts shall conform to ASTM A489 unless noted otherwise.

2.09 ANTISEIZE LUBRICANT

- A. Antiseize lubricant shall be C5-A Anti-Seize by Loctite Corporation, Molykote P-37 Anti-Seize Paste by Dow Corning, 3M Anti-Seize by 3M, or equal.

PART 3 – EXECUTION

3.01 MEASUREMENTS

- A. The Contractor shall verify all dimensions and review the Drawings and shall report any discrepancies to the Engineer for clarification prior to starting fabrication.

3.02 FASTENER INSTALLATION

- A. Anchor Rods, Concrete Anchors, and Masonry Anchors
 - 1. Anchor rods shall be installed in accordance with AISC "Code of Standard Practice" by securing rods where concrete will be placed and positioned by means of a rigidly secured template. Overhead anchors, and base plates or elements being anchored, shall be shored as required and securely held in place during anchor setting to prevent movement during anchor installation. Movement of anchors during curing is prohibited.
 - 2. The Contractor shall verify that all concrete and masonry anchors have been installed in accordance with the manufacturer's recommendations and that the capacity of the installed anchor meets or exceeds the specified safe holding capacity.

3. Post-installed concrete anchors shall not be used in place of cast-in-place anchor rods without Engineer's approval.
4. All stainless-steel threads shall be coated with anti-seize lubricant.

B. High Strength Bolts

1. All bolted connections for structural steel shall use high strength bolts. High strength bolts shall be installed in accordance with RCSC "Specification for Structural Joints Using High Strength Bolts". All bolted joints shall be Type N, snug-tight, bearing connections in accordance with AISC Specifications unless noted otherwise on the Drawings.

C. Stainless Steel Bolts

1. Where connections indicate the use of stainless-steel bolts, the bolts shall be installed to the snug tight condition. Connections shall include stainless steel washers under both the bolt head and the nut head. Lock washers shall be utilized for all connections and shall be placed under the nut head.

D. Concrete Anchors

1. Concrete at time of anchor installation shall be a minimum age of 21 days, have a minimum compressive strength of 2500 psi, and ambient temperature at time of installation shall be at least 50 degrees F.
2. Concrete Anchor Testing:
 - a. At all locations, at least 10 percent of all concrete anchors installed shall be proof tested to 80% of the yield strength of the anchor rod, with a minimum of one tested anchor per anchor group.
 - b. Contractor shall submit a plan and schedule indicating locations of anchors to be proof tested, load test values and proposed anchor testing procedure (including a diagram of the testing equipment proposed for use) to the Engineer for review prior to conducting any testing. Proof testing of anchors shall be in accordance with ASTM E3121 for the confined static tension test. If additional tests are required, inclusion of these tests shall be as stipulated on Contract Drawings.
 - c. Where Contract Documents indicate anchor design to be the Contractor's responsibility, the Contractor shall submit a plan and schedule indicating locations of anchors to be proof tested and load test values, sealed by a Professional Engineer currently registered in the State or Commonwealth in

which the project is located. Documentation shall also be submitted indicating the Contractor's proof testing procedures have been reviewed and the proposed procedures are acceptable. Proof testing procedures shall be in accordance with ASTM E3121.

- d. Concrete Anchors shall have no visible indications of displacement or damage during or after the proof test. Concrete cracking in the vicinity of the anchor after loading shall be considered a failure. Anchors exhibiting damage shall be removed and replaced. If more than 5 percent of tested anchors fail, then 100 percent of anchors shall be proof tested.
 - e. Proof testing of concrete anchors shall be performed by an independent testing laboratory hired directly by the Contractor and approved by the Engineer. The Contractor shall be responsible for costs of all proof testing, including additional testing required due to previously failed tests.
3. All concrete anchors shall be installed in strict conformance with the manufacturer's printed installation instructions. A representative of the manufacturer shall be on site when required by the Engineer.
4. All holes shall be drilled in accordance with the manufacturer's instructions except that cored holes shall not be allowed unless specifically approved by the Engineer. If cored holes are allowed, cored holes shall be roughened in accordance with manufacturer requirements. If hammer drills are used to drill holes in slabs, the drills shall be equipped with a depth stop device. The depth of hole shall be the minimum depth required for anchor embedment and development of required capacity. Prior to drilling, the contractor shall use GPR or other means to confirm anchor installation will not interfere with reinforcement or embedded items, especially electrical conduit. Thoroughly clean drill holes of all debris, drill dust, and water in accordance with the manufacturer's instructions prior to installation of adhesive and threaded rod unless otherwise recommended by the manufacturer. Degree of hole dampness shall be in strict accordance with manufacturer recommendations. Installation conditions shall be either dry or water saturated. Water filled or submerged holes shall not be permitted unless specifically approved by the Engineer. Injection of adhesive into the hole shall be performed to minimize the formation of air pockets in accordance with the manufacturer's instructions. Wipe rod free from oil that may be present from shipping or handling.
5. All adhesive anchor installations shall be conducted by a certified Adhesive Anchor Installer as certified by ACI/CSRI per ACI 318-19 26.7. Current AAI Certificate must be submitted to the Engineer of Record prior to commencement of any adhesive anchor installations.

E. Other Bolts

1. All dissimilar metal shall be connected with appropriate fasteners and shall be isolated via an approved dielectric.
2. All stainless-steel bolts shall be coated with anti-seize lubricant.

3.03 WELDING

- A. All welding shall comply with AWS Code for procedures, appearance, quality of welds, qualifications of welders and methods used in correcting welded work.
- B. Welded stud connectors shall be installed in accordance with AWS D1.1.
- C. Welds shown on the Drawings with a field weld symbol shall be field welded. All other welds shall be shop welded unless specifically approved by the Engineer.

3.04 INSPECTION

- A. High strength bolting will be visually inspected in accordance with RCSC "Specification for Structural Joints Using High Strength Bolts". Rejected bolts shall be either replaced or retightened as required.
- B. Field welds will be visually inspected in accordance with AWS Codes. Inadequate welds shall be corrected or redone as required in accordance with AWS Codes.
- C. Post-installed concrete anchors shall be inspected as required by ACI 318.

3.05 CUTTING OF EMBEDDED REBAR

- A. The Contractor shall not cut embedded rebar cast into concrete during installation of post-installed anchors without prior approval of the Engineer.

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SECTION 05 10 00
METAL MATERIALS

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. Metal materials not otherwise specified shall conform to the requirements of this Section.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Materials for fasteners are included in Section 05 05 23 – Metal Fastening.
- B. Requirements for specific products made from the materials specified herein are included in other sections of the Specifications. See the section for the specific item in question.

1.03 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

- A. ASTM A36 – Standard Specification for Structural Steel
- B. ASTM A47 – Standard Specification for Malleable Iron Castings
- C. ASTM A48 – Standard Specification for Gray Iron Castings
- D. ASTM A53 – Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless
- E. ASTM A167 – Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
- F. ASTM A276 – Standard Specification for Stainless and Heat-Resisting Steel Bars and Shapes
- G. ASTM A307 – Standard Specification for Carbon Steel Externally Threaded Standard Fasteners
- H. ASTM A446 – Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process, Structural (Physical) quality
- I. ASTM A500 – Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes
- J. ASTM A501 – Standard Specification for Hot-Formed Welded and Seamless Carbon Steel Structural Tubing

- K. ASTM A529 – Standard Specification for Structural Steel with 42 000 psi (290 Mpa) Minimum Yield Point (1/2 in. (12.7 mm) Maximum Thickness)
- L. ASTM A536 – Standard Specification for Ductile Iron Castings
- M. ASTM A570 – Standard Specification for Hot-Rolled Carbon Steel Sheet and Strip, Structural Quality
- N. ASTM A572 – Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel
- O. ASTM A992 – Standard Specification for Structural Steel Shapes
- P. ASTM A666 – Standard Specification for Austenitic Stainless Steel, Sheet, Strip, Plate, and Flat Bar for Structural Applications
- Q. ASTM A1085 – Standard Specification for Cold-Formed Welded Carbon Steel Hollow Structural Sections (HSS)
- R. ASTM B26 – Standard Specification for Aluminum-Alloy Sand Castings
- S. ASTM B85 – Standard Specification for Aluminum-Alloy Die Castings
- T. ASTM B108 – Standard Specification for Aluminum-Alloy Permanent Mold Castings
- U. ASTM B138 – Standard Specification for Manganese Bronze Rod, Bar, and Shapes
- V. ASTM B209 – Standard Specification for Aluminum-Alloy Sheet and Plate
- W. ASTM B221 – Standard Specification for Aluminum-Alloy Extruded Bars, Rods, Wire, Shapes, and Tubes
- X. ASTM B308 – Standard Specification for Aluminum-Alloy Standard Structural Shapes, Rolled or Extruded
- Y. ASTM B574 – Standard Specification for Nickel-Molybdenum-Chromium Alloy Rod
- Z. ASTM F468 - Standard Specification for Nonferrous Bolts, Hex Cap Screws, and Studs for General Use
- AA. ASTM F593 – Standard Specification for Stainless Steel Fasteners

1.04 SUBMITTALS

- A. Material certifications shall be submitted along with any shop drawings for metal products and fabrications required by other sections of the Specifications.

1.05 QUALITY ASSURANCE

- A. Owner may engage the services of a testing agency to test any metal materials for conformance with the material requirements herein. If the material is found to be in conformance with Specifications the cost of testing will be borne by the Owner. If the material does not conform to the Specifications, the cost of testing shall be paid by the Contractor and all materials not in conformance as determined by the Engineer shall be replaced by the Contractor at no additional cost to the Owner. In lieu of replacing materials, the Contractor may request further testing to determine conformance, but any such testing shall be paid for by the Contractor regardless of outcome of such testing.

PART 2 – PRODUCTS

2.01 CARBON AND LOW ALLOY STEEL

- A. Material types and ASTM designations shall be as listed below:

Steel W, C, and MC Shapes	A992
Steel HP, M, S, and L Shapes	A572 Grade 50
Steel Bars and Plates	A36
Rods	F 1554 Grade 55
Pipe - Structural Use	A53 Grade B
Hollow Structural Sections	A500 Grade C or A1085 Grade A
Cold-Formed Steel Framing	A 653

2.02 STAINLESS STEEL

- A. All stainless steel fabrications exposed to underwater service shall be Type 316. All other stainless steel fabrications shall be Type 304, unless noted otherwise.
- B. Material types and ASTM designations are listed below:

Plates and Sheets	ASTM A167 or A666 Grade A
Structural Shapes	ASTM A276

2.03 ALUMINUM

A. All aluminum shall be alloy 6061-T6, unless otherwise noted or specified herein.

B. Material types and ASTM designations are listed below:

Structural Shapes	ASTM B308
Castings	ASTM B26, B85, or B108
Extruded Bars	ASTM B221 - Alloy 6061
Extruded Rods, Shapes and Tubes	ASTM B221 - Alloy 6063
Plates	ASTM B209 - Alloy 6061
Sheets	ASTM B221 - Alloy 3003

C. All aluminum structural members shall conform to the requirements of Section 05 14 00 – Structural Aluminum.

D. All aluminum shall be provided with mill finish unless otherwise noted.

E. Where bolted connections are indicated, aluminum shall be fastened with stainless steel bolts.

2.04 CAST IRON

A. Material types and ASTM designations are listed below:

Gray	ASTM A48 Class 30B
Malleable	ASTM A47
Ductile	ASTM A536 Grade 60-40-18

2.05 BRONZE

A. Material types and ASTM designations are listed below:

2.06 DISSIMILAR METALS

- A. Dielectric isolation shall be installed wherever dissimilar metals are connected according to the following table.

	Zinc	Galvanized Steel	Aluminum	Cast Iron	Ductile Iron	Mild Steel/ Carbon Steel	Copper	Brass	Stainless Steel
Zinc			•	•	•	•	•	•	•
Galvanized Steel			•	•	•	•	•	•	•
Aluminum	•	•		•	•	•	•	•	•
Cast Iron	•	•	•				•	•	•
Ductile Iron	•	•	•				•	•	•
Mild Steel/ Carbon Steel	•	•	•				•	•	•
Copper	•	•	•	•	•	•			•
Brass	•	•	•	•	•	•			•
Stainless Steel	•	•	•	•	•	•	•	•	

1. "•" signifies dielectric isolation is required between the two materials noted.
2. Consult Engineer for items not listed in table.

PART 3 – EXECUTION (NOT USED)

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SECTION 05 12 00
STRUCTURAL STEEL

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. Furnish all equipment, labor, materials, and services required to provide all structural steel work in accordance with the Contract Documents. The term "structural steel" shall include items as defined in the AISC "Code of Standard Practice".

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 05 10 00 – Metal Materials
- B. Section 05 05 13 – Galvanizing
- C. Section 05 05 23 – Metal Fastening

1.03 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

- A. Without limiting the generality of the Specifications, all work specified herein shall conform to the applicable requirements of the following documents.
 - 1. International Building Code
 - 2. AISC – "Code of Standard Practice"
 - 3. AISC – "Specification for Structural Steel Buildings"
 - 4. AISC – RCSC "Specification for Structural Joints Using High Strength Bolts"
 - 5. AWS – "Structural Welding Code"
 - 6. ASTM A786 – Hot-Rolled Carbon, Low-Alloy, High-Strength Low-Alloy, and Alloy Steel Floor Plates

1.04 SUBMITTALS

- A. Submit the following in accordance with Section 01 33 00 – Submittal Procedures.
 - 1. Certified Mill Test Reports
 - 2. Affidavit of Compliance with grade specified
 - 3. Shop Drawings which include the following:

- a. Layout drawings indicating all structural shapes, sizes, and dimensions.
- b. Beam and column schedules.
- c. Detailed drawings indicating jointing, anchoring and connection details and vent and drain holes where required.

1.05 QUALITY ASSURANCE

- A. Shop inspection may be required by the Owner at the Owner's expense. The Contractor shall give ample notice to the Engineer prior to the beginning of any fabrication work so that inspection may be provided. The Contractor shall furnish all facilities for the inspection of materials and workmanship in the shop, and the inspectors shall be allowed free access to the necessary parts of the work. Inspectors shall have the authority to reject any materials or work which do not meet the requirements of these Specifications. Inspection at the shop is intended as a means of facilitating the work and avoiding errors, but is expressly understood that it will in no way relieve the Contractor from the responsibility for furnishing proper materials or workmanship under this Specification.
- B. The structural steel erector shall be a qualified installer who participates in the AISC Certification program and is designated an AISC Certified Erector.
- C. The structural steel fabricator shall be a qualified fabricator who participates in the AISC Certification program and is designated an AISC Certified Building Fabricator.

PART 2 – PRODUCTS

2.01 MATERIALS

- A. Structural Steel
 - 1. Structural steel for W, C, and MC shapes shall conform to ASTM A992 unless otherwise indicated.
 - 2. Structural steel for HP, S, M, and L shapes shall conform to ASTM A572 Grade 50 unless otherwise indicated.
 - 3. Structural steel for bars and plates shall conform to ASTM A36 unless otherwise indicated.
 - 4. Structural pipe shall be ASTM A53, Grade B.
 - 5. HSS shall be ASTM A500, Grade C or ASTM A1085 Grade A. All members shall be furnished full length without splices unless otherwise noted or accepted by the Engineer.

6. All unidentified steel will be rejected and shall be removed from the site and replaced by the Contractor, all at the expense of the Contractor.
7. Fasteners for structural steel shall be in accordance with Section 05 05 23 – Metal Fastening.

B. Welds

1. Electrodes for welding shall be in accordance with Section 05 05 23 – Metal Fastening.

PART 3 – EXECUTION

3.01 MEASUREMENT

- A. The Contractor shall verify all dimensions and shall make any field measurements necessary and shall be fully responsible for accuracy and layout of work. The Contractor shall review the Drawings and any discrepancies shall be reported to the Engineer for clarification prior to starting fabrication.

3.02 FABRICATION

- A. Fabrication shall be in accordance with the AISC "Specification for Structural Steel Buildings and AISC "Code of Standard Practice". Fabrication shall begin only after Shop Drawing approval.
- B. Except where otherwise noted on the Drawings or in this Specification, all shop connections shall be welded.
- C. All holes in structural steel members required for anchors, anchor rods, bolts, sag rods, vent and drain holes or other members or for attachment of other work shall be provided by the fabricator and detailed on the Shop Drawings.
- D. All materials shall be properly worked and match-marked for field assembly.
- E. Where galvanizing of structural steel is required, galvanizing shall be done in accordance with Section 05 05 13 – Galvanizing.
- F. Checkered floor plate shall meet the requirements of ASTM A786.

3.03 DELIVERY, STORAGE AND HANDLING

- A. Structural members shall be loaded in such a manner that they may be transported and unloaded without being over-stressed, deformed or otherwise damaged.

- B. Structural steel members and packaged materials shall be protected from corrosion and deterioration. Material shall be stored in a dry area and shall not be placed in direct contact with the ground. Materials shall not be placed on the structure in a manner that might cause distortion or damage to the members or the supporting structures. The Contractor shall repair or replace damaged materials or structures as directed.

3.04 ERECTION

- A. The erection of all structural steel shall conform to the applicable requirements of the AISC "Specification for Structural Steel Buildings" and AISC "Code of Standard Practice". All temporary bracing, guys and bolts as may be necessary to ensure the safety of the structure until the permanent connections have been made shall be provided by the Contractor.
- B. Structural members shall be set accurately to the lines and elevations indicated. The various members shall be aligned and adjusted to form a part of a complete frame or structure before permanently fastened.
- C. No cutting of structural steel members in the field will be allowed except by the written approval of the Engineer.
- D. Bearing surfaces and other surfaces which will be in permanent contact shall be cleaned before assembly.
- E. Field welding shall not be permitted unless specifically indicated in the Drawings or approved in writing by the Engineer. All field welding shall comply with Section 05 05 23 – Metal Fastening.
- F. All bolted connections shall use high strength bolts in accordance with Section 05 05 23 – Metal Fastening. High strength bolts shall be installed in accordance with RCSC "Specification for Structural Joints Using High Strength Bolts". Bolts specified or noted on the Drawings to be a tension or slip critical "SC" type connection shall be fully pretensioned with proper preparation of the faying surfaces. All other bolts shall be snug tightened unless otherwise noted on the Drawings.
- G. All field connections shall be accurately fitted up before being bolted. Drifting shall be only such as will bring the parts into position and shall not be sufficient to enlarge the holes or to distort the metal. All unfair holes shall be drilled or reamed.
- H. Misfits at Bolted Connections
 - 1. Where misfits in erection bolting are encountered, the Engineer shall be immediately notified. The Contractor shall submit a method to remedy the misfit for

review by the Engineer. The Engineer will determine whether the remedy is acceptable or if the member must be refabricated.

2. Incorrectly sized or misaligned holes in members shall not be enlarged by burning or by the use of drift pins. The Contractor shall notify the Engineer immediately and shall submit a proposed method of remedy for review by the Engineer.
3. Where misalignment between anchor rods and rod holes in steel members are encountered, the Engineer shall be immediately notified. The Contractor shall submit a method to remedy the misalignment for review by the Engineer.

I. Grouting of Base Plates and Bearing Plates

1. The bottom surface of the plates shall be cleaned of all foreign materials, and concrete or masonry bearing surface shall be cleaned of all foreign materials and roughened to improve bonding.
2. Accurately set all base and bearing plates to designated levels with steel wedges or leveling plates.
3. Baseplates shall be grouted with non-shrink grout to assure full uniform bearing. Grouting shall be done prior to placing loads on the structure. Non-shrink grout shall conform to Section 03 60 00 – Grout.
4. Anchor rods shall be tightened after the supported members have been positioned and plumbed and the non-shrink grout has attained its specified strength.

- J. Where finishing is required, assembly shall be completed including bolting and welding of units before start of finishing operations.

3.05 PAINTING

- A. Painting shall be performed according to Section 09 90 00 – Painting and the following additional requirements.
1. Concrete Encased Steel: Steel members which will be encased in concrete shall be cleaned but not painted prior to encasement.
 2. Contact Surfaces: Contact surfaces such as at field connections, shall be cleaned and primed but not painted.
 3. Finished Surfaces: Machine finished surfaces shall be protected against corrosion by a rust-inhibiting coating which is easily removed prior to erection or which has characteristics that make removal unnecessary prior to erection.

4. Surfaces Adjacent to Field Welds: Surfaces within 2 inches of any field weld location shall be free of materials that would prevent proper welding or produce objectionable fumes while welding is being done.

END OF SECTION

SECTION 05 13 00
STAINLESS STEEL

PART 1 – GENERAL

1.01 SECTION INCLUDES

- A. The Contractor shall furnish, install and erect the stainless steel work as shown on the Contract Drawings and specified herein.
- B. Stainless steel work shall be furnished complete with all accessories, mountings and appurtenances of the type of stainless steel and finish as specified or required for a satisfactory installation.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 01 33 00 – Submittal Procedures
- B. Section 05 10 00 – Metal Materials
- C. Section 05 05 23 – Metal Fastening
- D. Section 05 50 00 – Metal Fabrications

1.03 REFERENCES

- A. ASTM A193 – Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service
- B. ASTM A194 – Carbon and Alloy Steel Nuts for Bolts for High-Pressure and High-Temperature Service
- C. ASTM A262 – Practice for Detecting Susceptibility to Intergranular Attack in Austenitic Stainless Steel
- D. ASTM A276 – Stainless and Heat-Resisting Steel Bars and Shapes
- E. ASTM A314 – Stainless and Heat-Resisting Steel Billets and Bars for Forging
- F. ASTM A380 – Practice for Cleaning and Descaling Stainless Steel Parts, Equipment and Systems
- G. ASTM A473 – Stainless and Heat-Resisting Steel Forgings
- H. ASTM A666 – Austenitic Stainless Steel, Sheet, Strip, Plate and Flat Bar

- I. ASTM A774 – Stainless Steel Pipe Fittings
- J. ASTM A778 – Stainless Steel Pipe
- K. ASTM A967 – Standard Specification for Chemical Passivation Treatments for Stainless Steel Parts
- L. ASTM F593 – Stainless Steel Bolts, Hex Cap Screws and Studs
- M. ASTM F594 – Stainless Steel Nuts
- N. ANSI/ASME B1.1 – Unified Inch Screw Thread (UN and UNR Thread Form)

1.04 TESTS

- A. All stainless steel materials including stainless test welds, shall be checked for compliance with tests for susceptibility to intergranular attack. Such tests shall be Practices A, B and E of ASTM A262. Detailed procedures for the tests shall be submitted to the Engineer for approval prior to start of work. Practice A shall be used only for acceptance of materials but not for rejection of materials, and shall be used for screening material intended for testing in Practice B and Practice E. The maximum acceptable corrosion rate under Practice B shall be 0.004 inch per month, rounded off to the third decimal place. If the certified mill report indicates that such test has been satisfactory performed, the fabricator may not be required to repeat the test. Material passing Practice E shall be acceptable.
- B. Sample selection for the susceptibility to intergranular attack tests shall be as follows:
 - 1. One (1) sample per heat treatment lot for plates and forgings;
 - 2. One (1) sample per each Welding Procedure Qualification regardless of the joint design;
 - 3. If tests indicate a reduction in corrosion resistance, welding procedure shall be adjusted or heat treatment determined as needed to restore required corrosion resistance.
 - 4. The samples so chosen shall have received all the post-weld heat treatments identical to the finished part.

1.05 SUBMITTALS

- A. The Contractor shall prepare and submit for approval shop drawings for all stainless steel fabrication in accordance with Section 01 33 00 – Submittal Procedures.
- B. Submittals shall include, but not be limited to, the following:

1. Certified test reports for susceptibility to intergranular attack.
 2. Affidavit of compliance with type of stainless steel shown on the Contract Drawings or specified herein.
 3. Certified weld inspection reports.
 4. Cleaning and handling of stainless steel in accordance with Paragraph 3.04, Cleaning and Handling.
- C. Samples of finish, on each type of stainless steel to be furnished, shall be submitted to the Engineer upon request.

1.06 QUALITY ASSURANCE

- A. Shop inspections may be made by the Engineer. The Contractor shall give ample notice to the Engineer prior to the beginning of any stainless steel fabrication work so that inspection may be provided. The Contractor shall furnish all facilities for the inspection of materials and workmanship in the shop, and the inspectors shall be allowed free access to the necessary parts of the works.
- B. Inspectors shall have the authority to reject any materials or work which does not meet the requirements of the Contract Drawings or the Specifications.
- C. Inspection at the shop is intended as a means of facilitating the work and avoiding errors, but is expressly understood that it will in no way relieve the Contractor from the responsibility for furnishing proper materials or workmanship.

1.07 HANDLING, STORAGE AND DELIVERY

- A. Mechanical damage (e.g., scratches and gouges) to the stainless steel material shall not be permitted and is cause for rejection. Care shall be taken in the material handling since such mechanical damage will result in the passive oxide film being "punctured" leading to a possible lower resistance to the initiation of corrosion than the surrounding chemically-passivated surface.
- B. Stainless steel plates and sheets shall be stored vertically in racks and not be dragged out of the racks or over one another. Racks shall be protected to prevent iron contamination.
- C. Heavy stainless steel plates shall be carefully separated and chocked with wooden blocks so that the forks of a fork-lift could be inserted between plates without mechanically damaging the surface.
- D. Stainless steel plates and sheets laid out for use shall be off the floor and be divided by wooden planks to prevent surface damage and to facilitate subsequent handling.

- E. Plate clamps, if used, shall be used with care as the serrated faces can dig in, indent and gouge the surface.
- F. Stainless steel fabrications shall be loaded in such a manner that they may be transported and unloaded without being overstressed, deformed or otherwise damaged.
- G. Stainless steel fabrications and packaged materials shall be protected from corrosion and deterioration and shall be stored in a dry area. Materials stored outdoors shall be supported above ground surfaces on wood runners and protected with approved effective and durable covers.
- H. Stainless steel fabrications shall not be placed in or on a structure in a manner that might cause distortion or damage to the fabrication. The Contractor shall repair or replace damaged stainless steel fabrications or materials as directed by the Engineer.

1.08 FIELD MEASUREMENTS

- A. The Contractor shall verify all dimensions and shall make any field measurements necessary and shall be fully responsible for accuracy and layout of the work.
- B. The Contractor shall review the Contract Drawings and any discrepancies shall be reported to the Engineer for clarification prior to starting fabrication.

PART 2 – PRODUCTS

2.01 MATERIALS AND FINISHES

- A. Stainless steel shall be Type 304 unless noted otherwise herein or on the Contract Drawings. Stainless steel for underwater service, in confined areas containing fluid, or in corrosive environments shall be Type 316. Minimum mechanical finish shall be No. 4 as stated in Table 2 unless otherwise noted on the Contract Drawings.
- B. The basic mill forms (sheet, strip, plate and bar) are classified by size as shown on Table 1. Tables 2, 3 and 4 identify finishes and conditions in which sheet, bar and plate are available.
- C. Tables 2, 3 and 4 show numbered finishes and conditions for sheet, bar and plate. While there are no specific designations for polished finishes on bar or plate, the sheet finish designations are used to describe the desired effect. This also applies to finishes on ornamental tubing.
- D. There are three standard finishes for strip, which are broadly described by the finishing operations employed:
 - 1. No. 1 Strip Finish

- a. No. 1 strip finish is approximately the same as No. 2D Sheet Finish. It varies in appearance from dull gray matte to a fairly reflective surface, depending largely on alloy composition and amount of cold reduction.
2. No. 2 Strip Finish is approximately the same as a No. 2B sheet finish. It is smoother, more reflective than No. 1, and likewise varies with alloy composition.
3. Bright annealed finish is a highly reflective finish that is retained by final annealing in a controlled atmosphere furnace.

Table 1: Classification of Stainless Steel Product Form

Item	Description	Dimensions		
		Thickness	Width	Diameter or Size
Sheet	Coils and cut length:			
	Mill finishes Nos. 1, 2D and 2B			
	Polished finishes Nos. 3, 4, 6, 7 & 8	under 3/16"	24" and over all widths	-
Strip	Cold finished, coils or cut lengths:			
	Polished finishes Nos. 3, 4, 6, 7 & 8	under 3/16"	under 24" all widths	-
Plate	Flat rolled or forged	3/16" and over	over 10"	-
Bar	Hot finished rounds, squares, octagons and hexagons	-	-	1/4" and over
	Hot finished flats	1/8" to 8" incl.	1/4" to 10" incl.	-
	Cold finished rounds, squares, octagons and hexagons	-	-	over 1/8"
	Cold finished flats	1/8" to 4-1/2"	3/8" to 4-1/2"	-
Wire	Cold finishes only: (in coil)			
	Round, square, octagon, hexagon and flat wire	under 3/16"	under 3/8"	-
Pipe & Tubing	Several different classifications, with differing specifications, are available.			
Extrusion	Not considered "standard" shapes. Currently limited in size to approximately 6-1/2" diameter or structurals.			

Table 2: Standard Mechanical Sheet Finishes

Unpolished or Rolled Finishes		Polished Finishes	
No. 1	A rough dull surface which results from hot rolling to the specified thickness followed by annealing and descaling.	No. 3	An intermediate polish surface obtained by finishing with a 100 grit abrasive. Generally used where a semi-finished polished surface is required. A No. 3 finish usually receives additional polishing during fabrication
No. 2D	A dull finish which results from cold rolling followed by annealing and descaling, and may perhaps get a final light roll pass through unpolished rolls. A 2D finish is used where appearance is of no concern.	No. 4	A polished surface obtained by finishing with a 120-150 mesh abrasive, following initial grinding with coarser abrasives. This is a general purpose bright finish with a visible "grain" which prevents mirror reflection.
No. 2B	A bright cold-rolled finish resulting in the same manner as No. 2D finish, except that the annealed and descaled sheet receives a final light roll pass through polished rolls. This is the general purpose cold-rolled finish that can be used as is, or as a preliminary step to polishing.	No. 6	A dull satin finish having lower reflectivity than No. 4 finish. It is produced by Tampico brushing the No. 4 finish in a medium of abrasive and oil. It is used for architectural applications and ornamentation where a high luster is undesirable, and to contrast with brighter finishes.
		No. 7	A high reflective finish that is obtained by buffing finely ground surfaces but not to the extent of completely removing the "grit" lines. It is used chiefly for architectural and ornamental purposes.
		No. 8	The most reflective surface, which is obtained by polishing with successively finer abrasives and buffing extensively until all grit lines from preliminary grinding operations are removed. It is used for applications such as mirrors and reflectors.

Table 3: Conditions and Finishes for Bar

Conditions	Surface Finishes ¹
Hot worked only	(a) Scale not removed (excluding spot conditioning) (b) Rough turned ² (c) Pickled or blast cleaned and pickled.
Annealed or otherwise heat treated	(a) Scale not removed (excluding spot conditioning) (b) Rough turned (c) Pickled or blast cleaned and pickled (d) Cold drawn or cold rolled (e) Centerless ground (f) Polished
Annealed and cold worked to high tensile strength ³	(a) Cold drawn or cold rolled (b) Centerless ground (c) Polished

Table 4: Conditions and Finishes for Plate

Condition and Finish	Description and Remarks
Hot rolled	Scale not removed. Not heat treated. Plates not recommended for final use in this condition. ⁴
Hot rolled, annealed or heat treated	Scale not removed. Use of plates in this condition is generally confined to heat resisting applications. Scale impairs corrosion resistance. ¹
Hot rolled, annealed or heat treated, blast cleaned or pickled	Condition and finish commonly preferred for corrosion resisting and most heat resisting applications.
Hot rolled, annealed, descaled and temper passed	Smoother finish for specialized applications.

¹ Surface finishes (b), (e) and (f) are applicable to round bars only.

² Bars of the 4xx series stainless steels which are highly hardenable, such as Types 414, 420, 420F, 431, 440A, 440B and 440C, are annealed before rough turning. Other hardenable grades, such as Types 403, 410, 416 and 416Se, may also require annealing depending on their composition and size.

³ Produced in Types 302, 303Se, 304 and 316.

⁴ Surface inspection is not practicable on plates which have not been pickled or otherwise descaled.

Hot rolled, annealed, descaled cold rolled, annealed, descaled, optionally temper passed	Smooth finish with greater freedom from surface imperfection than the above.
Hot rolled, annealed or heat treated, surface cleaned and polished	Polished finishes refer to Table 2.

PART 3 – EXECUTION

3.01 FABRICATION

- A. Holes for bolts and screws shall be drilled. Fastenings shall be concealed where practicable. Joints exposed to the weather shall be formed to exclude water.
- B. As far as practicable, all fabricated units shall be fitted and assembled in the shop, with all cuts and bends made to precision measurements in accordance with details shown on approved shop drawings.
- C. Work shall be fabricated so that it is installed in a manner that will provide for expansion and contraction, prevent the shearing of bolts, screws and other fastenings, ensure rigidity, and provide close fitting of sections.
- D. All finished and/or machined faces shall be true to line and level. Stainless steel sections shall be well formed to shape and size with sharp lines and angles; curved work shall be sprung evenly to curves.
- E. All work shall be fitted together at the shop as far as possible, and delivered complete and ready for erection. Proper care shall be exercised in handling all work so as not to injure the finished surfaces.

3.02 WELDING

- A. Welding shall be done in a manner that will prevent buckling and in accordance with Section 05 05 23 – Metal Fastening, and as modified hereinafter.
- B. All welds exposed in the work shall be ground smooth and finished to match the finish of the adjacent stainless steel surfaces.
- C. Select weld rods that provide weld filler metal having corrosion resistant properties as nearly identical or better than the base metal to insure preservation of the corrosion-resistant properties. Provide heat treatment at welds where testing of weld procedure indicates it is required to restore the corrosion resistance.
- D. Thermal conductivity of stainless steel is about half that of other steels; and the following methods may be used to accommodate this situation:
 - 1. Use lower weld current setting.

2. Use skip-weld techniques to minimize heat concentration.
 3. Use back-up chill bars or other cooling techniques to dissipate heat.
- E. Edges of the stainless steel to be welded shall be cleaned of contaminants.

3.03 FASTENERS

- A. Stainless steel fasteners shall be used for joining stainless steel work.
- B. Stainless steel fasteners shall be made of alloys that are equal to or more corrosion resistant than the materials they join.

3.04 CLEANING AND HANDLING

- A. All stainless steel surfaces shall be precleaned, descaled, passivated and inspected before, during and after fabrication in accordance with the applicable sections of ASTM A380 and as detailed in the procedures to be submitted to the Engineer for approval prior to start of work. Chemical passivation in accordance with ASTM A967 is required for all stainless steel in contact with process water. Degreasing and passivation of stainless steel articles shall be conducted as the last step after fabrication.
- B. Measures to protect cleaned surfaces shall be taken as soon as final cleaning is completed and shall be maintained during all subsequent handling, storage and shipping.
1. The Contractor shall submit for approval specific procedures listing all the steps to be followed in detecting contamination and in descaling, cleaning, passivation and protecting of all stainless steel.
 2. Area showing clear indications of contamination shall be recleaned, repassivated and reinspected.
- C. At approved stages in the shop operations, contaminants such as scale, embedded iron, rust, dirt, oil, grease and any other foreign matter shall be removed from the metal, as directed or approved by the Engineer. The adequacy of these operations shall be checked by the Engineer. Operations in the shop shall be conducted so as to avoid contamination of the stainless steel and to keep the metal surfaces free from dirt and foreign matter.
- D. In order to prevent incipient corrosion during fabrication, special efforts shall be made at all times to keep all stainless steel surfaces from coming in contact with other metals.
1. Stainless steel and stainless steel welds shall be cleaned with clean sand free of iron, stainless steel wool, stainless steel brushes, or other approved means and

shall be protected at all times from contamination by any materials, including carbon steel, that shall impair its resistance to corrosion.

2. Approved methods of cutting, grinding and handling shall be used to prevent contamination. If air-arc, or carbon-arc cutting is used, additional metal shall be removed by approved mechanical means so as to provide clean, weldable edges. All grinding of stainless steel shall be performed with aluminum oxide or silicon carbide grinding wheels bonded with resin or rubber. Grinding wheels used on carbon steel shall not be used on stainless steel.
3. Sand, grinding wheels, brushes and other materials used for cleaning stainless steel shall be checked periodically by the Engineer for contaminants. Cleaning aids found to contain contaminants shall not be used on the work.

3.05 INSTALLATION

- A. All stainless steel fabrications shall be erected square, plumb and true, accurately fitted, adequately anchored in place, set at proper elevations and positions.
- B. All inserts, anchor rods and all other miscellaneous work specified in the Detailed Specifications or shown on the Contract Drawings or required for the proper completion of the work, which are embedded in concrete, shall be properly set and securely held in position in the forms before the concrete is placed.
- C. All stainless steel fabrications shall be installed in conformance with details shown on the Contract Drawings or on the approved shop drawings.

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SECTION 05 14 00
STRUCTURAL ALUMINUM

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. Furnish all equipment, labor, materials, and services required to provide all structural aluminum work in accordance with the Contract Documents. The term "structural aluminum" shall include items as defined in the Aluminum Association "Specifications for Aluminum Structures".

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 05 10 00 – Metal Materials
- B. Section 05 05 23 – Metal Fastening
- C. Section 09 90 00 – Painting

1.03 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

- A. Without limiting the generality of other requirements of the Specifications, all work specified herein shall conform to the applicable requirements of the following documents. All referenced specifications, codes, and standards refer to the most current issue available at the time of the Bid.
 - 1. International Building Code
 - 2. Aluminum Association "Specifications for Aluminum Structures"
 - 3. AWS D1.2 – "Structural Welding Code"

1.04 SUBMITTALS

- A. Submit the following in accordance with Section 01 33 00 – Submittal Procedures.
 - 1. Certified Mill Test Reports
 - 2. Affidavit of Compliance with grade specified
 - 3. Shop Drawings which include the following:
 - a. Layout drawings indicating all structural shapes, sizes, and dimensions.
 - b. Beam and column schedules.

- c. Detailed drawings indicating jointing, anchoring and connection details.

1.05 QUALITY ASSURANCE

- A. Shop inspection may be required by the Owner at the Owner's own expense. The Contractor shall give ample notice to the Engineer prior to the beginning of any fabrication work so that inspection may be provided. The Contractor shall furnish all facilities for the inspection of materials and workmanship in the shop, and the inspectors shall be allowed free access to the necessary parts of the work. Inspectors shall have the authority to reject any materials or work which do not meet the requirements of these Specifications. Inspection at the shop is intended as a means of facilitating the work and avoiding errors, but is expressly understood that it will in no way relieve the Contractor from the responsibility for furnishing proper materials or workmanship under this Specification.

PART 2 – PRODUCTS

2.01 MATERIALS

- A. Structural aluminum shall comply with Section 05 10 00 – Metal Materials.
- B. Fasteners for structural aluminum shall be in accordance with Section 05 05 23 – Metal Fastening.
- C. Electrodes for welding shall be in accordance with Section 05 05 23 – Metal Fastening.

PART 3 – EXECUTION

3.01 MEASUREMENT

- A. The Contractor shall verify all dimensions and shall make any field measurements necessary and shall be fully responsible for accuracy and layout of work. The Contractor shall review the Drawings and any discrepancies shall be reported to the Engineer for clarification prior to starting fabrication.

3.02 FABRICATION

- A. Fabrication shall be in accordance with the Aluminum Association "Specifications for Aluminum Structures". Fabrication shall begin only after Shop Drawing approval.
- B. Except where otherwise noted on the Drawings or in this Specification, all shop connections shall be welded.

- C. All holes in structural aluminum members required for anchors, anchor rods, bolts, or other members or for attachment of other work shall be provided by the fabricator and detailed on the Shop Drawings.
- D. All materials shall be properly worked and match-marked for field assembly.

3.03 DELIVERY, STORAGE AND HANDLING

- A. Structural members shall be loaded in such a manner that they may be transported and unloaded without being over-stressed, deformed or otherwise damaged.
- B. Structural aluminum members and packaged materials shall be protected from corrosion and deterioration. Material shall be stored in a dry area and shall not be placed in direct contact with the ground. Materials shall not be placed on the structure in a manner that might cause distortion or damage to the members or the supporting structures. The Contractor shall repair or replace damaged materials or structures as directed.

3.04 ERECTION

- A. All temporary bracing, guys and bolts as may be necessary to ensure the safety of the structure until the permanent connections have been made shall be provided by the Contractor.
- B. Structural members shall be set accurately to the lines and elevations indicated. The various members shall be aligned and adjusted to form a part of a complete frame or structure before being permanently fastened.
- C. No cutting of structural aluminum members in the field will be allowed except by the written approval of the Engineer.
- D. Bearing surfaces and other surfaces which will be in permanent contact shall be cleaned before assembly.
- E. Field welding shall not be permitted unless specifically indicated in the Drawings or approved in writing by the Engineer. All field welding shall comply with Section 05 05 23 – Metal Fastening.
- F. All bolted connections shall comply with Section 05 05 23 – Metal Fastening.
- G. All field connections shall be accurately fitted up before being bolted. Drifting shall be only such as will bring the parts into position and shall not be sufficient to enlarge the holes or to distort the metal. All unfair holes shall be drilled or reamed.
- H. Misfits at Bolted Connections

1. Where misfits in erection bolting are encountered, the Engineer shall be immediately notified. The Contractor shall submit a method to remedy the misfit for review by the Engineer. The Engineer will determine whether the remedy is acceptable or if the member must be refabricated.
 2. Incorrectly sized or misaligned holes in members shall not be enlarged by burning or by the use of drift pins. The Contractor shall notify the Engineer immediately and shall submit a proposed method of remedy for review by the Engineer.
 3. Where misalignment between anchor bolts and bolt holes in aluminum members are encountered, the Engineer shall be immediately notified. The Contractor shall submit a method to remedy the misalignment for review by the Engineer.
- I. Grouting of Base Plates and Bearing Plates
1. The bottom surface of the plates shall be cleaned of all foreign materials, and concrete or masonry bearing surface shall be cleaned of all foreign materials and roughened to improve bonding.
 2. Accurately set all base and bearing plates to designated levels with steel wedges or leveling plates.
 3. Baseplates shall be grouted with non-shrink grout to assure full uniform bearing. Grouting shall be done prior to placing loads on the structure. Non-shrink grout shall conform to Section 03 60 00 – Grout.
 4. Anchor bolts shall be tightened after the supported members have been positioned and plumbed and the non-shrink grout has attained its specified strength.
- J. Where finishing is required, assembly shall be completed including bolting and welding of units before start of finishing operations.

3.05 PAINTING

- A. Painting shall be performed according to Section 09 90 00 – Painting.
- B. Aluminum surfaces in contact with concrete or dissimilar metals shall be thoroughly protected with two coats of epoxy paint with a minimum total thickness of 16 mils or other approved isolating material in accordance with the requirements of Section 09 90 00 – Painting.

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SECTION 05 50 00
METAL FABRICATIONS

PART 1 – GENERAL

1.01 REQUIREMENT

- A. Furnish all materials, labor, and equipment required to provide all metal fabrications not specifically included in other Sections, complete and in accordance with the requirements of the Contract Documents.
- B. Work shall include but may not be limited to lintels and guard posts.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 05 10 00 – Metal Materials
- B. Section 05 05 23 – Metal Fastening
- C. Section 05 05 13 – Galvanizing
- D. Certain specific items are included in other Sections of the Specifications. See the section for the specific item in question.

1.03 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

- A. Without limiting the generality of other requirements of the Specifications, all work specified herein shall conform to the applicable requirements of the following documents. All referenced specifications, codes, and standards refer to the most current issue available at the time of Bid.
 - 1. International Building Code
 - 2. AISC – Specification for Structural Steel Buildings
 - 3. AISI – Specifications for the Design of Cold-Formed Steel Structural Members
 - 4. Aluminum Association Specifications for Aluminum Structures

1.04 SUBMITTALS

- A. Submit the following in accordance with Section 01 33 00 – Submittal Procedures.
 - 1. Complete fabrication and erection drawings of all metalwork specified herein.

2. Other submittals as required in accordance with Section 05 10 00 – Metal Materials and Section 05 05 23 – Metal Fastening.

PART 2 – PRODUCTS

2.01 METAL MATERIALS

- A. Metal materials used in metal fabrications shall conform to Section 05 10 00 – Metal Materials, unless noted otherwise.

2.02 METAL FASTENING

- A. All welds and fasteners used in metal fabrication shall conform to Section 05 05 23 – Metal Fastening, unless noted otherwise.

2.03 LINTELS

- A. Provide lintels as shown on the Drawings and specified herein with 8 inches minimum bearing each side unless noted otherwise.
- B. All lintels shall be steel in accordance with Section 05 12 00 – Structural Steel and shall be galvanized in accordance with Section 05 05 13 – Galvanizing, unless noted otherwise.

2.04 GUARD POSTS (BOLLARDS)

- A. Guard posts shall be 6-inch diameter Schedule 40 galvanized steel pipe in accordance with ASTM A53.
- B. Guard posts shall be concrete filled and crowned, as detailed in the Drawings.

PART 3 – EXECUTION

3.01 FABRICATION

- A. All measurements and dimensions shall be based on field conditions and shall be verified by the Contractor prior to fabrication. Such verification shall include coordination with adjoining work.
- B. All fabricated work shall be shop fitted together as much as practicable, and delivered to the field, complete and ready for erection. All miscellaneous items such as stiffeners, fillets, connections, brackets, and other details necessary for a complete installation shall be provided.

- C. All work shall be fabricated and installed in a manner that will provide for expansion and contraction, prevent shearing of bolts, screws, and other fastenings, ensure rigidity, and provide a close fit of sections.
- D. Finished members shall conform to the lines, angles, and curves shown on the Drawings and shall be free from distortions of any kind.
- E. All shearings shall be neat and accurate, with parts exposed to view neatly finished. Flame cutting is allowed only when performed utilizing a machine.
- F. All shop connections shall be welded unless otherwise indicated on the Drawings or specified herein. Bolts and welds shall conform to Section 05 05 23 – Metal Fastening. All fastenings shall be concealed where practicable.
- G. Fabricated items shall be shop painted when specified in Section 09 90 00 – Painting.

3.02 INSTALLATION

- A. Assembly and installation of fabricated system components shall be performed in strict accordance with manufacturer's recommendations.
- B. All miscellaneous metalwork shall be erected square, plumb and true, accurately fitted, adequately anchored in place, and set at proper elevations and positions.
- C. Metal work shall be field painted when as specified in accordance with Section 09 90 00 – Painting.

END OF SECTION

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SECTION 05 51 00
METAL STAIRS

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. Furnish all materials, labor, and equipment required to provide all metal stairs in accordance with the Contract Documents.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 05 10 00 – Metal Materials
- B. Section 05 05 13 – Galvanizing
- C. Section 05 05 23 – Metal Fastening
- D. Section 05 12 00 – Structural Steel
- E. Section 05 14 00 – Structural Aluminum
- F. Section 05 52 00 – Guards and Railings
- G. Section 05 53 00 – Gratings, Access Hatches, and Access Doors
- H. Section 05 55 00 – Stair Treads and Nosings

1.03 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

- A. Without limiting the generality of the other requirements of the specifications, all work herein shall conform to the applicable requirements of the following documents. All referenced specifications, codes, and standards refer to the most current issue available at the time of Bid.
 - 1. International Building Code
 - 2. AISC – Specification for Structural Steel Buildings
 - 3. AISI – Specification for the Design of Cold-Formed Steel Structural Members
 - 4. Aluminum Association Specifications for Aluminum Structures

1.04 SUBMITTALS

- A. Submit the following in accordance with Section 01 33 00 – Submittal Procedures.

1. Complete fabrication and erection drawings of all metal work specified herein.
2. Other submittals as required in accordance with Section 05 10 00 – Metal Materials and Section 05 05 23 – Metal Fastening.
3. Submit structural calculations and detailed erection drawings for steel pan stairs. Calculations and drawings shall be signed and sealed by a Professional Engineer currently registered in the State or Commonwealth in which the project is located.

PART 2 – PRODUCTS

2.01 METAL MATERIALS

- A. Metal materials used for metal stairs shall conform to Section 05 10 00 – Metal Materials, unless noted otherwise.

2.02 METAL FASTENING

- A. All welds and fasteners used in metal stairs shall conform to Section 05 05 23 – Metal Fastening, unless noted otherwise.

2.03 METAL STAIRS AND LANDINGS

- A. Stair stringers and structural framing of landings shall be fabricated from steel or aluminum as indicated on the Drawings.
 1. Steel stairs shall be fabricated from steel in accordance with Section 05 12 00 – Structural Steel.
 2. Aluminum stairs shall be fabricated from aluminum alloy 6061-T6 in accordance with Section 05 14 00 – Structural Aluminum.
- B. Regardless of material of stringers, all stair treads shall be aluminum in accordance with Section 05 55 00 – Stair Treads and Nosings.
- C. Where metal landings are required as indicated on the Drawings, gratings at landings shall conform to Section 05 53 00 – Gratings, Access Hatches, and Access Doors.
- D. Guards for metal stairs shall conform to Section 05 52 00 – Guards and Railings. Contractor shall coordinate attachment of guards to metal stairs.
- E. All clips, anchors, and necessary appurtenances shall be provided for a complete and rigid installation.
- F. Closure plates shall be provided for all exposed ends of stringers.

- G. All exposed connections shall be welded and ground smooth, unless otherwise indicated on the Drawings.
- H. Stairs and landings shall be designed to support a 100 psf live load, minimum, unless otherwise indicated on the Drawings.

2.04 STEEL PAN STAIRS

A. General

1. All steel stairs and landings with concrete filled steel pan risers and treads shall meet all applicable OSHA, ANSI, and NFPA codes.
2. Stair assemblies shall conform to the dimensions and arrangements shown on the Drawings.
3. Stair assemblies shall be designed to support a minimum 100 psf live load unless otherwise indicated on the Drawings.
4. Steel framing, hangers, columns, struts, clips, brackets, bearing plates, and other necessary appurtenances shall be provided for support of stairs and platforms as shown on the Drawings.
5. Exposed portions of steel pans, platforms, framing system stringers, and portions of aluminum nosings in contact with concrete, steel, or masonry shall be painted in accordance with Section 09 90 00 – Painting.
6. Concrete fill shall be 3-inches thick for platforms and 1-1/2 inches thick for pan treads.
7. Cast-in-place safety stair nosings in accordance with Section 05 55 00 – Stair Treads and Nosings, shall be provided for treads and platforms.
8. Metal pan treads, platforms, and risers shall be fabricated from 0.1084-inch thick (12 gauge minimum), galvanized structural steel sheets.
9. Risers and treads shall be supported by steel angle brackets welded to the stringers. Metal pans shall be secured to the brackets with welds.
10. Closure pieces shall be provided for ends of stringers.
11. Contractor shall be exclusively responsible for the design of steel pan stairs as shown on the Drawings including, but not limited to, treads, risers, landings, framing, hangers, beams, columns, struts, clips, brackets, bracing, bearing plates, connections (bolts, welds, concrete anchors, fasteners, etc.), guardrail, handrail,

and other necessary components and appurtenances required for complete design and assembly of the steel pan stair system.

- a. Steel pan stairs shall be designed for all applicable loads (dead, live, wind, seismic, snow, etc.) as required by the governing building code and ASCE 7. See Structural Drawings and as specified herein for minimum required loads and site-specific parameters. Design shall consider all loads, erection, temperature, and anchorage stresses.
- b. All welds and fasteners used in steel pan stairs shall conform to Section 05 05 23 – Metal Fastening, unless noted otherwise.
- c. Design of concrete anchors shall include design of anchor size, embedment, and edge distances.

B. Connections

1. All connections between steel components shall be welded unless otherwise shown on the Drawings or specified herein. All welds shall be continuous and ground smooth where exposed. Welding and fasteners shall conform to Section 05 05 23 – Metal Fastening.
2. Assemblies shall be fabricated such that bolts and other fastenings do not appear on finished surfaces.
3. All joints shall be true and tight, and connections between parts shall be light-proof tight.

- C. Guards for steel pan stairs shall conform to Section 05 52 00 – Guards and Railings. Contractor shall coordinate connection of guards to stairs.**

PART 3 – EXECUTION

3.01 FABRICATION

- A. All measurements and dimensions shall be based on field conditions and shall be verified by the Contractor prior to fabrication. Such verification shall include coordination with all adjoining work.
- B. All fabricated work shall be shop fitted together as much as practicable, and delivered to the field, complete and ready for erection. All miscellaneous items such as stiffeners, fillets, connections, brackets, and other details necessary for a complete installation shall be provided.

- C. All work shall be fabricated and installed in a manner that will provide for expansion and contraction, prevent shearing of bolts, screws, and other fastenings, ensure rigidity, and provide a close fit of sections.
- D. Finished members shall conform to the lines, angles, and curves shown on the drawings and shall be free from distortions of any kind.
- E. All shearings shall be neat and accurate, with parts exposed to view neatly finished. Flame cutting is allowed only when performed utilizing a machine.
- F. All shop connections shall be welded unless otherwise indicated on the Drawings or specified herein. Bolts and welds shall conform to Section 05 05 23 – Metal Fastening. All fastenings shall be concealed where practicable.
- G. Fabricated items shall be shop painted when specified in accordance with Section 09 90 00 – Painting.

3.02 INSTALLATION

- A. Assembly and installation of metal stairs shall be performed in strict accordance with manufacturer's recommendations.
- B. All miscellaneous metalwork shall be erected square, plumb and true, accurately fitted, adequately anchored in place, and set at proper elevations and positions.
- C. Metal stairs shall field painted when specified in accordance with Section 09 90 00 – Painting.

END OF SECTION

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SECTION 05 51 33

LADDERS

PART 1 – GENERAL

1.01 REQUIREMENT

- A. Furnish all materials, labor, and equipment required to provide all ladders in accordance with the requirements of the Contract Documents.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 05 10 00 – Metal Materials
- B. Section 05 05 23 – Metal Fastening

1.03 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

- A. Without limiting the generality of the Specifications, all work specified herein shall conform to the applicable requirements of the following documents.
 - 1. International Building Code
 - 2. Aluminum Association Specifications for Aluminum Structures
 - 3. Occupational Safety and Health Administration (OSHA) Regulations

1.04 SUBMITTALS

- A. Submit the following in accordance with Section 01 33 00 – Submittal Procedures.
 - 1. Complete fabrication and erection drawings of all metalwork specified herein.
 - 2. Other submittals as required in accordance with Section 05 10 00 – Metal Materials and Section 05 05 23 – Metal Fastening.

PART 2 – PRODUCTS

2.01 METAL MATERIALS

- A. Metal materials used for ladders shall conform to Section 05 10 00 – Metal Materials, unless noted otherwise.

2.02 METAL FASTENING

- A. All welds and fasteners used for ladders shall conform to Section 05 05 23 – Metal Fastening, unless noted otherwise.

2.03 LADDERS

- A. Ladders shall be furnished with all mounting brackets, baseplates, fasteners, and necessary appurtenances for a complete and rigid installation.
- B. Unless noted otherwise on the Drawings, all ladders shall be aluminum alloy 6061-T6 or 6063-T5, with a clear, anodized finish, Aluminum Association M12C22A41.
- C. All ladders shall conform to dimensions indicated on the Drawings and shall comply with OSHA requirements.
- D. Side rails shall be 1-1/2 inch diameter Schedule 80 pipe, minimum.
- E. Rungs shall be serrated 3/4 inch diameter, minimum.
- F. All exposed connections shall be welded and ground smooth.
- G. Ladders shall be as manufactured by Thompson Fabricating Company, or equal.

2.04 LADDER SAFETY SYSTEM

- A. All ladders with an uninterrupted climb length exceeding 24 feet between rest platform landings or floors shall be installed with a ladder safety system.
- B. All ladders, regardless of height, shall be installed with a ladder safety system.
- C. Ladder safety system shall comply with all OSHA requirements and meet ANSI A14.3 design requirements.
- D. Ladder safety system shall include all necessary components to provide a fully operational system, including one full body safety harness with a 310 lb. weight capacity for each ladder safety system.
- E. Ladder Safety Systems shall be Miller Vi-Go by Honeywell, LAD_SAF by DBI Sala, or approved equal.

2.05 LADDER RETRACTABLE SAFETY EXTENSION

- 1. Where the Contract Documents indicate fixed ladders are required under access doors and checkered floor plates, they shall be provided with “LadderUp, Model

LU-4" by Bilco Company, "L1E Ladder Extension" by Halliday Products Inc., or "Ladder Climb-out Device" by Thompson Fabricating.

2. For access doors, the safety extension shall be manufactured from the same material as the access door with telescoping tubular sections that lock automatically when fully extended.
3. Upward and downward movement shall be controlled by a stainless-steel balancing mechanism.
4. Safety extension shall be assembled in strict accordance with manufacturer's recommendations.

PART 3 – EXECUTION

3.01 FABRICATION

- A. All measurements and dimensions shall be based on field conditions and shall be verified by the Contractor prior to fabrication. Such verification shall include coordination with adjoining work.
- B. All fabricated work shall be shop fitted together as much as practicable, and delivered to the field, complete and ready for erection.
- C. All work shall be fabricated and installed in a manner that will provide for expansion and contraction, prevent shearing of bolts, screws, and other fastenings, ensure rigidity, and provide a close fit of sections.
- D. Finished members shall conform to the lines, angles, and curves shown on the Drawings and shall be free from distortions of any kind.
- E. All shearings shall be neat and accurate, with parts exposed to view neatly finished. Flame cutting is allowed only when performed utilizing a machine.
- F. All shop connections shall be welded unless otherwise indicated on the Drawings or specified herein. Bolts and welds shall conform to Section 05 05 23 – Metal Fastening. All fastenings shall be concealed where practicable.
- G. Fabricated items shall be shop painted when specified in accordance with Section 09 90 00 – Painting.

3.02 INSTALLATION

- A. Assembly and installation of fabricated system components shall be performed in strict accordance with manufacturer's recommendations.

- B. All miscellaneous metalwork shall be erected square, plumb and true, accurately fitted, adequately anchored in place, and set at proper elevations and positions.
- C. Metalwork shall be field painted when specified in accordance with Section 09 90 00 – Painting.

END OF SECTION

SECTION 05 52 00
GUARDS AND RAILINGS

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. Furnish all materials, labor, and equipment required to provide all metal guards and railings in accordance with the Contract Documents.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 05 10 00 – Metal Materials
- B. Section 05 05 23 – Metal Fastening

1.03 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

- A. Without limiting the generality of the other requirements of the specifications, all work herein shall conform to the applicable requirements of the following documents. All referenced specifications, codes, and standards refer to the most current issue available at the time of Bid.
 - 1. International Building Code
 - 2. Aluminum Association Specifications for Aluminum Structures
 - 3. Occupational Safety and Health Administration (OSHA) Regulations

1.04 SUBMITTALS

- A. Submit the following in accordance with Section 01 33 00 – Submittal Procedures.
 - 1. Complete fabrication and erection drawings of all metal work specified herein, sealed by a Professional Engineer currently licensed in the State or Commonwealth in which the Project is located.
 - 2. Other submittals as required in accordance with Section 05 10 00 – Metal Materials and Section 05 05 23 – Metal Fastening.
 - 3. Structural calculations on guard and handrail system sealed by a Professional Engineer currently licensed in the State or Commonwealth in which the project is located.

PART 2 – PRODUCTS

2.01 METAL MATERIALS

- A. Metal materials used for guards and railings shall conform to Section 05 10 00 – Metal Materials, unless noted otherwise.

2.02 METAL FASTENING

- A. All welds and fasteners used in guards and railings shall conform to Section 05 05 23 – Metal Fastening, unless noted otherwise.

2.03 GUARDS AND RAILINGS

- A. General – Design of guard and handrail systems is the exclusive responsibility of the Contractor. Guard systems shall consist of all railings, posts, toeboards, baseplates, anchors, and accessories required for a complete and rigid installation.
 - 1. All guard systems shall be fabricated from extruded aluminum alloy 6061-T6 or 6105-T5, with Aluminum Association M12C22A41 finish, unless otherwise noted.
 - 2. Metal railings shall be fabricated from 1-1/2 inch Schedule 40 minimum pipe. Metal railing support posts shall be fabricated from 1-1/2 inch Schedule 80 minimum pipe.
 - 3. The top of the upper guard rail shall be 42 inches above the walking surface for level guards. For stair guards, the top of the upper guard rail shall be 42 inches above the leading edge of the tread nosing. The top of stair handrail shall be 34 inches above the leading edge of the tread nosing.
 - 4. Posts
 - a. Maximum horizontal spacing between posts for level rail shall be six feet.
 - b. Maximum horizontal spacing between posts for stair rail shall be five feet.
 - 5. All rail joints shall be finished flush and shall occur only at supports. Posts shall not interrupt the continuation of the top rail at any point along the railing, including corners and end terminations. The top surface of the top railing shall be smooth and shall not be interrupted by projecting fittings.
 - 6. Toeboards
 - a. Toeboards shall project 4-inches above the walking surface and shall not infringe on the minimum required walkway width.

- b. Aluminum toeboards shall be extruded from aluminum alloy 6063-T6 unless otherwise noted.
 - c. Toeboards shall have a minimum thickness of 1/8" at any point. Geometry of toeboard shall closely resemble geometry shown on Drawings.
- 7. Expansion joint splices shall be provided at 30 foot maximum spacing and at all expansion joints in the structure supporting the guards.
- 8. The guard system shall be designed to resist the design loads specified by both OSHA and the International Building Code.
- 9. Provide handrail extensions at top and bottom of stairs and ramps in accordance with the International Building Code.
- B. The Contractor shall have the option of providing a guard system of either an all welded type construction or a component type construction.
 - 1. With both the all welded or component type construction, the baseplates and toeboards shall be furnished as shown on the Drawings.
 - 2. Component Type System
 - a. All fittings and brackets shall be designed for stainless steel concealed set screws with internal type connectors.
 - b. Exposed fittings shall be cast or extruded aluminum, or stainless steel to match guard material, except where corrosion-resistant steel is employed as a standard fabricator's item for use.
 - c. Component type guards shall be as manufactured by Thompson Fabricating Company, Inc., or Hollaender Manufacturing Company, Inc.
 - 3. Welded guards may be field assembled using component type fittings as described herein.
- C. Guards shall be either Type I guards as shown on the Drawings.
 - 1. Type I guards shall be a two-rail system. The intermediate rail shall be located as required to prevent passage of a 21-inch diameter sphere at any point.
- D. Where gates are required in guards as shown on the Drawings, they shall be self-closing and shall be provided by the same manufacturer as the guards. Gates shall swing away from the opening being protected by the guards.

- E. Where safety chains are required in guards as shown on the Drawings, chains shall be constructed of Type 304 stainless steel. Chains shall be straight link style, 3/16-inch diameter, with at least twelve links per foot, and with snap hooks on each end. Snap hooks shall be boat type and eye bolts for attachment of chains shall be 3/8-inch bolts with 3/4-inch eye diameter welded to the railing posts. Two (2) chains, four inches longer than the anchorage spacing shall be supplied for each guarded area.

PART 3 – EXECUTION

3.01 FABRICATION

- A. All measurements and dimensions shall be based on field conditions and shall be verified by the Contractor prior to fabrication. Such verification shall include coordination with all adjoining work.
- B. All fabricated work shall be shop fitted together as much as practical, and delivered to the field, complete and ready for erection.
- C. All work shall be fabricated and installed in a manner that will provide for expansion and contraction, prevent shearing of bolts, screws, and other fastenings, ensure rigidity, and provide a close fit of sections.
- D. Finished members shall conform to the lines, angles, and curves shown on the drawings and shall be free from distortions of any kind.
- E. All shearings shall be neat and accurate, with parts exposed to view neatly finished. Flame cutting is allowed only when performed utilizing a machine.
- F. Concrete anchors and bolts for attachment of guard baseplates to supporting members shall conform to Section 05 05 23 – Metal Fastening.
- G. All fabricated items shall be shop painted in accordance with Section 09 90 00 – Painting.

3.02 INSTALLATION

- A. Assembly and installation of guards and railings shall be performed in strict accordance with manufacturer's recommendations.
- B. All guards and railings shall be erected square, plumb and true, accurately fitted, adequately anchored in place, and set at proper elevations and positions.

END OF SECTION

SECTION 05 53 00
GRATINGS, CHECKERED FLOOR PLATES, AND ACCESS DOORS

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. Furnish all materials, labor, and equipment required to provide all gratings, floor plates, and access doors in accordance with the Contract Documents.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 05 10 00 – Metal Materials
- B. Section 05 05 13 – Galvanizing
- C. Section 05 05 23 – Metal Fastening

1.03 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

- A. Without limiting the generality of the other requirements of the specifications, all work herein shall conform to the applicable requirements of the following documents. All referenced specifications, codes, and standards refer to the most current issue available at the time of Bid.
 - 1. International Building Code
 - 2. Aluminum Association Specifications for Aluminum Structures
 - 3. Occupational Safety and Health Administration (OSHA) Regulations
 - 4. ANSI/NAAMM MBG 531 – NAAMM Metal Bar Grating Manual
 - 5. ASTM C1802 – Design, Testing, Manufacture, Selection, and Installation of Fabricated Metal Access Hatches for Utility, Water, and Wastewater Structures

1.04 SUBMITTALS

- A. Submit the following in accordance with Section 01 33 00 – Submittal Procedures.
 - 1. Complete fabrication and erection Drawings of all gratings, floor plates, and access doors specified herein.
 - 2. For checkered floor plates, structural calculations signed and sealed by a currently registered Professional Engineer in the State or Commonwealth in which the

Project is located verifying the proposed floor plate meets the minimum load and deflection requirements stipulated herein.

3. For access doors provided by a manufacturer not specifically named herein, structural calculations signed and sealed by a Professional Engineer currently registered in the State or Commonwealth in which the Project is located verifying the proposed access door meets the minimum load and deflection requirements stipulated herein. For access doors provided by a named manufacturer, sealed calculations are not required provided the applicable ASTM C1802 load rating is clearly indicated in the submittal for each proposed product.
4. Other submittals as required in accordance with Section 05 10 00 – Metal Materials and Section 05 05 23 – Metal Fastening.

PART 2 – PRODUCTS

2.01 METAL MATERIALS

- A. Metal materials used for gratings, floor plates, and access doors shall conform to Section 05 10 00 – Metal Materials, unless noted otherwise.

2.02 METAL FASTENING

- A. All welds and fasteners used for gratings, floor plates, and access doors shall conform to Section 05 05 23 – Metal Fastening, unless noted otherwise.

2.03 GRATING

- A. General - Grating, including support frames, fastenings, and all necessary appurtenances for a complete installation, shall be furnished as indicated on the Drawings.
 1. All exposed bearing ends of grating shall be enclosed in a perimeter band of the same dimensions and material as the main bars, including ends at all cutouts.
 2. Grating shall be fabricated into easily removable sections and shall be fastened at each corner and as required with fasteners provided by the grating manufacturer. No fasteners shall be permitted to project above the walking surface.
 3. Grating shall be designed for a loading of 150 psf unless otherwise required by the Drawings. Grating deflection shall not exceed 1/4 inch under a uniform load of 150 psf. Minimum grating depth shall be 1-1/2 inches, unless structural requirements based on clear span require more depth.

4. Grating installed in cast-in-place concrete shall be provided with embedded support frames on all perimeter and bearing edges. Support frames shall be extruded frames with continuous means of anchoring frames to concrete around entire perimeter of frame. Support frames shall be fabricated from the same material as the grating.

B. Aluminum Grating

1. Aluminum grating shall be of I-bar type and shall consist of extruded bearing bars positioned and locked by crossbars. All supports, cross members, etc. shall be aluminum. Plank clips for grating attachment to frames and any other required attachments, shall be aluminum or stainless steel. Bolts shall be stainless steel. Provide embedded aluminum support frames for cast-in-place concrete installations.
2. Grating shall be "IB" by Harsco Industrial IKG, "I-Bar 19SGI4", by Ohio Grating Inc., or "I-Bar" by Thompson Fabricating LLC.

2.04 CHECKERED FLOOR PLATES

- A. Floor plates shall meet the requirements of ASTM C1802 for Load Level 1 – Light Pedestrian Load, minimum, unless otherwise indicated on the Drawings.
- B. Floor plates shall be aluminum unless noted otherwise.
- C. All floor plates shall be checkered plate with an approved raised pattern, non-skid surface.
- D. Openings greater than 42 inches in either direction shall require two plates opening via hinges in opposite directions.
- E. Floor plates shall be designed to carry a minimum service level live load of 150 psf, or a concentrated load of 300 pounds applied over a 5.50 inch by 5.50 inch area, whichever produces the greatest stress, unless indicated otherwise on the Drawings. Loading shall be positioned to produce the greatest stresses, both due to maximum moment and maximum shear load conditions.
- F. All components of checkered floor plates shall have a minimum tensile yield strength of 23,000 psi and a minimum compressive yield strength of 21,000 psi. Yield strengths shall be indicated on both the structural calculations and the fabrication drawings.
- G. Live load deflection shall be limited to $L/200$ of the span, but no greater than 3/16 inch.
- H. All checkered floor plates shall be fabricated from 1/4" plate, minimum and shall be stiffened as required to maintain allowable stress and deflection requirements specified herein.

- I. Stiffeners shall consist of angles or bars welded to the bottom of the plate.
- J. Checkered floor plate hinges shall be either stainless steel or aluminum with stainless steel pins and fasteners.
- K. All checkered floor plates shall be provided with recessed handles. Handle material shall be as shown on the Contract Drawings.
- L. Air-tight and water-tight checkered floor plates shall be provided with a 1/8-inch-thick neoprene gasket between the checkered plate and the support frame. Gasket material shall be bonded to the support frame and checkered floor plates shall be bolted to the structural support frame with countersunk stainless-steel flathead screws.
- M. All floor plates shall be clearly marked with the information listed below. Markings shall be indicated on metal or plastic tags permanently attached to the floor plate or frame or shall be permanently painted or printed.
 - 1. The manufacturer's name or trademark, location, and telephone contact number.
 - 2. The manufacturer's model number and ASTM designation.
 - 3. The design load level as indicated in ASTM C1802. If the design requires deviation from the Load Level requirements specified in ASTM C1802, a description of the modifications shall be included.
 - 4. Date of manufacture and/or serial number.

2.05 ACCESS DOORS

A. General

- 1. Door opening sizes, number, and direction of swing of door leaves, and locations shall be as shown on the Drawings. The Drawings shall indicate the dimensions of the openings in the concrete. Clear opening dimensions shall be no smaller than six inches less than the concrete opening.
- 2. All doors shall be aluminum unless otherwise noted.
- 3. All door components shall have a minimum tensile yield strength of 23,000 psi and a minimum compressive yield strength of 21,000 psi. Yield strengths shall be indicated on both the structural calculations and the fabrication drawings.
- 4. Openings larger than 42 inches in either direction shall have double leaf doors.
- 5. Doors shall be designed for flush mounting and for easy opening from both inside and outside.

6. All doors shall be provided with an automatic hold-open arm with release handle.
7. Double leaf doors shall be provided with safety bars to go across the open sides of the door, when in the open position. Brackets shall be provided on the underside of the doors to hold the safety bars when not in use.
8. All hardware, including but not limited to, all parts of the latch and lifting mechanism assemblies, hold open arms and guides, brackets, hinges, springs, pins, and fasteners shall be stainless steel.
9. All doors specifically required to be watertight shall be installed with a continuous gasket.
10. Access door frames with integral gutter systems shall be equipped with a 1-1/2-inch minimum drainpipe located by the manufacturer. The drainpipe shall be provided by the Contractor and shall extend to the nearest point of discharge acceptable to the Engineer.
11. All doors shall be clearly marked with the information listed below. Markings shall be indicated on metal or plastic tags permanently attached to the door or frame or shall be permanently painted or printed.
 - a. The manufacturer's name or trademark, location, and telephone contact number.
 - b. The manufacturer's model number and ASTM designation.
 - c. The design load level as indicated in ASTM C1802. If the design requires deviation from the Load Level requirements specified in ASTM C1802, a description of the modifications shall be included.
 - d. The nominal door opening dimensions and/or the manufacturer's model number.
 - e. Date of manufacture and/or serial number.

B. Floor, Wet Well and Dry Pit Access Doors

1. Door leaves shall be 1/4 inch, minimum, diamond pattern plate with an approved raised pattern, non-skid surface. Plate shall be stiffened as required to maintain allowable stress and deflection requirements. Stiffeners shall consist of angles or bars welded to the bottom of plate.
2. Doors shall be designed for flush mounting and for easy opening from both inside and outside.

3. All doors shall have an enclosed compression spring assist and open to 90 degrees.
4. Doors not required to support traffic loading shall meet the requirements of ASTM C1802 for Load Level 2 – Pedestrian Load as a minimum and the following:
 - a. Doors shall be designed to carry a minimum service level live load of 300 psf or a concentrated load of 600 pounds applied over a 5.50 inch by 5.50 inch area, whichever produces the greatest stress, unless indicated otherwise on the Drawings. Loading shall be positioned to produce the maximum stresses, both due to maximum moment and maximum shear load conditions.
 - b. Live load deflection shall be limited to $L/200$ of the span, but not greater than 3/16 inch.
 - c. Unless otherwise noted, exterior doors shall have an integral gutter system and be Type "FDDP" by Nystrom, Type "W1S" or "W2S" by Halliday Products Inc., Type "TPS" or "TPD", by U.S.F. Fabrication Inc., or Type "THG" or "THG-D", by Thompson Fabricating LLC, or Type "J-AL" or "JD_AL" by the Bilco Company.
 - d. Unless otherwise noted, interior doors shall be Type "FDNP" by Nystrom, Type "S1S" or "S2S" by Halliday Products Inc., Type "APS300" or "APD300", by U.S.F. Fabrication Inc., or Type "TH" or "TH-D", by Thompson Fabricating LLC.
5. Doors required to support traffic loadings shall meet the requirements of ASTM C1802 for Load Level 4 – Occasional Truck Traffic, unless otherwise indicated on the Drawings.
 - a. For openings less than or equal to 48 inches, the design loading shall consist of a service level 16,000 pound load applied over a 10 inch by 20 inch area with traffic both parallel and perpendicular to the span considered. Loadings shall be positioned to produce the maximum stresses, both due to maximum moment and maximum shear load conditions.
 - b. For openings greater than 48 inches, two load cases shall be considered. Load Case 1 shall consist of two service level 16,000 pound loads spaced at 48 inches on center with each load applied over a 10 inch by 20 inch area and assuming the traffic direction is perpendicular to the span of the door. Load Case 2 shall consist of two service level 12,500 pound loads spaced at 48 inches on center with each load applied over a 10 inch by 20 inch area and assuming the traffic direction is parallel to the span of the door. Loadings for both cases shall be positioned to produce the maximum

stresses, both due to maximum moment and maximum shear load conditions.

- c. Live load deflections shall be limited to $L/250$ of the span, but not greater than $3/16$ inch, and shall be determined based off a service level 16,000 pound load.
- d. Unless otherwise noted, doors rated for HS-20 traffic loading shall have an integral gutter system and be Type "FDDH" by Nystrom, Type "H1C" or "H2C" by Halliday Products, Inc., Type "THS" or "THD" by U.S.F. Fabrication Inc., Type "THG-H20" by Thompson Fabricating LLC, or "Type JAL-H20" or "JDAL-H20" by the Bilco Company.

C. Roof Access Doors

- 1. Doors shall be designed for 40 psf live load unless noted otherwise.
- 2. Doors shall be Bilco Type F roof Scuttle.

2.06 FALL THROUGH PREVENTION SYSTEM

- A. All checkered floor plates and access doors covering openings measuring 12 inches or more in its least dimension through which persons may fall shall be equipped with a fall through prevention system, except as noted on the Contract Drawings. Checkered floor plates and access doors shall be provided with a permanent installed fall through prevention grate system that provides continuous safety assurance in both its closed and open positions. The grate system shall be made with 6061-T6 aluminum or FRP and be designed for a 300 psf minimum live load, unless noted otherwise.

PART 3 – EXECUTION

3.01 FABRICATION

- A. All measurements and dimensions shall be based on field conditions and shall be verified by the Contractor prior to fabrication. Such verification shall include coordination with adjoining work.
- B. All fabricated work shall be shop fitted together as much as practicable, and delivered to the field, complete and ready for erection. All miscellaneous items such as stiffeners, fillets, connections, brackets, and other details necessary for a complete installation shall be provided.

- C. All work shall be fabricated and installed in a manner that will provide for expansion and contraction, prevent shearing of bolts, screws, and other fastenings, ensure rigidity, and provide a close fit of sections.
- D. Finished members shall conform to the lines, angles, and curves shown on the Drawings and shall be free from distortions of any kind.
- E. All shearings shall be neat and accurate, with parts exposed to view neatly finished. Flame cutting is allowed only when performed utilizing a machine.
- F. All shop connections shall be welded unless otherwise indicated on the Drawings or specified herein. Bolts and welds shall conform to Section 05 05 23 – Metal Fastening. All fastenings shall be concealed where practicable.

3.02 INSTALLATION

- A. Assembly and installation of fabricated system components shall be performed in strict accordance with manufacturer's recommendations.
- B. All gratings, checkered floor plates, and access doors shall be erected square, plumb and true, accurately fitted, adequately anchored in place, and set at proper elevations and positions. Embedded support frames shall be set level and square.
- C. Where access doors utilize leveling bolts, or are placed on irregular surfaces, and are not to be embedded in concrete, the area beneath the frames shall be fully grouted with non-shrink grout to create a uniformly loaded bearing surface.
- D. Grating shall not be field cut or modified unless approved by Engineer.
- E. Grating shall not be used for equipment support or anchorage.

END OF SECTION

SECTION 05 55 00
STAIR TREADS AND NOSINGS

PART 1 – GENERAL

1.01 REQUIREMENT

- A. Furnish all materials, labor, and equipment required to provide all stair treads and nosings in accordance with the requirements of the Contract Documents.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 05 10 00 – Metal Materials
- B. Section 05 05 23 – Metal Fastening
- C. Section 05 51 00 – Metal Stairs

1.03 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

- A. Without limiting the generality of the other requirements of the specifications, all work herein shall conform to the applicable requirements of the following documents. All referenced specifications, codes, and standards refer to the most current issue available at the time of Bid.
 - 1. International Building Code
 - 2. Aluminum Association Specifications for Aluminum Structures.

1.04 SUBMITTALS

- A. Submit the following in accordance with Section 01 33 00 – Submittal Procedures.
 - 1. Complete fabrication and erection drawings of all work specified herein.
 - 2. Other submittals as required in accordance with Section 05 10 00 – Metal Materials and Section 05 05 23 – Metal Fastening.

PART 2 – PRODUCTS

2.01 METAL MATERIALS

- A. Metal materials used for stair treads and nosings shall conform to Section 05 10 00 – Metal Materials, unless noted otherwise.

2.02 METAL FASTENING

- A. All welds and fasteners used for stair treads and nosings shall conform to Section 05 05 23 – Metal Fastening, unless noted otherwise.

2.03 SAFETY STAIR NOSINGS

- A. Abrasive cast aluminum, safety stair nosings shall be provided on all concrete or concrete filled steel pan stairs, including the top stair of metal stairs that attach to concrete, and as shown on the Drawings unless noted otherwise.
- B. Nosing shall be 3 inches wide and shall extend the full width of the stairway minus 3 inches on either side. Nosing shall be cast into the concrete and held in place with butterfly type extruded anchors.
- C. The nosing shall be "Style 231-A", by Amstep Products, "Alumogrit Type 101", by Wooster Products, Inc., "Type AX", by Safe-T-Metal Company. For steel pan concrete filled stairs, nosing shall be "Type 101-SP", Wooster Products, Inc., or "Type AXPE", by Safe-T-Metal Company. For pan stairs, nosing shall be continuous over corner of stair treads to fully protect corner of treads from abrasion. All exposed fasteners shall be Type 304 stainless steel.

2.04 STAIR TREADS

- A. Stair treads shall be aluminum with an abrasive nosing as shown on the Drawings.
- B. Stair treads shall be designed for the live load specified in Section 05 51 00 – Metal Stairs.
- C. Stair treads shall be as manufactured by IKG Industries, Ohio Gratings, Inc., or Safe-T-Metal Company.

PART 3 – EXECUTION

3.01 FABRICATION

- A. All measurements and dimensions shall be based on field conditions and shall be verified by the Contractor prior to fabrication. Such verification shall include coordination with adjoining work.
- B. All fabricated work shall be shop fitted together as much as practicable, and delivered to the field, complete and ready for erection. All miscellaneous items such as stiffeners, connections, brackets, and other details necessary for a complete installation shall be provided.

- C. All work shall be fabricated and installed in a manner that will provide for expansion and contraction, prevent shearing of bolts, screws, and other fastenings, ensure rigidity, and provide a close fit of sections.
- D. All shearings shall be neat and accurate, with parts exposed to view neatly finished. Flame cutting is allowed only when performed utilizing a machine.
- E. All shop connections shall be welded unless otherwise indicated on the Drawings or specified herein. Bolts and welds shall conform to Section 05 05 23 – Metal Fastening. All fastenings shall be concealed where practicable.

3.02 INSTALLATION

- A. Assembly and installation of stair treads and nosings shall be performed in strict accordance with manufacturer's recommendations.
- B. All stair treads and nosings shall be erected square, plumb and true, accurately fitted, adequately anchored in place, and set at proper elevations and positions.

END OF SECTION

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SECTION 05 56 00
CASTINGS

PART 1 – GENERAL

1.01 REQUIREMENT

- A. Furnish all materials, labor, and equipment required to provide all castings in accordance with the requirements of the Contract Documents.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 33 05 61 – Utility Structures
- B. Section 05 10 00 – Metal Materials

1.03 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

- A. Without limiting the generality of the other requirements of the specifications, all work herein shall conform to the applicable requirements of the following documents. All referenced specifications, codes, and standards refer to the most current issue available at the time of Bid.
 - 1. International Building Code
 - 2. AASHTO M306 – Standard Specification for Drainage, Sewer, Utility, and Related Castings

1.04 SUBMITTALS

- A. Submit the following in accordance with Section 01 33 00 – Submittal Procedures.
 - 1. Complete fabrication and erection drawings of all castings specified herein.
 - 2. Other submittals as required in accordance with Section 05 10 00 – Metal Materials and Section 05 05 23 – Metal Fastening.

PART 2 – PRODUCTS

2.01 METAL MATERIALS

- A. Metal materials used for castings shall conform to Section 05 10 00 – Metal Materials, unless noted otherwise.

2.02 METAL FASTENING

- A. All welds and fasteners used for castings shall conform to Section 05 05 23 – Metal Fastening, unless noted otherwise.

2.03 IRON CASTINGS

- A. General - Iron Castings shall include, but not be limited to frames, covers, and grates for trench drains, catch basins, and inlets/.
 - 1. Castings shall be of gray iron of uniform quality, free from defects, smooth and well cleaned by shotblasting.
 - 2. Catalog numbers on the Drawings are provided only to show required types and configuration. All covers shall be cast with raised letters as designated on the Drawings.
 - 3. Castings shall be as manufactured by East Jordan, US Foundry, or Neenah Foundry Company.
- B. Covers and Grates
 - 1. Covers and grates shall be provided with matching frames. Cover shall fit flush with the surrounding finished surface. The cover shall not rock or rattle when loading is applied.
 - 2. Round covers and frames shall have machined bearing surfaces.
 - 3. Design loadings:

At all locations, castings shall meet H-20 loading ratings in accordance with AASHTO M306, unless otherwise noted.

- C. Watertight gasketing, bolting, locking devices, patterns, lettering, pickholes, vents, or self-sealing features shall be as detailed on the Drawings.

PART 3 – EXECUTION

3.01 FABRICATION

- A. All measurements and dimensions shall be based on field conditions and shall be verified by the Contractor prior to fabrication. Such verification shall include coordination with adjoining work.

- B. All fabricated work shall be shop fitted together as much as practicable, and delivered to the field, complete and ready for erection. All miscellaneous items such as stiffeners, fillets, connections, brackets, and other details necessary for a complete installation shall be provided.
- C. Finished members shall conform to the lines, angles, and curves shown on the Drawings and shall be free from distortions of any kind.

3.02 INSTALLATION

- A. Assembly and installation of fabricated system components shall be performed in strict accordance with manufacturer's recommendations.
- B. All castings shall be erected square, plumb and true, accurately fitted, adequately anchored in place, and set at proper elevations and positions.

END OF SECTION

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SECTION 06 10 00
ROUGH CARPENTRY

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. Furnish labor, materials, equipment and appliances required for complete execution of Work shown on the Drawings and specified herein.
- B. Principal items of work include:
 - 1. Wood blocking, nailers, grounds, furring, ties, centering, etc., necessary or required for attachment or support of work under this Section and other Sections.
 - 2. Fasteners, including nails, screws, bolts, anchors and other fastenings, required to secure work under this Section.
 - 3. Temporary enclosures and protective boarding.
 - 4. Wood preservative treatment for all wood members in contact with roofing, masonry, concrete, and exposed to the elements.

1.02 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

- A. Without limiting the generality of these specifications Work shall conform to the applicable requirements of the following documents:
 - 1. AWPA-CA – Preservative Standards, Lumber and Plywood
 - 2. AWPA-C20 – Structural Lumber Fire-Retardant Treatment by Pressure Process
 - 3. AWPC-C27 – Plywood Fire-Retardant Treatment by Pressure Process
 - 4. AWPA-M4 – Standards for Care of Preservative Treated Wood Products
 - 5. APA – Guide to Plywood Grades
 - 6. FM 1-49 – Perimeter Flashing

1.03 SUBMITTALS

- A. In accordance with the procedures and requirements set forth in Section 01 33 00 – Submittal Procedures, submit the following:
 - 1. Certifications of Preservative and Fire Retardant Treatment.

2. Warranty of treatment manufacturer.
3. Certification of type and grade of lumber to be used.
4. Certification of type, rating and conformance to APA Standards.

1.04 DELIVERY AND STORAGE

- A. Take all measures necessary to protect products against damage during delivery and storage.
- B. Store lumber in enclosed places in such a manner to provide ventilation and protection from the weather.

PART 2 – PRODUCTS

2.01 MATERIALS

- A. Blocking, nailers, grounds and the like: Eastern Spruce or Douglas Fir - No. 3 Dimension Lumber or Construction Grade, with a moisture content not to exceed 19%.
- B. Plates, blocking, and nailers in contact with concrete or masonry: Pressure treated southern yellow pine or Douglas Fir.
- C. Plywood: Identified with APA Grade trademarks of the American Plywood Association, in thickness as shown on the Drawings.
 1. Exterior: AC-EXT-APA where exposed to view or a finish is required, CD-EXT-APA where concealed.
 2. Interior: AC-INT-APA where exposed to view or a finish is required, CD-INT-APA where concealed.
- D. Structural Framing Lumber: Douglas Fir No.1 grade with fb = 1,500 pounds per square inch and E = 1,700,000 pounds per square inch, 19 percent moisture content.
- E. Fasteners: Provide clamps, connectors, straps, nails, bolts, screws, anchors, ties and other accessories and fasteners shown or required to properly secure all rough carpentry. Fasteners and accessories shall be stainless steel, galvanized, or other noncorrosive metal recommended for use. Fasteners used with pressure treated wood shall be compatible with the wood preservative treatment to prevent corrosion of fasteners.
- F. Wood Preservative Treatment: Waterborne pressure treatment in conformance with the American Wood Preservers' Association standard P5. Retention shall be in accordance with AWP Standards and be a minimum of 0.40 pounds per cubic foot for contact with

or below ground, concrete, or masonry and 0.25 pounds per cubic foot for above ground. Stamp each piece of treated wood with a trademark identifying the classification of the treatment or a certificate from the processor for each shipment.

- G. Fire Retardant Treatment: Fire-retardant lumber and plywood must have an Underwriters Laboratories stamp signifying a FR-S rating and certifying a 25 or less flame spread and smoke developed value, when tested in accordance to UL 723, ASTM E 84, and NFPA 255 "Tunnel Test", and when the test is extended for 20 additional minutes. Treatment formulation shall contain no halogens, sulfates, chlorides or ammonium phosphate. Smoke toxicity shall be no more than that of untreated wood.

PART 3 – EXECUTION

3.01 COORDINATION

- A. Coordinate with all trades as to nailers, blocking, grounds and the like required for the attachment of their work and other items requiring same. Carry out all work as required to cooperate work of other trades.

3.02 INSTALLATION

- A. Perform work in conformance manufacturer's recommendations and specifications, industry, national and local standards and codes.
- B. Layout, cut, fit and erect rough blocking, nailers, furring and other rough carpentry. Do cutting work in connection with carpentry and finish for other trades. Brace plumb and level all members in true alignment and rigidly secure in place with sufficient nails, spikes, screws and bolts. Defects which render any piece or part unable to serve its intended purpose shall be discarded or, cut out and replaced.
- C. Provide all bracing, supports and shoring required to support construction.
- D. Protect all masonry including edges of concrete platforms and similar items. Remove protective covering when directed. Take special precautions at masonry openings and corners of the building.
- E. Set all rough hardware, such as plates, spikes, bolts, nails, lag screws, lagging bolts, anchors, etc., as required to hold woodwork together or to anchor or secure it to other materials and construction.
- F. Provide wood grounds, nailing strips and similar items wherever necessary or required throughout the project for the support, proper erection or installation of the work and support of mirrors, cabinets, shelf cleats, base and similar items. Thoroughly secure in place by approved means.

- G. Secure wood grounds, nailing strips and similar items to metal plugs set in masonry, toggle or expansion bolts. Give the mason all necessary information to enable them to lay out correctly the location for metal wall plugs. Wood plugs will not be accepted.
- H. Construct joints to support dead loads, live loads, snow loads, wind loads, or combinations in conformance with "National Design Specifications for Stress Grade Lumber and its Fastenings", recommended by National Forest Products Association.
- I. Nailers and Blocking: Provide and secure wood nailers, blocking, for the reception of roof curbs, roofing, etc. in accordance with FM I-49, or as required by the Building Code, whichever is most stringent. Coordinate attachment with roofing system, where roofing system design includes design of nailers provide attachment in accordance with engineered roofing design.
 - 1. Provide nailers of sizes, shapes and profiles indicated on the Drawings. Nailers shall not be less than 2 x6. Build up nailers as required to achieve thickness of insulation or as required to provide proper attachment of roofing and curbs. Provide anchors as required for secure attachment of roofing systems, copings, gravel stops or other edge terminations.

3.03 TEMPORARY PROTECTION

- A. Provide and install all temporary protection in accordance with applicable provisions of the Contract Documents, OSHA regulations, and as follows:
 - 1. Temporary protection shall include wood doors, railings, protection of floor or roof openings, temporary partitions, and the like; adequately maintained in good repair during the life of the Contract.
 - 2. Furnish and set temporary partitions with wood doors at all exterior doorways, exterior openings or in locations exposed to weather. Substantially build and hang, with proper hinges, locks and other necessary hardware, and remove and reset whenever required to accommodate the Work and keep in good repair.
 - 3. Provide substantial temporary wood covering or guards for openings left in floor or roof slabs for ducts, shafts, etc., using rough planking at least 2 inch thick, cleated together and otherwise made sufficiently strong and put in place wherever required immediately after the forms have been removed.

3.04 JOB CONDITIONS

- A. If the installation of metal frames and glass does not promptly follow the completion of the exterior enclosures, and if the absence of enclosures would cause damage, close in all such openings temporarily by the use of heavy polyethylene plastic sheeting, or canvas stretched over and nailed to frames of 1 inch x 2 inch or heavier strips.

3.05 REMOVAL OF TEMPORARY WORK

- A. Remove all temporary protection when so directed, or prior to acceptance of this project.

END OF SECTION

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SECTION 06 51 00
GLASS FIBER AND RESIN FABRICATIONS

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. The Contractor shall furnish and install all fiberglass items as specified herein and as shown on the Drawings. The Contractor shall be responsible for the coordination with related work specified elsewhere and to provide all hardware, accessories and appurtenances required for a complete installation, including all fabrication and mounting hardware.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 05 05 23 – Metal Fastening
- B. Section 07 90 00 – Joint Fillers, Sealants, and Caulking
- C. Section 09 90 00 – Painting

1.03 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

- A. Without limiting the generality of the other requirements of the specifications, all work herein shall conform to the applicable requirements of the following documents. All referenced specifications, codes, and standards refer to the most current issue available at the time of Bid.
 - 1. ASTM D635 – Standard Test Method for Rate of Burning and/or Extent and Time of Burning of Plastics in a Horizontal Position
 - 2. ASTM D3647 – Standard Practice for Classifying Reinforced Plastic Pultruded Shapes According to Composition
 - 3. ASTM D3917 – Standard Specification for Dimensional Tolerances of Thermosetting Glass - Reinforced Plastic Pultruded Shapes
 - 4. ASTM D4385 – Standard Practice for Classifying Visual Defects in Thermosetting Reinforced Plastic Pultruded Products
 - 5. ASTM E84 – Standard Test Method for Determining Surface Burning Characteristics for Building Materials

1.04 SUBMITTALS

- A. The Contractor shall submit shop drawings showing fabrication details and a Performance Affidavit for all items specified herein in accordance with Section 01 33 00 – Submittal Procedures and Section 46 00 00 – Equipment General Provisions.
- B. Certification of compliance with ASTM Standards.
- C. Where specifically requested, design drawings and calculations sealed by a currently Registered Professional Engineer in the State or Commonwealth in which the project is located. FRP grating floor system and guard and handrail systems will require these sealed items.

1.05 QUALITY ASSURANCE

- A. All fiberglass items of the same type provided shall be the products of a single manufacturer for compatibility.
- B. The Contractor is responsible for ensuring that the fiberglass items and appurtenances furnished shall be compatible and have the necessary operating clearances with the structural elements and equipment shown on the Drawings.
- C. Manufacturer shall provide a 3-year warranty on all FRP products against defect in material and workmanship.

PART 2 – MATERIALS

2.01 GENERAL

- A. All manufacturing shall occur in the United States. The manufacturer shall maintain a continuous quality control program and shall, upon request, furnish the Engineer with certified test reports consisting of physical tests of samples.
- B. Ultraviolet light resistive resins shall be used for all exterior locations and where specified.
- C. All FRP resins shall be flame resistant and shall meet the requirements of ASTM D 635 and ASTM E 84, Class 1 with a maximum flame spread rating of 25.
- D. All edges shall be sealed in the mold where possible. Machined or cut edges shall be sealed with a compatible resin system.
- E. ALL WETTED COMPONENTS USED IN POTABLE WATER TREATMENT, INCLUSIVE OF CHEMICAL STORAGE AND FEED SYSTEMS, SHALL BE ANSI/NSF 61 CERTIFIED.

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2.02

2.02 GRATING FLOOR SYSTEM

- A. Contractor shall be responsible for design of Grating Floor System. Provide drawings and structural calculations both sealed by a Professional Engineer currently registered in the State or Commonwealth where the project is located. Fiberglass grating floor system shall be furnished and installed in areas shown on the Drawings and shall include all FRP angle supports, FRP adjustable pedestal supports, FRP cross bracing, fasteners, and accessories as required for a complete system. Grating shall consist of bidirectional molded FRP gratings. Grating and supports shall be provided by a single manufacturer and installed in accordance with the manufacturer's recommendations to provide a level walking surface.
- B. Grating shall be fabricated into easily removable sections as large as possible up to 150 lbs. per section.
- C. Fasteners shall not project above the walking surface.
- D. Fiberglass grating and supports shall be manufactured of VEFr. Grating and supports shall be produced by Fibergrate, Inc., American Grating with Bedford Plastics, Strongwell, or equal.
- E. Grating and supports shall be designed for a uniform loading of 100 psf. Grating deflection shall be limited to 0.25".
- F. Grating clips and metal fasteners shall be Type 316 stainless steel.

2.03 FIBERGLASS WEIRS AND BAFFLES

- A. Fiberglass reinforced polyester (FRP) weirs and baffles shall be installed where shown on the Drawings. All weir plates, scum baffle plates, buff plates, and cover plates shall be FRP. A "low profile" resin system shall be used to ensure that all surfaces are smooth, resin rich, free of voids and porosity, without dry spots, crazes, or unreinforced areas to provide increased corrosion and weather resistance. All edges shall be sealed in the mold. Resin shall be ISOFR. Plate thickness shall be 3/8 inch minimum, or as shown on the Drawings. FRP weirs and baffles shall be blue green in color. Each section shall be of the depth and overall length as indicated on the Drawings. Each section shall be provided with mounting holes at 12 inches on center, unless shown otherwise on the Drawings, to provide a minimum 2 inch vertical or horizontal adjustment. Sections shall be secured to walls or trough with Type 316 stainless steel anchor rods and 5-inch minimum diameter washers to prevent short-circuiting. Ends of weir plates shall be secured with 6-inch-wide butt plates arranged to allow for horizontal expansion. Type 316 stainless steel anchor rods shall be furnished by the FRP supplier.
- B. Laminate shall contain a glass content of 30+2% using Type "E" glass with chrome or silane finish. Powdered reinforcements shall consist of 47.5+1% of resin mixture. Final laminate thickness shall be within +10 percent of the nominal specified thickness.

Ultraviolet absorbers shall be added to the resin to prevent deterioration from sunlight. Where weir plates are of nonstandard length or nonstandard mounting hole configuration, such machined or cut edges shall be resin sealed with seal mix.

- C. All items shall be manufactured in accordance with ASTM D2996 and ASTM D3917. The manufacturer shall maintain a continuous quality control program and shall, upon request, furnish the Engineer with certified test reports consisting of physical tests of samples to verify that the laminate has the following minimum physical properties:

Requirement	Minimum Results	Test Method
Tensile Strength (psi)	14,000	ASTM D638
Flexural Strength (psi)	25,000	ASTM D790
Flexural Modulus (psi)	1.0×10^6	ASTM D790
Impact, Notched, Izod, (foot pound per inch)	15.0	ASTM D256
Barcol Hardness	40	ASTM D2583
Water Absorption, (% after 24 hours)	0.2 Max	ASTM D570
Average coefficient of thermal expansion (inch per inch per °F)	10.5×10^{-6}	ASTM D696

- D. The procedure used in determining the above properties shall be in accordance with the ASTM Standards, Part 35, using the method designated above. Hardness tests shall be made on the resin rich surfaces of the test samples. Test coupons shall be prepared in accordance with the appropriate ASTM test method.
- E. Baffle plate lengths shall be made to fit the installation, but lengths shall not exceed 10 feet. Lap plates shall be provided to secure the ends of the plates. Type 316 stainless steel hardware shall be furnished by the FRP supplier for securing baffle plates to 316 SS support brackets and lap plates. Type 316 SS anchor bolts shall be used for anchoring scum baffle supports to the wall.
- F. All items furnished under this Section shall be as manufactured by MFG Construction and Water Products, Warminster Fiberglass, NEFCO, or equal.

2.04 MANHOLE LADDERS

- A. The ladders shall be of fiberglass construction with pultruded structural channel shapes, non-skid grit surfaces used on top surface of each rung and a synthetic surfacing veil for chemical and ultraviolet resistance and high strength. Ladders shall possess Class one fire retardant, with an ASTM E-84 flame-spread rating of 25 maximum and shall conform

to OSHA 1910.23 and 1910.28. Color shall be safety yellow (beige for immersed ladders).

- B. Ladders shall utilize channel side rails and 1-3/8-inch minimum diameter round rungs. Rung to side connections shall utilize a keyed, pinned, and bonded joint for prevention of rung rotation and pullout. The ladders shall be attached to the bracket angles with two stainless steel bolts, washers, and nuts per angle bracket.
- C. Concrete anchors shall be minimum 5/8-inch diameter with 3-inch embedment and shall comply with Section 05 05 23 – Metal Fastening. Fiberglass pultruded parts shall be ISOFR except where VEFR is specifically required on the Contract Drawings. Shapes shall be manufactured by Strongwell, Inc., Fibergrate Composite Structures, or equal. Ladders shall conform to OSHA requirements and to the details shown on the Drawings.

2.05 FIXED LADDERS

- A. The Contractor shall provide fixed ladder systems with all safety cages, landings, mounting clips, fasteners, and necessary appurtenances for a complete and rigid installation.
- B. The ladder systems shall be designed to meet or exceed all OSHA requirements.
- C. Ladders shall be fabricated from pultruded shapes conforming to ISOFR except where VEFR is specifically required on the Contract Drawings. Shapes shall be manufactured by Strongwell, Inc., Fibergrate Composite Structures, or equal.
- D. Ladder side rails shall be fabricated from channel members or 1-3/4 inch minimum square tube.
- E. Side rails shall be anchored with FRP standoff clips manufactured of ISOFR except where VEFR is specifically required on the Contract Drawings. Clips shall be placed at the top and bottom of the ladder and at 6-foot maximum vertical centers.
- F. Rungs
 - 1. Rungs shall be 18 inches long, 1-1/4" fluted tubes for non-skid surfaces or serrated and covered with a silica grit to produce an anti-skid surface.
 - 2. Rungs shall be uniformly spaced at 12 inches on center.
 - 3. Rungs shall be designed to support a 1,200-pound vertical load applied at midspan.
 - 4. Rungs shall be both mechanically attached, and epoxy bonded to the side rails.
- G. Ladder safety system shall be as specified in Section 05 51 33 – Ladders.

2.06 CONNECTIONS

- A. All connections shall be non-corrosive, non-staining, and concealed where practical, as detailed on the Drawings or specified herein.
- B. Fiberglass fasteners shall be "Fibrebolt", as manufactured by Strongwell, Inc., or equal.
- C. All metal fasteners shall be Type 316 stainless steel, except where Hastelloy C-276 or fiberglass fasteners are specifically required on the Contract Drawings.
- D. Holes for bolts and screws shall be drilled.
- E. Joints exposed to weather shall be formed to exclude water.
- F. Design and installation of fiberglass items shall provide for expansion and contraction, prevent shearing of bolts, screws, and other fastenings, and provide close fitting of sections.

PART 3 – EXECUTION

3.01 FABRICATION

- A. All cut edges and holes shall be sealed with a compatible resin.
- B. All FRP items shall conform to the dimensions indicated on the Drawings.
- C. All fiberglass items described in this Section shall be supplied by a manufacturer that normally fabricates such items so that appearance and quality control are acceptable.

3.02 HANDLING, TRANSPORTING, AND STORING

- A. All FRP items shall be properly packed, labeled and stored in accordance with Specifications and as directed by the Engineer.

3.03 INSTALLATION

- A. Installation of all items shall be according to manufacturer's instructions, unless otherwise noted.
- B. Exposed threads of FRP bolts shall be sealed with a compatible resin after installation of the bolts. Where bolts are attaching removable items, the exposed threads shall be sealed with a light coat of polyurethane sprayed onto the threads.
- C. Weirs and baffles shall be installed in full accordance with the manufacturer's recommendations. Joints between weir plates and concrete and butting weir plates shall

be watertight. The Contractor shall seal all weirs with caulk approved by the Engineer after weirs are set, checked for level, and are within specified tolerances.

END OF SECTION

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SECTION 07 11 00
DAMPPROOFING

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. Furnish labor, materials, equipment and appliances required for complete execution of work as shown on Drawings and specified herein.
- B. Principal items of work include:
 - 1. Dampproofing on exterior side of interior wythe of masonry cavity walls above grade.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 04 20 00 – Unit Masonry

1.03 REFERENCE SPECIFICATIONS CODES AND STANDARDS

- A. Without limiting the generality of these specifications Work shall conform to the applicable requirements of the following documents:
 - 1. ASTM D 449 – Standard Specification for Asphalt Used in Dampproofing and Waterproofing

1.04 SUBMITTALS

- A. In accordance with the procedures and requirements set forth in the Section 01 33 00 – Submittal Procedures, submit the following:
 - 1. Manufacturers product literature, specification data sheets and installation instructions.

1.05 DELIVERY, STORAGE AND HANDLING

- A. Deliver materials in manufacturer's unopened containers identified with name, brand, type, grade, class and all other qualifying information.
- B. Store materials in dry location to prevent damage or intrusion of foreign matter. Remove damaged materials from the job site.

PART 2 – PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Subject with compliance with the Specifications provide products from one of the following:
 - 1. Karnak Corp.
 - 2. W.R. Meadows
 - 3. Koch Materials Co.
 - 4. Master Builders Solutions

2.02 MATERIALS

- A. Asphalt Primer: Type recommended by manufacturer.
- B. Dampproofing: Non-asbestos, fibrated mastic conforming to ASTM D-1227, Type II, Class 1, compatible with cavity wall insulation.

PART 3 – EXECUTION

3.01 EXAMINATION OF SURFACES

- A. Examine all surfaces and installation of work done by other trades.

3.02 APPLICATION

- A. Prime surfaces with manufacturers recommended primer. Apply dampproofing at the rate of 6 gallons per 100 square feet.
- B. Apply dampproofing to substrates to provide a complete moisture resistant coating.

3.03 PROTECTION

- A. Protect building from damage resulting from spillage, dripping and dropping of materials. Repair work damaged during dampproofing operations.
- B. Take precautions against fire and other hazards during delivery, storage and installation of flammable materials. Comply with local ordinances and fire regulations in the installation of hazardous materials.

3.04 CLEANING

- A. Clean adjacent materials and finishes which have been soiled.

END OF SECTION

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SECTION 07 13 50
WATERPROOFING

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. Furnish all labor, materials, equipment and appliances required for the complete execution of the Work as shown on the Drawings and specified herein.
- B. Principal items of work include:
 - 1. Waterproofing on the exterior sides of walls below grade.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 03 30 00 – Cast-in-Place Concrete

1.03 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

- A. Without limiting the generality of these specifications Work shall conform to the applicable requirements of the following documents:
 - 1. ASTM D146 – Sampling and Testing Felted and Woven Fabrics Saturated with Bituminous Substances for Use in Waterproofing and Roofing
 - 2. ASTM D412 – Tests for Rubber Properties in Tension
 - 3. ASTM E96 – Tests for Water Vapor Transmission of Materials in Sheet Form

1.04 SUBMITTALS

- A. In accordance with the procedures and requirements set forth in Section 01 33 00 – Submittal Procedures, submit the following:
 - 1. Manufacturers product literature, specification data sheets and installation instructions.
 - 2. Samples of composite drainage panel and waterproofing.
 - 3. Complete layout and installation drawings and schedules with clearly indicated dimensions.
 - 4. Detail drawings showing all anchoring details and construction details at corners, penetrations and flashing.

5. Letter from manufacturer stating that installer is an approved applicator.

1.05 DELIVERY, STORAGE AND HANDLING

- A. Deliver materials in manufacturer's unopened containers identified with name, brand, type, grade, class and all other qualifying information.
- B. Store materials in dry location, in such manner as to prevent damage or intrusion of foreign matter. Conspicuously mark "Rejected" on materials which have been damaged and remove from the job site.

PART 2 – PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Subject to compliance with the Specifications provide products manufactured by one of the following:
 1. Grace Construction Products.
 2. Carlyle Coating and Waterproofing
 3. Polyguard Products.
 4. Garland Company

2.02 PRODUCTS

- A. Waterproofing Membrane: Self-adhering membrane consisting of a minimum 56 mils of rubberized asphalt laminated to a minimum 4 mils of polyethylene to form a minimum of 60 mil membrane. Provide a cold-applied membrane which requires no special adhesives or heating equipment.
- B. Physical Properties

Properties	Test Method	Result
Pliability (@ -25 f)	ASTM D-146	No Effect
Tensile Strength Membrane	ASTM D-412	250 psi min.
Tensile Strength Film	ASTM D-412	4000 psi min.
Elongation	ASTM D-412	300% min.
Puncture Resistance Membrane	ASTM E-154	40 lbs. min.

Properties	Test Method	Result
Puncture Resistance Film	ASTM D-781	250 in. oz. tear
Permeance	ASTM E-96 (B)	0.1 max. grains/sf/hr/in.Hg
Water Absorption	ASTM D-570	0.2 max. (% by weight)
Adhesion to Concrete	ASTM D-903	5.0 lbs./in. width max.

- C. Primer: As recommended by manufacturer.
- D. Mastic: As recommended by manufacturer. Use mastic to seal cut edge terminations.

2.03 COMPOSITE DRAINAGE PANEL

- A. Composite drainage panel: Three dimensional, high impact, polystyrene core with a nonwoven filter fabric bonded to the core. Provide a polymeric sheet adhered to the flat side of the polystyrene core. Extend filter fabric beyond the edges to provide total filtering integrity of the drainage system.

B. Physical Properties

Properties	Test Method	Result
Compressive Strength (Core)	ASTM D-1621	15,000 psf
Apparent Opening Size (Filter Fabric)	ASTM D-4751	100 United States Standard Sieve
Water Flow Rate (Filter Fabric)	ASTM D-4491	150 gpm/ft
Water Flow (Composite System)	ASTM D-4716	15 gpm/ft. width

C. Composite System Requirements

1. Provide one inch flange on longitudinal edge.
2. Bond filter fabric to each dimple of polymeric core.
3. Extend filter fabric beyond the edge of polymeric core to provide total filtering integrity of the drainage system.
4. System shall be approved for use over waterproofing membrane.

PART 3 – EXECUTION

3.01 EXAMINATION OF SURFACES

- A. Examine all surfaces and installation of work done by other trades.
- B. Coordinate all work under this Section with contiguous work of other trades.
- C. Concrete shall be cured for a minimum of 28 days. Remove curing compounds that are not approved by manufacturer.

3.02 APPLICATION

- A. Install waterproofing membrane, and composite drainage system in strict accordance with manufacturer's printed instructions and recommendations.
- B. Where drainage piping is shown on Drawings, extend systems to allow for proper drainage.
- C. Cover and seal all terminal edges. Cut systems and seal around penetrations.
- D. Provide a written report from the Manufacturer's representative stating that the waterproofing membrane and composite drainage system were installed correctly.

END OF SECTION

SECTION 07 16 16
CRYSTALLINE WATERPROOFING

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. Furnishing all labor, materials, services and equipment necessary for the supply and installation of topical cementitious crystalline waterproofing to concrete substrates, above-grade or below-grade, on either dry or wet side of substrates, as indicated on drawings and as specified herein.
- B. Principal items of work include: see drawings for all locations. Areas to focus on include wall cavities between the internal stair and the pressure vessel gallery 208 at PO Hoffer; cavity wall at electrical room 203 at PO Hoffer; exposed concrete ceiling in corridors 205 and 207 at PO Hoffer; cavity wall between the electrical room 504 and filter gallery 505 at Glenville Lake; cavity wall between the filter gallery and internal stair at Glenville Lake; ceiling in corridor and mechanical rooms 502 and 503 at Glenville Lake.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 03 30 00 – Cast-in-Place Concrete

1.03 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

- A. Without limiting the generality of these specifications Work shall conform to the applicable requirements of the following documents:
 - 1. American Society for Testing and Materials (ASTM)
 - 2. Army Corps of Engineers (CRD)
 - 3. NSF International (NSF)

1.04 SUBMITTALS

- A. In accordance with the procedures and requirements set forth in Section 01 33 00 – Submittal Procedures, submit the following:
 - 1. Submit product data, including manufacturer's specifications, installation instructions, and general recommendations for waterproofing applications. Include manufacturer's certification or other data substantiating that products comply with requirements of the Contract Documents.

2. Submit complete test reports from approved independent testing laboratories certifying that waterproofing system conforms to performance characteristics and testing requirements specified herein.
3. Provide certificates signed by manufacturer or manufacturer's representative certifying that the materials to be installed comply in all respects with the requirements of this specification, and that the applicator is qualified and approved to install the materials in accordance with manufacturer's product data.

1.05 SYSTEM PERFORMANCE REQUIREMENTS

- A. Testing Requirements: Crystalline waterproofing system shall be tested in accordance with the following standards and conditions, and the testing results shall meet or exceed the performance requirements as specified herein.
- B. Independent Laboratory: Testing shall be performed by an independent laboratory meeting the requirements of ASTM E 329 and certified by the United States Bureau of Standards. Testing laboratory shall obtain all concrete samples and waterproofing product samples.
- C. Crystalline Penetration: Crystallizing capability of waterproofing material shall be evidenced by independent SEM (Scanning Electron Microscope) photographs documenting penetration of crystal-forming waterproofing material to a depth of 2 inches.
- D. Permeability: Independent testing shall be performed according to U.S. Army Corps of Engineers CRD C48-73 "Permeability of Concrete".
 1. Concrete samples (treated and untreated) to have design strength of 2000 psi and thickness of 2 inches. No admixtures permitted.
 2. Coatings to have maximum thickness of 0.05 inches per coat with up to two coats permitted.
 3. Samples to be pressure tested to 175 psi (405 feet head of water).
 4. Treated samples, after crystalline growth has occurred, shall exhibit no measurable leakage.
- E. Chemical Resistance: Independent testing shall be performed according to ASTM C 267 "Chemical Resistance of Mortars" and ASTM C 39 "Compressive Strength of Cylindrical Concrete Specimens".
 1. Concrete samples (treated and untreated) to have design strength of 4000 psi. No admixtures permitted.

2. Coatings to have maximum thickness of 0.05 inches per coat with up to two coats permitted.
 3. Untreated and treated specimens to be immersed for a minimum of 84 days in following chemical solutions: hydrochloric acid (3.5pH), brake fluid, transformer oil, ethylene glycol, toluene, caustic soda.
 4. Treated specimens shall exhibit no detrimental effects after exposure, and shall have a minimum of 14% increase in compressive strength versus untreated control specimens.
- F. Potable Water Approval: Independent testing shall be performed according to NSF Standard 61/600 and approval for use of waterproofing material on structures holding potable water shall be evidenced by NSF certification.

1.06 DELIVERY, STORAGE AND HANDLING

- A. Deliver materials in manufacturer's unopened containers identified with name, brand, type, grade, class, and all other qualifying information.
- B. Store materials in dry location, in such manner as to prevent damage or intrusion of foreign matter. Conspicuously mark "Rejected" on materials which have been damaged and remove from the job site.

PART 2 – PRODUCTS

2.01 SYSTEM DESCRIPTION

- A. Cementitious Crystalline Waterproofing: Blend of portland cement, fine treated silica sand and active proprietary chemicals. When mixed with water and applied as a cementitious coating, the active chemicals cause a catalytic reaction which generates a non-soluble crystalline formation of dendritic fibers within the pores and capillary tracts of concrete. This process causes concrete to become permanently sealed against the penetration of liquids from either direction.

2.02 ACCEPTABLE MANUFACTURERS

- A. Subject to compliance with the Specifications provide products manufactured by one of the following:
 1. Xypex Chemical
 2. Tamms (Euclid)
 3. Vandex (Euclid)

4. Kryton International

2.03 PRODUCTS

- A. Crystalline Waterproofing Materials as follows:

1. Xypex Concentrate
2. Tamms Hey'Di K-11
3. Vandex Super
4. Krystol T1

2.04 SOURCE QUALITY

- A. Obtain proprietary crystalline waterproofing products from a single manufacturer.

PART 3 – EXECUTION

3.01 EXAMINATION OF SURFACES

- A. Verify that the concrete surfaces are sound and clean, and that form release agents and materials used to cure the concrete are compatible with waterproofing treatment.
- B. Examine surfaces to be waterproofed for form tie holes and structural defects such as honeycombing, rock pockets, faulty construction joints and cracks. Such defects to be repaired in accordance with manufacturer's product data and Section 3.02 below.
- C. Coordinate all work under this Section with contiguous work of other trades.

3.02 PREPARATION

- A. Concrete Finish: Concrete surfaces to receive waterproofing treatment shall have an open capillary system to provide tooth and suction, and shall be free from scale, excess form oil, laitance, curing compounds and foreign matter. Horizontal surfaces shall have a rough wood float or broom finish. Where a smooth trowel finish is required on horizontal surface, crystalline waterproofing material shall be applied by dry shake method at time of concrete finishing in accordance with manufacturer's product data.
- B. Surface Preparation: Smooth surfaces (e.g. where steel forms are used) or surfaces covered with excess form oil or other contaminants shall be washed, lightly sand-blasted, water-blasted, or acid etched with muriatic acid as necessary to provide a clean absorbent surface. Surfaces to be acid-etched shall be saturated with water prior to application of acid.

- C. Repair of Defects: Surface defects shall be repaired in accordance with Specification Section 03 30 00 – Cast-in-Place Concrete.
- D. Wetting Concrete: Prior to application of waterproofing treatment, thoroughly saturate concrete surfaces with clean water as required to ensure migration of crystalline chemicals into voids and capillary tracts of the concrete. Remove free surface water before application.

3.03 APPLICATION

- A. Surface Application: After repairs, surface preparation, treatment of construction joints, and sealing strip placement have been completed in accordance with manufacturer's product data and as specified herein, apply crystalline waterproofing treatment uniformly to concrete surfaces with semi-stiff bristle brush or broom, or suitable spray equipment. Application rates and locations shall be in accordance with manufacturer's product data, unless otherwise indicated on the Drawings. When brushing, work slurry well into surface of the concrete, filling surface pores and hairline cracks. When spraying, hold nozzle close enough to ensure that slurry is forced into pores and hairline cracks.
 - 1. First Coat (of one or two coat applications): Apply crystalline waterproofing slurry coat to specified locations and as indicated on the drawings in accordance with manufacturer's product data.
 - 2. Second Coat (of two coat applications): Where indicated on drawings or as required by manufacturer's product data, apply crystalline waterproofing slurry coat while first coat of crystalline waterproofing is still "green" but after it has reached an initial set. Use light pre-watering between coats. Contractor shall ensure that all curing requirements are met prior to application. If curing requirements are not met, contractor shall follow manufacturer recommendations to remediate.

3.04 CURING

- A. Begin curing as soon as crystalline waterproofing has hardened sufficiently so as not to be damaged by a fine spray. Cure with a mist fog spray of clean water three times a day for 2 to 3 days, or cover treated surfaces with damp burlap for the prescribed period. In warm climates, more than three sprayings per day may be necessary to prevent excessive drying of coating.
- B. Do not lay plastic sheeting directly on the waterproofing coating as air contact is required for proper curing. If poor circulation exists in treated areas, it may be necessary to provide fans or blown air to aid in curing of waterproofing treatment.
- C. For concrete holding structures such as reservoirs, water treatment tanks and wet wells, cure for three days and allow treatment to set (air cure) for 12 days before filling structure with liquid. For structures holding hot or corrosive liquids, cure waterproofing treatment for three days and allow to set for 18 days before filling.

- D. During the curing period, protect treated surfaces from damage by wind, sun, rain and temperatures below 36°F. If plastic sheeting is used for protection, sheets must be elevated above waterproofing coating to allow sufficient air circulation.

3.05 FIELD QUALITY CONTROL

- A. Do not conceal installed waterproofing system before installation has been observed by Architect/Engineer and other designated entities.
- B. Flood Testing:
 - 1. Perform flood test on completed waterproofing installation before placement of other construction.
 - 2. Plug or dam drains and fill area with water to a depth of two inches (50 mm) or to within 0.5 inch (12.5 mm) of top of waterproofing treatment.
 - 3. Let water stand for 24 hours.
 - 4. If leaks are discovered, repairs shall be made in accordance with requirements of manufacturer and approved by the Engineer. After completion of repairs, repeat test until no leaks are observed.

3.06 CLEANING AND PROTECTION

- 1. Clean spillage and soiling from adjacent surfaces using appropriate cleaning agents and procedures.
- 2. Take measures to protect completed coating from damage after application. Do not permit traffic on unprotected coating.

END OF SECTION

SECTION 07 21 00
BUILDING INSULATION

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. Furnish labor, materials, equipment and appliances required for complete execution of Work as shown on Drawings and specified herein.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 03 30 00 – Cast-in-Place Concrete
- B. Section 04 20 00 – Unit Masonry

1.03 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

- A. Without limiting the generality of these specifications Work shall conform to applicable requirements of the following documents:
 - 1. ASTM C726 – Insulation Board, Thermal (Mineral Fiber)
 - 2. ASTM C 578 – Specification for Preformed, Block Type Cellular Polystyrene Thermal Insulation
 - 3. ASTM C 665 – Specification for Mineral fiber Blanket Thermal Insulation for Light Frame Construction and Manufactured Housing

1.04 SUBMITTALS

- A. In accordance with the procedures and requirements set forth in Section 01 33 00 – Submittal Procedures, submit the following:
 - 1. Manufacturer's literature, specifications, installation instructions, technical data, and general recommendations.
 - 2. Samples of each type of insulation specified.
 - 3. Shop drawing for tapered insulation.

1.05 DELIVERY, STORAGE AND HANDLING

- A. Deliver materials in unopened, undamaged original packaging with bearing the manufacturer's name.

- B. Store materials in clean, dry, protected areas. Do not leave materials exposed to the weather or sunlight, except to the extent necessary to perform the work.
- C. Protect against ignition.

PART 2 – PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Subject to compliance with the requirements, provide products as manufactured by the following:
 - 1. Manufacturers of Extruded Polystyrene Board Insulation
 - a. Amoco Foam Products Company
 - b. DuPont
 - c. UC Industries
 - 2. Manufacturers of Polyisocyanurate Foam Insulation
 - a. RMax.
 - b. Atlas Energy Products.
 - c. Johns Manville.
 - 3. Manufacturers of Sprayed Polyurethane Foam (Gap Sealant)
 - a. The DuPont
 - b. Or approved equal

2.02 MATERIALS

- A. Unit Masonry Insulation: Fill ungrouted cells of masonry with foamed in place two component thermal insulation. Insulation shall be a Class A material with an R value of 4.9 per inch. Provide masonry insulation as manufactured by CORE-FILL 500 as manufactured by Tailored Chemical Products, Hickory, NC, or acceptable equal. Where shown on Drawings.

- B. Cavity Wall Insulation: Extruded polystyrene insulation boards meeting or exceeding the requirements of ASTM C578, Type IV, and with a "K" factor of 0.20 or less when tested in accordance with ASTM C 518. Provide insulation 1-1/2 inches thick unless otherwise shown.
- C. Roof Insulation: Provide polyisocyanurate insulation or as shown on Drawings and achieve energy code compliance. Provide a minimum of two staggered layers, unless otherwise indicated. Provide tapered insulation where roof structure does not slope. Roof insulation shall be approved by roofing manufacturer in accordance with the requirements of the roofing warranty. Roof insulation shall meet the requirements of roof manufacturer. Insulation shall have a minimum aged R-value of 5 per inch. The minimum R-Value of the insulation system shall be R-30 unless otherwise noted. Secure insulation as required by the roofing manufacturer to resist wind. Install ½" glass faced gypsum roof cover board above insulation in accordance with roof manufacturer's instructions and recommendations.
- D. I.
- E. Adhesive and Fasteners: Type compatible with insulation, masonry, concrete, or other substrate and as recommended or produced by the insulation manufacturer.
- F. Sealer and Tape: Type recommended by insulation manufacturer and having perm rating and fire resistance characteristics similar to that of the insulation.
- G. Gap Sealant: General Purpose Type: single-component polyurethane sealant. Gun-applied and Straw-applied products, Thermal Value R3.5 per inch. Provide GREATSTUFF PRO™ Gaps & Cracks Insulating Foam Sealant as manufactured by The Dow Chemical Company or approved equal. Provide Substrate Cleaner as recommended by foam sealer manufacturer.

PART 3 – EXECUTION

3.01 GENERAL

- A. Insulation shall be provided in walls, slabs and roofs and where shown on Drawings.

3.02 INSTALLATION OF INSULATION

- A. Install in accordance with the manufacturer's printed installation instructions to provide maximum sound and thermal benefits for material specified. Install to fill or cover voids. Cut neatly to snugly fit angles, corners and irregular areas and carefully wrapped around pipes, conduits, outlets, switches, beams, etc., to maintain continuity of insulation. Avoid gaps or bridges.
- B. Cavity Wall Insulation

1. On vertical surfaces of masonry adhere to inner wythe of block.
 2. Joints between insulation board units shall coincide with masonry joint reinforcing.
- C. Block Insulation: Install foamed in place two component thermal insulation in all ungrouted cells of masonry interior walls shown on Drawings.
- D. Roofing Insulation: Install roofing insulation in accordance with insulation and roofing manufacturer printed instructions and recommendations.
- E. Mineral Wool Batt Insulation: Install insulation in accordance with UL design requirements and in accordance with manufacturer's recommendations.
- F. Gap Sealant: Seal all gaps at perimeter of walls and penetrations and openings. Install in strict accordance with manufacturer's recommendations. Remove excess gap sealant to finish flush with the adjacent materials where visible or required to allow installation of finish materials.

3.03 ADJUSTMENT AND CLEANING

- A. Adequately protect Work from damage resulting from subsequent construction operations. Replace damaged or soiled Work.

END OF SECTION

SECTION 07 24 00
EXTERIOR INSULATION FINISH SYSTEM (EIFS)

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. Furnish labor, materials, equipment and appliances required for the complete execution of Work as shown on Drawings and specified herein.

1.02 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

- A. Without limiting the generality of these specifications, the Work shall conform to the applicable requirements of the following documents:
 - 1. ASTM C578 – Rigid, Cellular Polystyrene Thermal Insulation
 - 2. ASTM E84 – Surface Burning Characteristics of Building Materials
 - 3. EIMA 101 – Resistance of Exterior Insulation and Finish Systems, Class PB, to the Effects of Rapid Deformation (Impact)

1.03 SUBMITTALS

- A. In accordance with the procedures and requirements set forth in Section 01 33 00 – Submittal Procedures, submit the following:
 - 1. Manufacturer's data on each product to be used.
 - 2. Manufacturer's printed recommendations and installation instructions.
 - 3. Layout drawings.
 - 4. Samples showing finish matching existing precast concrete.

1.04 QUALITY ASSURANCE

- A. Use only EIFS installers trained and approved by the EIFS manufacturer and having successfully installed at least five years of experience.

1.05 WARRANTY

- A. Provide manufacturer's five year warranty against loss of bond, peeling, flaking, chipping, fading, and water resistance.

1.06 ENVIRONMENTAL CONDITIONS

- A. Do not apply EIFS during inclement weather unless appropriate protection is provided.
- B. Apply materials only at ambient temperatures of 40 degrees Fahrenheit or above and rising.

1.07 DELIVERY, STORAGE AND HANDLING

- A. Delivery materials to job site in original unopened packages, with manufacturer's label indicating name, and description of contents.
- B. Store materials off the ground in a clean, dry, well ventilated space and in accordance with manufacturer's recommendations.
- C. Do not expose insulation and flammable components to flame or ignition sources.

PART 2 – PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Subject to compliance with the Specifications provide products manufactured by one of the following:
 - 1. Senergy Inc.
 - 2. Dryvit Systems Inc.
 - 3. Sto Finish Systems
 - 4. Simplex Products Division

2.02 SYSTEM DESCRIPTION

- A. Provide manufacturer's standard mechanically fastened high impact Exterior Finish System with a sand textured finish.

2.03 INSULATION

- A. Provide thermal insulation recommended by the EIFS manufacturer for the type of application and in conformance with ASTM C578. Thickness shall be 6" minimum to match thickness and align with the level of precast.

2.04 ADHESIVE

- A. Provide type recommended by manufacturer for type application.

2.05 MECHANICAL FASTENERS

- A. Provide corrosion resistant type recommended by manufacturer for type of application, and space as recommended by manufacturer.

2.06 BASE COAT

- A. Manufacturer's standard acrylic resin based product with Type 1 Portland cement.

2.07 REINFORCING FABRIC

- A. Manufacturer's standard, balanced, alkali resistant, open weave, glass fiber mesh.
 - 1. Detail Mesh; 4.0 ounces per square yard.
 - 2. Standard Mesh; 4.4. ounces per square yard.
 - 3. Hi-Impact Mesh; 19.2 ounces per square yard.

2.08 FINISH COAT

- A. Manufacturer's standard acrylic with color fast mineral pigments and meeting the following:

Abrasion Resistance	ASTM D968	Very slight smoothing
Mildew Resistance	MIL-STD-810	No growth
Accelerated Weathering	ASTM G23	No deterioration
Salt spray Resistance	ASTM B117	No deleterious effects

2.09 SEALANT

- A. Manufacturer approved polyurethane sealant and complying with ASTM C920, Class 25. Provide primer and backer rod as recommended by sealant and EIFS manufacturer. Color of sealant shall closely match color of EIFS finish and as selected by the Owner.

PART 3 – EXECUTION

3.01 EXAMINATION

- A. Examine substrate and existing conditions to determine that substrate is acceptable to manufacturer's recommendations. Do not proceed with installation until deficiencies are corrected.

3.02 SURFACE PREPARATION

- A. Perform surface preparation in accordance with manufacturer's recommendations and instructions.

3.03 INSTALLATION

A. General

1. Install EIFS as indicated and in strict accordance with manufacturer's installation instructions and shop drawings. Install EIFS only by trained applicators and approved by the EIFS manufacturer.
2. Provide adequate protection of adjacent surfaces to prevent damage during EIFS installation.
3. Provide impact resistant finish for the full height.

B. Insulation Board

1. Place horizontally from level base line. Stagger vertical joints and interlock corners. Butt joints tightly. Mechanically attach insulation to substrate as recommended by manufacturer, but not more than 2 feet (600 mm) horizontally and vertically. Do not leave insulation exposed, without approval of insulation manufacturer and Engineer.

C. Reinforcing Fabric

1. Install reinforcing fabric in accordance with manufacturer's instructions. Provide diagonal reinforcement at opening corners, backwrapping, and any other reinforcement recommended by EIFS manufacturer.

D. Base Coat

1. Mix base coat in accordance with manufacturer's instructions. Apply to provide complete coverage of fiberglass reinforcing fabric, panel joints and fasteners. Apply base coat to level out surface areas.

E. Finish Coat

1. Apply and level finish coat in accordance with manufacturer's recommendations and in one operation. Obtain final texture by trowel, float, or spray application to achieve approved finish. Provide finish surfaces that are plumb and smooth, with no deviation greater than 1/4 inch (6 mm) in 10 feet (3000 mm). Finish shall match adjacent precast panel finish and color.

3.04 JOINT SEALANT

- A. Prior to sealing, remove loose matter from joint. Ensure that joint is dry and free of foreign matter. Apply primer as required by sealant and EIFS manufacturers.
- B. Install sealant in accordance with manufacturer's recommendations and instructions. Use gun having nozzle size that fits joint width. Fill joint solidly with sealant without air pockets. Tool sealant to provide a uniform, smooth and wrinkle free joint. Clean adjacent surfaces to remove excess sealant.

3.05 CLEANUP

- A. Remove temporary protection of adjacent surfaces and repair any areas which were damaged to the satisfaction of the Engineer.

END OF SECTION

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SECTION 07 26 16
VAPOR BARRIER

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. Furnish labor, material, equipment and appliances required for complete execution of Work.
- B. Principal items of work include:
 - 1. Vapor barrier below structural slabs on grade.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 03 30 00 – Cast-in-Place Concrete

1.03 SUBMITTALS

- A. In accordance with the procedures and requirements set forth in Section 01 33 00 – Submittal Procedures, submit the following:
 - 1. Manufacturer's data and installation instructions.

PART 2 – PRODUCTS

2.01 VAPOR BARRIER

- A. Vapor Barrier: A reinforced laminate membrane with a minimum tensile strength of 55 lbs/in. in accordance with ASTM D-882, vapor transmission rating of 0.02 perms in accordance with E-96, and a puncture resistance of 25 lbs in accordance with ASTM D4833 or 2,200 grams in accordance with ASTM D-1709.
- B. Adhesive/Tape: Type approved by the Manufacturer of the vapor material.
- C. Penetration sealing: Provide manufacturer's recommended penetration seals at all pipe, conduit, and similar penetrations.

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2.02 ACCEPTABLE MANUFACTURERS

- A. Subject to compliance with the Specifications, provide products from one of the following manufacturers:
 - 1. Viper Vapercheck 10 by Insulation Solutions, Inc.
 - 2. Griffolyn Type-85, by Reef Industries, Inc.
 - 3. Or Equal

PART 3 – EXECUTION

3.01 VAPOR BARRIER

- A. Vapor barrier shall be placed on top of 4 inches minimum of compacted structural fill stone, free of debris and protrusions for structural slabs.
- B. Lap edges 12 inches and seal with adhesive tape. Lay with seams perpendicular to and lapped in the direction of placement. Do not penetrate vapor barrier.
- C. Protect from damage until concrete is placed. Punctures and tears in vapor barrier shall be repaired using patches of the material which overlaps puncture or tear a minimum of 12 inches; seal with tape or adhesive.
- D. Penetrations through vapor barrier, such as pipe, drains, conduits and similar penetrations, shall be sealed in strict accordance with manufacturer's recommended instructions.

END OF SECTION

SECTION 07 52 00
BUILT-UP BITUMINOUS ROOFING

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. Furnish all labor, materials, equipment and appliances required for the complete execution of Work shown on Drawings and specified herein.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 06 10 00 – Rough Carpentry
- B. Section 07 21 00 – Building Insulation
- C. Section 07 60 00 – Flashing and Sheet Metal
- D. Section 07 70 00 – Roof Specialties and Accessories

1.03 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

- A. Without limiting the generality of these specifications Work shall conform to the applicable requirements of the following documents:
 - 1. ASTM D41 – Asphalt Primer Used in Roofing, Dampproofing, and Waterproofing
 - 2. ASTM D312 – Asphalt Used in Roofing
 - 3. ASTM D2178 – Asphalt Felt Used in Roofing and Waterproofing
 - 4. FS HH-I-1972/GEN – Insulation Board, Thermal, Faced, Polyurethane or Polyisocyanurate

1.04 SUBMITTALS

- A. In accordance with the procedures and requirements set forth in Section 01 33 00 – Submittal Procedures, submit the following:
 - 1. Product data for glass fiber ply sheet, modified bitumen sheet membrane, insulation and base flashing materials.
 - 2. Manufacturer's installation instructions.
 - 3. Shop Drawings including roof plan and flashing details and other details to show extend of work..

4. Certification that materials meet or exceed specified requirements.
5. Certification that installer is approved by the manufacturer.
6. Copy of manufacturer's 20 year system warranty.
7. Samples of each product.
8. Color samples of cap sheet.
9. Field report at the end of all roofing and related work.

1.05 QUALITY ASSURANCE

- A. Applicator: Company well experienced in modified bitumen roofing membrane application and approved by product manufacturer.
- B. Products and installation shall be in accordance with the following:
 1. Underwriters Laboratories, Inc. (UL): Class A Fire Hazard Classification.
 2. Factory Mutual Engineering Corporation (FM): Roof assembly classification, FMRC, Approval Standard 4470, Class I, and I90 approvals.
 3. Design roof to meet wind design criteria in the current Building Code of the State or Commonwealth in which the project is located
 4. Field Report: After all work has been completed, including setting of roof top equipment, and other work required on the roof, provide a report from a Professional Engineering firm or manufacturer's representative verifying watertight and quality installation conforming to all warranty conditions. Report shall include sub surface moisture evaluations and recommendations for necessary repairs of defects and irregularities.
- C. Manufacturer's Representative: Provide a minimum of three site visits including one at start of work, one during progress and one at completion.

1.06 ENVIRONMENTAL REQUIREMENTS

- A. Do not apply roofing membrane during inclement weather.
- B. Do not apply roofing membrane to damp or frozen deck surfaces.
- C. Do not expose materials vulnerable to water or sun damage in quantities greater than can be weatherproofed during the same day.

- D. At lower air temperatures, to assure sound adhesion, care must be exercised to provide asphalt, at the point of application, at the asphalt's equiviscous temperature (EVT) plus 20 degrees Fahrenheit or at 400 degrees Fahrenheit, whichever is higher.

1.07 GUARANTEE

- A. Provide a manufacturer's twenty year total system guarantee covering the repair of leaks which result from either material or workmanship, including insulation, coping, flashing, and attributable to ordinary wear and tear.

1.08 DELIVERY, STORAGE AND HANDLING

- A. Deliver products to site in factory sealed cartons and crating bearing the manufacturer's labels.
- B. Store materials in weather protected environment, clear of ground and moisture, in accordance with manufacturer's instructions. Maintain membranes above 50 degrees Fahrenheit prior to their installation.

PART 2 – PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Subject to compliance with the Specifications provide products manufactured by one of the following:
 - 1. The Garland Company
 - 2. Tremco Roofing
 - 3. Johns Manville

2.02 SYSTEM DESCRIPTION

- A. Four ply, hot asphalt applied modified bitumen membrane system with mineral granule surface cap sheet as the fourth ply.

2.03 SHEET MATERIALS

- A. Base Sheets: Glass Fiber 6 Ply Sheet: ASTM D2178, Type VI, UL Type G1 BUR.
- B. Membrane: Premium, fire-retarding, modified bitumen membrane and surfaced with light colored mineral granules. ASTM D6162 Type III cap sheet shall have the following properties:
 - 1. Minimum Thickness: 140 mils

2. Tensile Strength – (ASTM D-5147): 400 lbs.

3. Tear Strength – (ASTM D-5147): 400 lbs.

2.04 BITUMINOUS MATERIALS

A. Asphalt Bitumen: ASTM D312, Type IV

B. Asphalt Primer: ASTM D41, Asphalt/Concrete Primer

C. Asbestos-Free Cement: ASTM D 4586 Type II

2.05 INSULATION

A. Provide insulation approved by the manufacturer and in accordance with the requirements of Section 07 21 00 – Building Insulation.

B. Provide manufacturer's recommended roof cover board, 1/2 inches thick, above insulation.

2.06 FLEXIBLE FLASHING

A. Manufacturer's recommended modified bitumen flashing.

2.07 ACCESSORIES

A. Roofing Nails: Galvanized or non-ferrous type and size as required to suit application.

B. Pressure Relieving Vents: Plastic or Metal one-way valves. Provide vents in accordance with manufacturer's recommendations.

C. Mechanical Fasteners for Insulation: Manufacturer's recommended fasteners and as required to meet FM I-90 requirements.

D. Traffic Surfacing: Manufacturer's standard cap sheet of a color contrasting. Provide traffic surfacing from point of access to roof installed equipment, and each side of roof installed equipment

PART 3 – EXECUTION

3.01 EXAMINATION

A. Verify deck surface is dry, sound, clean and smooth, free of depressions, waves, or projections, properly sloped to gutter.

B. Beginning of installation means acceptance of the surface of the substrates.

3.02 PROTECTION

- A. Protect building surfaces against damage from roofing work.
- B. Where work must continue over finished roof membrane, protect surfaces.

3.03 INSULATION APPLICATION

- A. For structural concrete decks, prime deck surface with Asphalt/Concrete Primer then embed in a 25 pound per square (plus or minus 20%) mopping of ASTM Type III or IV asphalt, two layers of insulation in accordance with manufacturer's instructions. Lay second layer of insulation with joints staggered from first layer.
- B. Lay insulation boards with tightly butted, staggered joints. Cut insulation to fit neatly to perimeter blocking and around protrusions through roof.
- C. Install no more insulation than can be properly covered by the end of the each day with roofing membrane.

3.04 MEMBRANE APPLICATION

- A. Install glass fiber ply sheets and modified bitumen sheets and flashing in accordance with manufacturer's instructions.
- B. Prime all masonry and metal surfaces with GAF Asphalt/ Concrete Primer and allow to dry thoroughly.
- C. Asphalt should be heated so that felts are installed with the asphalt within its equiviscous temperature range. Mop applied sheets must be installed with ASTM D 312, Type III or IV asphalt at a minimum temperature of 400 degrees Fahrenheit, at the point of application, with a target temperature of 425 degrees Fahrenheit, or 20 degrees Fahrenheit above the EVT, whichever is higher. The maximum allowable asphalt temperature, in the kettle, is 500 degrees Fahrenheit. Heat the asphalt in accordance with the manufacturer's instructions.
- D. Install glass fiber ply sheets using Type IV asphalt at a rate of 25 pounds per square (plus or minus 20%).
- E. Install membrane by solidly mopping in 25 pounds per square (plus or minus 20%) of asphalt to base.
- F. Apply glass fiber ply sheets and membrane smoothly without wrinkles, fishmouths or tears. Provide membrane side laps of 4 inches and 6 inch end laps. Side and end laps should have 1/4 inch minimum flow out of bitumen.

- G. Extend glass fiber ply sheets and membranes 2 inches past the top of the cants onto vertical surfaces.
- H. When inclement weather is expected, install a water cut-off at the end of the day's operation. Mop three plies of base sheets and one ply of membrane. Install cut-off at all exposed edges of roofing and at roof penetrations. Remove water cut-off upon resumption of work.

3.05 TRAFFIC SURFACING

- A. Using maximum 10' lengths of the cap sheet membrane solidly mop one ply of smooth membrane and one surfaced membrane to the surface of the applied roof. Allow 6"-12" openings between adjacent sheets for drainage.

3.06 FLASHING

- A. Install flashing according to Manufacturer's specifications.
- B. Install one pressure relief vent per 1,000 square feet, or part thereof, of roof surface.
- C. Seal flashing and flanges on all items setting on or protruding through the membrane. Seal flanges between two plies of membrane.

3.07 FIELD QUALITY CONTROL

- A. Inspection and testing will be performed by a Professional Engineering firm or manufacturer's representative approved by the Engineer.
- B. Correct defects and irregularities reported.

3.08 CLEANING

- A. Remove bituminous markings from finished surfaces. In areas where finished surfaces are soiled by asphalt or any other source of soiling caused by work of this Section, consult manufacturer of surfaces for cleaning advice and conform to those instructions.

END OF SECTION

SECTION 07 60 00
FLASHING AND SHEET METAL

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. Furnish labor, materials, equipment and appliances required for complete execution of Work shown on Drawings and specified herein.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 04 20 00 – Unit Masonry
- B. Section 07 52 00 – Built-Up Bituminous Roofing
- C. Section 07 70 00 – Roof Specialties and Accessories
- D. Section 07 90 00 – Joint Fillers, Sealants and Caulking

1.03 REFERENCES SPECIFICATIONS, CODES AND STANDARDS

- A. Without limiting the generality of these specifications Work shall conform to the applicable requirements of the following documents:
 - 1. OF-506C – Flux, Soldering, Paste, and Liquid
 - 2. ASTM A176 – Stainless and Heat-Resisting Chromium Steel Plate, Sheet and Strip
 - 3. ASTM B32 – Specifications for Solder Metal
 - 4. ASTM D1187 – Test Method for Asphalt-Base Emulsions for use as Protective Coatings for Metal
 - 5. "Architectural Sheet Metal Manual" by Sheet Metal and Air Conditioning Contractors National Association.
 - 6. FM Global Data Sheet 1-49, Perimeter Flashing

1.04 SUBMITTALS

- A. In accordance with the procedures and requirements set forth in Section 01 33 00 – Submittal Procedures, submit the following:
 - 1. Manufacturer's literature and installation instructions.

2. Complete layout and installation Drawings and schedules with clearly indicated dimensions.
3. Provide drawings of proposed flashing.
4. Color samples.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Store materials in a clean dry protected area in such manner to preclude damage by denting, warping, or other distortion.

PART 2 – MATERIALS

2.01 MATERIALS

- A. Metal Flashing (See Specification Section 07 70 00 for Coping)
 1. Exposed to View: Provide prefinished 0.050 inches aluminum. Provide a full-strength Kynar 500 baked-on paint finish with a 20-year warranty.
 2. Concealed from View: Provide a minimum of 22 ga. galvanized. steel sheet, stainless steel sheet, or mill-finished aluminum sheet.
- B. Nails, screws, rivets, bolts and other fasteners: same material as sheet metal being attached. Nails shall be 18-gauge diameter shank, 1/4-inch diameter flat head, annular-thread, diamond point, long enough to penetrate backing by at least 1 inch. Nails shall be spaced 3 inches on center unless other spacing is indicated. Exposed fasteners shall match finish of metal being fastened.
- C. Reglets shall be formed of 300 series stainless steel, minimum of 0.020 inch. Reglets shall be Model CO for insertion in concrete, MA-4 for insertion in masonry as manufactured by FRY Reglet Corporation. Corners shall be factory made, mitered and sealed. Furnish reglets to proper trade in sufficient time to be incorporated into the masonry or concrete work.
- D. Bituminous plastic cement shall conform to ASTM D4586.
- E. Sealants shall be silicone type or as recommended for specific application.
- F. Sealer tape shall be polyisobutylene tape specifically manufactured for setting flanges on bituminous roofing or as recommended by roofing manufacturer.

PART 3 – EXECUTION

3.01 FABRICATION

- A. Shop fabricate Work to greatest extent possible. Comply with details shown and applicable requirements of SMACNA "Architectural Sheet Metal Manual" and other recognized industry standards. Fabricate for waterproof and weather resistant performance; with expansion provisions for running work, sufficient to permanently prevent leakage, and damage or deterioration of the work. Comply with material manufacturer's instructions and recommendations for forming material. Form exposed work without excessive oil-canning, buckling and tool marks, true to line and levels as indicated, with exposed edges folded back to form hems.
- B. Roof penetration sheet metal work shall be provided and coordinated with the roofing system. The design and details shall conform to SMACNA "Architectural Sheet Metal Manual". Sheet metal items shall be built into roofing in strict accordance with the instructions of the roofing manufacturer.
- C. Perimeter flashing related to roof systems shall be installed in accordance with FM 1-49 requirements.

END OF SECTION

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SECTION 07 70 00
ROOF SPECIALTIES AND ACCESSORIES

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. Furnish all labor, materials, equipment and appliances required for the complete execution of Work shown on Drawings and specified herein.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 06 10 00 – Rough Carpentry
- B. Section 07 52 00 – Built-Up Bituminous Roofing
- C. Section 07 60 00 – Flashing and Sheet Metal
- D. Section 07 90 00 – Joint Fillers, Sealants and Caulking

1.03 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

- A. Without limiting the generality of these specifications Work shall conform to the applicable requirements of the following documents:
 - 1. TT-P-641 (1) – Primer Coating, Zinc Dust - Zinc Oxide (for galvanized surfaces)
 - 2. ASTM A 525 – Specification for General Requirements for Steel Sheet, Zinc Coated (Galvanized) by the Hot-Dip Process
 - 3. ASTM A 526 – Specification for Steel Sheet, Zinc Coated (Galvanized) by the Hot-Dip Process, Commercial Quality
 - 4. ASTM B 209 – Specification for Aluminum and Aluminum-Alloy Sheet and Plate
 - 5. Sheet Metal and Air Conditioning Contractors National Association "Architectural Sheet Metal Manual" (ASMM)
 - 6. The Aluminum Association "Specification for Aluminum Sheet Metal Work in Building Construction."
 - 7. American Welding Society (AWS).
 - 8. FM Global Data Sheet 1-28 Wind Design
 - 9. FM Global Data Sheet 1-49 Perimeter Flashing

1.04 SUBMITTALS

- A. In accordance with the procedures and requirements set forth in Section 01 33 00 – Submittal Procedures, submit the following:
 - 1. Manufacturers literature and installation instructions.
 - 2. Samples, of each material listed.
 - 3. Provide shop drawings for the full extent of each item to be provided. Provide overall plans and details of each transition. Provide details of each item.

1.05 DELIVERY, STORAGE AND HANDLING

- A. Deliver all materials in factory packed unopened cartons and crating bearing the manufacturer's labels.
- B. Store materials in clean, dry protected area in such manner to preclude damage of any nature.
- C. Handle all materials with proper care to avoid denting, marring, warping or other distortions during delivery, storage and handling.

PART 2 – PRODUCTS

2.01 MATERIALS

- A. General: Provide roof specialties and accessories of design and construction compatible and approved for use with roofing manufacturer.
- B. Fasteners: Provide all fasteners and attachments required to secure item to substrate and support loads required by applicable Building Code. Use only non-corrosive fasteners which are compatible with materials being joined.
- C. Colors: Colors shall be selected by Owner from full range of colors.

2.02 GUTTERS, DOWNSPOUTS, SCUPPERS, AND CONDUCTOR HEADS

- A. Material: 0.040 inch aluminum.
- B. Design: Manufacture gutters tapered and notched to provide telescoping joint. Design gutters and downspouts to accommodate expected thermal movement.
- C. Fabricate scuppers and conductor head using SMCNA requirements and the Drawings.

- D. Supports and Fasteners: Provide manufacturers' standard straps, brackets and fasteners. Place supports and fasteners at 36 inches on center or as recommended by the manufacturer. Finish of supports, brackets and fasteners shall match gutter and downspout.
- E. Accessories: Provide end caps, flashing, trim, and other items required for a complete installation.
- F. Finish: Baked on Kynar, with 20 year warranty.

2.03 ROOF CURBS

- A. Material: 18 gauge, G-90 galvanized steel, 12 inches high with mitered and continuous welded corners and seams, factory installed pressure treated wood nailers, and rigid fiberglass insulation.
- B. Design: Provide roof curb units manufactured to fit manufactured roof panels. Provide integral water diverter. Design roof curb to support weight of equipment. Coordinate roof curb unit with roof panel manufacturer to ensure proper fit. Roof curb shall be approved for use by manufacturer.
- C. Accessories: Provide interior liner, flashing, trim and other items required for a complete installation.

2.04 COPINGS

- A. Material: 0.050 inches aluminum with smooth surfaces.
- B. Splice Plate: Aluminum and finished to match coping. Provide six inch wide units at twelve foot centers with extruded butyl seal strips.
- C. Anchor Plate: Galvanized steel. Anchor to substrate with anchors as recommended by manufacturer.
- D. Provide manufactured product by Garland, Hickman, or equal. Provide products tested in accordance with ANSI/SPRI/FM 4435/ES-1.
- E. Finish: "Baked" on Kynar, with 20 year warranty. Provide color chart with full range of colors.
- F. Guarantees: Twenty year performance guarantees relative to blow-off, leaktightness and finish.

PART 3 – EXECUTION

3.01 INSTALLATION - GENERAL

- A. Install roof accessories and specialties in accordance with the manufacturer's instructions. Provide a complete watertight and weatherproof installation. Install with provision for expansion and contraction.
- B. Installation for copings shall be in accordance with ANSI/SPRI/FM 4435/ES-1 requirements for wind speeds shown on Structural Drawings.
- C. Separate copings from roofing accessories for non-compatible materials.

3.02 DAMAGED MATERIAL

- A. Repair or replace materials damaged during installation.

3.03 ADJUSTING AND CLEANING

- A. Check levels and adjust as necessary after roofing and flashing is complete.
- B. Protect materials from damage by other trades. Remove protective coatings at completion of project.

END OF SECTION

SECTION 07 84 00
FIRESTOPPING

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. Furnish labor, materials and equipment required to complete the installation of troweled or gun applied firestopping as indicated on the Drawings and specified herein.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Division 22 - Plumbing
- B. Division 23 - Mechanical
- C. Division 26 – Electrical

1.03 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

- A. Without limiting the generality of these specifications Work shall conform to the applicable requirements of the following documents:
 - 1. ASTM E84 – Test Method for Surface Burning Characteristics of Building Materials
 - 2. ASTM E119 – Method for Fire Tests of Building Construction and Materials
 - 3. ASTM E814 – Test Method of Fire Tests of Through- Penetration Firestops
 - 4. ASTM E 1966 – Standard Test Method for Fire Resistive Joint Systems
 - 5. UL-01 – Building Materials Directory
 - 6. UL-1479 – Fire Test of Through-Penetration Firestops
 - 7. UL-2079 – Tests for Fire Resistance of Building Joint Systems

1.04 SUBMITTALS

- A. In accordance with the procedures and requirements set forth in Section 01 33 00 – Submittal Procedures, submit the following:
 - 1. Product data on characteristics, performance, and limitation criteria.
 - 2. UL and manufacturer's detail drawings and installation instructions to achieve required fire ratings.

3. Certification that products meet or exceed requirements.

1.05 QUALITY ASSURANCE

- A. A manufacturer's direct representative (not distributor or agent) to be on-site during initial installation of firestop systems to train appropriate contractor personnel in proper selection and installation procedures. This will be done per manufacturer's written recommendations published in their literature and drawing details.
- B. Firestop System installation must meet requirements of ASTM E-814, UL 1479 or UL 2079 tested assemblies that provide a fire rating equal to that of construction being penetrated.
- C. Proposed firestop materials and methods shall conform to applicable governing codes having local jurisdiction.
- D. Firestop Systems do not reestablish the structural integrity of load bearing partitions/assemblies or support live loads and traffic. Installer shall consult the structural engineer prior to penetrating any load bearing assembly.
- E. Engage an installer with a minimum of 5 years of experience and who is certified, licensed, or otherwise qualified by firestopping manufacturer as having been provided the necessary training to install manufacturer's products per specified requirements.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Deliver materials undamaged in manufacturer's clearly labeled, unopened containers, identified with brand, type, and UL label where applicable.
- B. Coordinate delivery of materials with scheduled installation date to allow minimum storage time at job-site.
- C. Store materials under cover and protect from weather and damage in compliance with manufacturer's requirements, including temperature restrictions.
- D. Comply with recommended procedures, precautions or remedies described in material safety data sheets as applicable.
- E. Do not use damaged or expired materials.

1.07 PROJECT CONDITIONS

- A. Do not use materials that contain flammable solvents.
- B. Schedule installation of firestopping after completion of penetrating item installation but prior to covering or concealing of openings.

- C. Verify existing conditions and substrates before starting work. Correct unsatisfactory conditions before proceeding.
- D. Weather conditions: Do not proceed with installation of firestop materials when temperatures exceed the manufacturer's recommended limitations for installation printed on product label and product data sheet.
- E. During installation, provide masking and drop cloths to prevent firestopping materials from contaminating any adjacent surfaces.

PART 2 – PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Subject to compliance with the Specifications provide products manufactured by one of the following:
 - 1. Hilti, Inc.
 - 2. 3M Corp.
 - 3. Specified Technologies, Inc.

2.02 MATERIALS

- A. Provide firestopping materials of commercially manufactured products complying with the following minimum requirements and as listed in Underwriters Laboratories, Inc. - Building Materials Directory.
 - 1. ASTM E84 or UL 723 with a flame spread of 25 or less; smoke development rating of 50 or less; fuel contribution of 50 or less.
 - 2. Non-toxic and non-corrosive during each stage of application and during fire conditions.
 - 3. Penetrations: ASTM E814 or UL 1479 with 2 hour ratings or as shown on Drawings.
 - 4. Joints: UL 2079 2 hour rating or as shown on Drawings.
 - 5. Non-combustible when tested in accordance with ASTM E136.
 - 6. Materials shall impede the passage of smoke and gases.
- B. Backing Material: Unfaced non-combustible mineral wool, or manufacturer pre-fabricated backer rod, as per Underwriters Laboratories, Inc. Building Materials Data.

- C. Accessories: Collars, fasteners, straps, and other accessories shall be manufacturer's standard products approved for UL through penetrations.

PART 3 – EXECUTION

3.01 SURFACE PREPARATION

- A. Perform preparation and cleaning procedures in compliance with manufacturer's instructions.

3.02 INSTALLATION

- A. Install firestopping as shown on the Drawings, as specified, and as required by UL-system. Firestop the following:
 - 1. Duct, conduit, and pipe penetrations through below-grade floors and time-rated partitions.
 - 2. Penetrations of vertical shafts.
 - 3. Gaps between fire rated partitions and structure above, or exterior walls.
- B. Install firestopping in strict accordance with UL through-penetrations systems requirements.
- C. Cure finished work as recommended by the manufacturer to avoid shrinkage cracks.

3.03 MIXING

- A. Mix and prepare materials in compliance with the manufacturer's directions.
- B. Store materials in tightly covered containers. Maintain containers used in storage, mixing, and application of firestopping in a clean condition, free of foreign materials and residue.
- C. Mix materials to produce a uniform density and as required for application of the materials.

3.04 INSPECTION

- A. Examine the substrates to receive firestopping and the conditions under which the work is to be performed and notify the Engineer in writing of any conditions detrimental to the proper and timely completion of the work and performance of the firestopping. Do not proceed with the work until unsatisfactory conditions have been corrected in a manner acceptable to the material manufacturer and Engineer.

- B. Commencement of firestopping work shall be interpreted as proof of acceptability of the substrates, by the applicator and the applicator's acceptance of responsibility for any failure of bond between installation of firestopping and substrate in any particular area.
- C. Do not apply materials over incompatible steel primers, dirt, rust, grease, moisture or other conditions unacceptable according to the manufacturer's instructions.

3.05 FIELD QUALITY CONTROL

- A. Examine sealed penetration areas to ensure proper installation before concealing or enclosing areas.
- B. Keep areas of work accessible until inspection by applicable code authorities.
- C. Inspection of through-penetration firestopping shall be performed in accordance with ASTM E 2174, "Standard Practice for On-Site Inspection of Installed Fire Stops" or other recognized standard.
- D. Perform under this section patching and repairing of firestopping caused by cutting or penetrating of existing firestop systems already installed by other trades.

3.06 ADJUSTMENT AND CLEANING

- A. Upon completion of work, clean spattered surfaces. Remove spattered materials by methods of washing and scraping, using care not to scratch or otherwise damage finish surfaces. Clean with manufactures recommended solution.
- B. Protect work of other trades, whether to be coated or not, against damage by the work. Correct damage by cleaning, repairing or replacing and recoating. Leave all work in undamaged condition.
- C. Take precautions to ensure that workmen and work areas are adequately protected from fire hazards and health hazards resulting from handling, mixing and application of firestopping.

END OF SECTION

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SECTION 07 90 00
JOINT FILLERS, SEALANTS AND CAULKING

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. Furnish labor, materials, equipment and appliances required for the complete execution of Work shown on the Drawings and specified herein.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 03 15 00 – Concrete Accessories
- B. Section 03 15 16 – Joints in Concrete
- C. Section 04 20 00 – Unit Masonry
- D. Section 08 80 00 – Glass and Glazing

1.03 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

- A. Without limiting the generality of the other requirements of the specifications, all work herein shall conform to the applicable requirements of the following documents. All referenced specifications, codes, and standards refer to the most current issue available at the time of Bid.
 - 1. ASTM C-920 – Elastomeric Joint Sealants
 - 2. ASTM D-1056 – Flexible Cellular Materials – Sponge or Expanded Rubber
 - 3. SWRI – Sealant and Caulking Guide Specification

1.04 SUBMITTALS

- A. In accordance with the procedures and requirements set forth in Section 01 33 00 – Submittal Procedures, submit the following:
 - 1. Manufacturers literature and installation instructions. Label each product submitted with Type as indicated in paragraph 2.01 A.
 - 2. Color samples of each type of sealant.

1.05 QUALITY ASSURANCE

- A. Applicator shall be a company specializing in the installation of sealants with a minimum of five years of experience.

1.06 DELIVERY, STORAGE AND HANDLING

- A. Deliver materials in unopened labeled packages.
- B. Store materials in location protected from freezing or damages.
- C. Reject and remove from the site materials within broken or damaged packaging.

PART 2 – PRODUCTS

2.01 MATERIALS

- A. Sealants
 - 1. Type 1: Multi-component, non-sag, low-modulus polyurethane rubber sealant meeting ASTM C-920, Type M, Grade NS, Class 25, use NT, M, A, and O. Capable of withstanding 25% in extension or compression such as Sikaflex-2C NS/SL, Sika Corporation, or Sonolastic NP-2, Sonneborn, or DynaTrol II by Pecora Corporation.
 - 2. Type 2: Single component polyurethane sealant meeting ASTM C-920, Type S, Grade NS, Class 25, Use NT, M, A, and O. Capable of withstanding 25% in extension or compression such as Sikaflex 1A by Sika Corporation, DynaTrol 1-XL by Pecora Corporation, or Sonolastic NP-1 by Master Builders Solutions.
 - 3. Type 3: Single component, low-modulus moisture curing silicone meeting ASTM C920, Type S, Grade NS, Class 50, Use NT, M, G, and A. Capable of withstanding 50% extension and compression. Pecora 890 by Pecora Corporation, Sonolastic Omni Seal by Master Builders Solutions.
 - 4. Type 4: Single component, mildew resistant, moisture-curing silicone meeting ASTM C-920, Type S, Grade NS, Class 25, Use NT, M, G, and A. Pecora 898 by Pecora Corporation, Sonolastic Omni Plus by Master Builders Solutions.
 - 5. Type 5: Single component, acrylic latex meeting ASTM C-834. AC-20+ Silicone by Pecora Corporation, Sonneborn Sonolac by Master Builders Solutions.
 - 6. Type 6: High grade butyl sealant meeting Federal Specification TT-S-00-1657. BC-158 by Pecora Corporation or equal.

- 7. Type 7: Multi-component chemical resistant polysulfide sealant conforming to ASTM C-920, Type M, Grade NS, Class 25 such as Deck-O-Seal by W.R. Meadows, Tammsflex by DuraJoint Concrete Accessories, or Synthacalk GC2+ by Pecora Corporation.
 - 8. Type 8: Nonsag, Multi Component, traffic grade polyurethane sealant meeting ASTM C920, Type M, Grade NS, Class 25, use T, M, A, and O. DynaTread by Pecora Corporation, MasterSeal CR 195 by Master Builders Solutions.
- B. Primer: Non-staining primer recommended by sealant manufacturer for the substrates on this project.
 - C. Backer Rod: Closed cell foam, nonreactive with caulking materials, non-oily, and approved by the sealant manufacturer. Minimum density shall be 2.00 pounds per cubic foot. Use no asphalt or bitumen-impregnated fiber with sealants.
 - D. Joint Cleaner: Recommended by sealant or caulking compound manufacturer.
 - E. Bond breaker: Either polyethylene film or plastic tape as recommended by the sealant manufacturer.
 - F. Color: Where manufacturer's standard colors do not closely match materials being sealed, provide a custom color.

PART 3 – EXECUTION

3.01 QUALITY CONTROL

- A. Coordinate work with details shown on approved shop drawings prepared by other trades.
- B. Verify conditions in the field.
- C. Schedule work to follow closely the installation of other trades.
- D. Apply sealants and related items in temperatures and dry conditions recommended by the manufacturers.
- E. Do not paint sealant, unless recommended by sealant and paint manufacturer.

3.02 PREPARATION

- A. Protect finished surfaces adjoining by using masking tape or other suitable materials.
- B. Clean and prime joints before starting any caulking or sealing work.

C. Thoroughly clean joints and spaces of mortar and other foreign materials. Cleaning agent shall be Xylol or similar non-contaminating solvent to remove any film from metal surfaces. Masonry or concrete surfaces shall be brushed or air jet cleaned.

D. Joint Requirements

1. All joints and spaces to be sealed in exterior work shall be less than ½-inch deep and not less than 1/4 inch wide. If joints in masonry are less than that specified herein, the mortar shall be cut out to the required width and depth. All joints and spaces to receive sealant shall be completely prepared and thoroughly dry before installation of sealant.
2. Unless otherwise specified, joints and spaces which are open to a depth of 1/2 inch or greater shall be solidly filled with back-up material to within 1/4 inch of the surface. Back-up material shall be packed tightly and made continuous throughout the length of the joints. Bond breaker shall be applied as required. If joints are less than ¼-inch deep, the back-up material may be omitted, a bond breaker substituted and the joint completely filled with sealant. The back-up material shall not project beyond the ¼-inch depth of the open space in any joint. The following width-to-depth ratio table shall be adhered to, unless otherwise recommended by manufacturer.

Joint Width	Sealant Depth	
	Minimum	Maximum
¼ inch	1/4 inch	1/4 inch
Over 1/4 inch to 1/2 inch	1/4 inch	Equal to width
Over 1/2 inch to 1 inch	1/2 inch	Equal to width
Over 1 inch to 2 inches	1/2 inch	1/2 of width

3.03 APPLICATION

- A. Exercise care before, during, and after installation so as not to damage any material by tearing or puncturing. All finished work shall be approved before covering with any other material or construction.
- B. Apply sealant by an approved type of gun except where the use of a gun is not practicable, suitable hand tools shall be used. Avoid applying the compound to any surface outside of the joints or spaces to be sealed. Mask areas where required to prevent overlapping of sealant.
- C. All joints shall be waterproof and weathertight.

- D. Point sealed joints to make a slightly concave joint, the edges of which are flush with the surrounding surfaces. Exposed joints in the interior side of the door and other frames shall be neatly pointed flush or to match adjacent jointing work.
- E. Adjacent materials which have been soiled shall be cleaned immediately and the work left in neat and clean condition.
- F. Comply with sealant manufacturer's written instructions except where more stringent requirements are shown or specified and except where manufacturer's technical representative directs otherwise.

3.04 ADJUSTMENT AND CLEANING

- A. Remove misplaced sealant compounds promptly using methods and materials recommended by the manufacturer, as the work progresses.
- B. Allow sealants to cure and remove protective edging, of doors, louvers, saddles windows etc. as directed by the Engineer.

3.05 SCHEDULE

Schedule of Sealants

Application	Sealant	Color
Vertical and horizontal expansion and construction joints in concrete structures unless noted otherwise herein or on Drawings.	Type 1	To closely match adjacent surfaces or mortar and as selected by the Owner.
Vertical and horizontal joints bordered on both sides by masonry, precast concrete, natural stone or other porous building material, unless noted otherwise herein or on Drawings.	Type 2	To closely match adjacent surfaces or mortar and as selected by the Owner.
Vertical and horizontal joints bordered on both sides by painted metals, anodized aluminum, mill finished aluminum, PVC, glass or other non-porous building material.	Type 3	To closely match adjacent surfaces and as selected by the Owner.
Masonry expansion and control joints less than 1¼" wide.	Type 2	To closely match adjacent surfaces and as selected by the Owner.
Masonry expansion and control joints equal or greater than 1¼ inches wide and not to exceed 2".	Type 1	To closely match adjacent surfaces and as selected by the Owner.
Sanitary areas, joints in ceramic tile, around plumbing fixtures, countertops, and back splashes. ¹	Type 4	To closely match adjacent surfaces and as selected by the Owner.
Perimeter sealing of doors, windows, louvers, piping, ducts, and electrical conduit. ²	Type 2 OR Type 3	To closely match adjacent surfaces and as selected by the Owner.
Below thresholds.	Type 6	Manufacturer's standard

Schedule of Sealants

Application	Sealant	Color
Submerged in liquids. ^{3,4}	Type 1	Manufacturer's standard
Submerged in liquids with high concentration of chlorine (> 2 ppm) or wastewater.	Type 7	Manufacturer's standard
Horizontal Joints exposed to vehicular or pedestrian traffic.	Type 8	To closely match adjacent surfaces.
Other joints indicated on the drawings or customarily sealed but not listed.	Type recommended by manufacturer	To closely match adjacent surfaces and as selected by the Owner.

¹ Sealant for Laboratory Countertop shall be as recommended by countertop manufacturer.

² Provide UL approved sealants for penetrations thru fire-rated walls and as specified in Section 07 84 00 - Firestopping.

³ Sealants which will come in contact with potable water shall meet the requirements of NSF 61.

⁴ Where sealant will be immersed in liquid chemicals verify compatibility prior to installation of sealant.

END OF SECTION

SECTION 07 95 00
EXPANSION JOINT COVERS

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. Furnish labor, materials, equipment and appliances required for the complete execution of Work shown on the Drawings and specified herein.

- 1. Joints greater than 1".

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 03 15 16 – Joints in Concrete
- B. Section 03 30 00 – Cast-in-Place Concrete
- C. Section 04 20 00 – Unit Masonry
- D. Section 05 12 00 – Structural Steel
- E. Section 06 10 00 – Rough Carpentry
- F. Section 07 13 50 – Waterproofing
- G. Section 07 21 00 – Building Insulation
- H. Section 07 52 00 – Built-up Bituminous Roofing
- I. Section 07 60 00 – Flashing and Sheet Metal
- J. Section 07 70 00 - Roof Specialties and Accessories
- K. Section 07 90 00 – Joint Fillers, Sealants and Caulking

1.03 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

Without limiting the generality of the other requirements of the specifications, all work herein shall conform to the applicable requirements of the following documents. All referenced specifications, codes, and standards refer to the most current issue available at the time of Bid.

- 1. American Society for Testing and Materials (ASTM):

- a. ASTM B221, "Standard Specifications for Aluminum and Aluminum-Alloy Extrusions."
 - b. ASTM B209, "Standard Specification for Aluminum and Aluminum Alloy Sheet and Plate."
 - c. ASTM E1399 "Cyclic Movement and Measuring of Minimum/Maximum Joint Widths of Architectural Joint Systems."
 - d. ANSI/U.L. No. 263, UL2079, ULCS115, EN1366-4 Fire Rated Testing for full rated period. Underwriter's Laboratories shall classify adjacent substrate assemblies.
 - e. ASTM E1612, Standard Specification for Preformed Architectural Compression Seals for Buildings and Parking Structures.
2. American National Standards Institute (ANSI):
- a. ANSI A137.1/A326.3 (2018), "Method for Measuring Dynamic Coefficient of Friction on Hard Flooring Materials"

1.04 SUMMARY

- A. Scope of Work
 - 1. Interior expansion control systems
 - 2. Exterior expansion control systems
 - 3. Expansion Joint accessories including provisions for fire rated assemblies, moisture barriers, waterproofing, acoustic and thermal measures.

1.05 DEFINITIONS

- A. Nominal Joint Width: The width of the expansion joint opening as specified in the project documents, at which the expansion joint will be constructed and the cover will be installed
- B. Movement Capability: The amount of movement in a single direction (open or close), given as a percentage of the nominal joint width, that the joint cover is required to accommodate without damage to its components

1.06 SUBMITTALS

In accordance with the procedures and requirements set forth in Section 01 33 00 – Submittal Procedures, submit the following:

- A. Submittals shall contain the following as required for each specified system
 - 1. Shop Drawings showing complete fabrication details for all joint covers, including required anchorage to surrounding construction, recesses, blocking, backing, and connections between similar and dissimilar joint cover assemblies
 - 2. Manufacturer's product data including product details, installation instructions, maintenance and cleaning instructions, Safety Data Sheets.
 - 3. Certificates, copies of independent test reports, or research reports showing compliance with fire resistance rating and other specified performance requirements
 - 4. Color chips representing manufacturer's full range of available colors and patterns
 - 5. Three (3) 6" (152mm) samples of the specified systems

1.07 QUALITY ASSURANCE

- A. Manufacturer: Obtain joint cover assemblies through one source from a single manufacturer.
- B. Manufacturer shall have a minimum of ten (10) years of experience in the fabrication of joint cover assemblies.
- C. Installer: All products listed in this section shall be installed by a single installer with demonstrated experience in installing products of the same type and scope as specified. Installer shall be insured and licensed as required by agencies within the project's jurisdiction.

1.08 Coordination

- A. Submittals shall be completed and approved prior to fabrication and shipment of material to the jobsite.
- B. Schedule for the work of this section shall be planned to allow sufficient time for manufacturer's production and delivery scheduling.
- C. Coordinate installation of products and systems with interfacing and adjoining construction to provide a successful and proper installation.
- D. Coordinate installation of exterior joint assemblies to ensure that transitions are watertight.
- E. Verify product types, quantities, dimensions, and attachment methods shown on shop drawings against field conditions prior to releasing materials for fabrication by the manufacturer.
- F. Communicate necessary changes on the manufacturer's shop drawings

1.09 DELIVERY, STORAGE AND HANDLING

- A. Provide temporary protective cover on anodized aluminum, stainless steel, and bronze finished surfaces.
- B. Deliver joint covers to jobsite in clean, unopened crates of sufficient size and strength to protect materials during transit.
- C. Store components in original containers in a clean, dry location.

1.10 Warranty

- A. Submit manufacturer's warranty that materials furnished will perform as specified for a period of not less than one (5) years when installed in accordance with manufacturer's recommendations.

PART 2 – PRODUCTS

2.01 Manufacturers

- A. Furnish and install as noted in specifications and as indicated on drawings as manufactured by Balco, Inc., Construction Specialties, Inpro, inpro.com, The Garland Co., SIKA, or equal.

2.02 Expansion and Seismic Joint Systems

- A.** General: Provide architectural joint systems of design, basic profile, materials, and operation indicated. Provide units with the capability to accommodate variations in adjacent surfaces.
- B.** Design architectural joint systems for the following size and movement characteristics:
 - 1. Nominal Joint Width: As indicated on the Drawings.
 - 2. Maximum Joint Width: + 25% nominal joint width.
 - 3. Minimum Joint Width: - 25% nominal joint width.
- C.** Interior Expansion and Seismic Joint Systems
 - 1. Inpro, 808 series standard cover plate system or equal.
 - 2. Inpro, 1200 series wall expansion joint system.
- D.** Roof Expansion and Seismic Joint Systems
 - 1. Inpro, 691 aluminum, exterior expansion joint or equal.
- E.** Roof to Wall Expansion Joint System
 - 1. Inpro, 691 Series roof to wall expansion joint system.
- F.** Exterior Wall Expansion Joint System
 - 1. Inpro, 300E series wall expansion joint system. For parapet wall.
 - 2. Inpro, 1200 series wall expansion joint system. Exposed exterior wall.

2.03 Materials

- A.** Metals
 - 1. Aluminum extrusions: ASTM B221, alloys 6063-T5, 6005A-T6, 6061-T6
 - 2. Aluminum plate and sheet: ASTM B209, alloys 6061-T6, 5052-H32
 - 3. Steel: ASTM A36 Plate
 - 4. Stainless steel: ASTM A666, type 304
- B.** Silicone: ASTM D 2000 4GE 709 M
- C.** Santoprene
 - 1. 75 shore A durometer, 15 sec, ISO 868
 - 2. Face seals to be installed in exterior conditions shall be UV resistant.
- D.** Abrasive: Two (2) part Epoxy combined with aluminum oxide grit
- E.** Water Barrier: Flexible EPDM, Class I, ASTM D4637, 45 mils thick (minimum)
- F.** Standard fasteners required for assembly and installation shall be included
- G.** All surfaces in contact with masonry or concrete shall be protected by a factory-applied coating.

2.04 Finishes

- A.** Aluminum
 - 1. Floors:
 - a. Mill finish plate, AA-M30 (Directional textured finish, unspecified)
 - 2. Interior Walls and Ceilings:
 - a. Clear anodized, Class II, AA-M12 C22 A31
 - 3. Exterior Walls and Roofs:
 - a. High-Performance Organic Coating (Kynar or Trinar)
 - 4. All surfaces in contact with masonry or concrete shall be protected by a factory-applied coating
 - 5. Colors to match roof metal colors.
- B.** Elastomeric Seals:
 - 1. Color as selected and approved from manufacturer's samples

- C. Abrasive:
 - 1. Black (Standard)

PART 3 – EXECUTION

3.01 QUALITY CONTROL

- A. Coordinate work with details shown on approved shop drawings prepared by other trades.
- B. Verify conditions in the field.
- C. Schedule work to follow closely the installation of other trades.
- D. Apply sealants and related items in temperatures and dry conditions recommended by the manufacturers.
- E. Do not paint sealant, unless recommended by sealant and paint manufacturer.

3.02 Examination

- A. Installer shall examine conditions under which work is to be performed and shall notify the contractor in writing of unsatisfactory conditions. Installer shall not proceed until all unsatisfactory conditions have been corrected in a manner acceptable to the installer.

3.03 Preparation

- A. Prepare surfaces using methods recommended by the manufacturer for achieving the required results within project conditions.
- B. Concrete repair material must be applied and allowed to cure in accordance to the manufacturer of the product recommendations and instructions.
- C. Clean dirt, debris, and other contaminants from both the joint opening
- D. Mask areas adjacent to the joint as required to achieve neat, clean joint lines. Remove masking prior to the curing process.

3.04 Installation

- A. Install expansion and seismic joint covers in accordance with the manufacturer's instructions.
- B. Centering bars shall be fully engaged with base members.
- C. Locate fasteners at interval recommended by manufacturer as shown on shop drawings.
- D. Floor systems: Where shimming is required, provide continuous support for base members to prevent vertical deflection when in service.
- E. Fire-rated joint covers: Install fire rated covers in accordance with requirements of applicable fire rated product. Install fire barriers and flame sealant as shown on shop drawings and in accordance with installation instructions.
- F. Water barrier: Install water barriers at exterior joints and where called for on shop drawings. Provide drainage fittings where called for on shop drawings.

3.05 Protection and Cleaning

- A.** Protect the installation from damage by work of other sections.
- B.** Where required, remove and store cover plates and install temporary protection over joints and re-install cover plates prior to substantial completion of work.
- C.** Do not remove protective coverings until finish work in adjacent areas is complete.
- D.** Prior to project closeout, clean exposed surfaces with a suitable cleaner as recommended by manufacturer.

END OF SECTION

SECTION 08 11 13
STEEL DOORS AND FRAMES

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. Furnish labor, material, equipment and appliances required for complete execution of Work shown on Drawings and specified herein.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 04 20 00 – Unit Masonry
- B. Section 08 71 00 – Finish Hardware
- C. Section 08 80 00 – Glass and Glazing
- D. Section 09 90 00 – Painting

1.03 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

- A. Without limiting the generality of these specifications, the work shall conform to the applicable requirements of the following documents:
 - 1. ANSI/DHI A115 – Series Specifications for Steel Door and Frame Preparation for Hardware
 - 2. ANSI/SDI 100 – Recommended Specifications: Standard Steel Doors and Frames
 - 3. ASTM A153 – Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
 - 4. ASTM A366/A 366M – Standard Specification for Steel, Sheet, Carbon, Cold-Rolled Commercial Quality
 - 5. ASTM A525 – Standard Specification for General Requirements for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process
 - 6. ASTM E152 – Standard Methods of Fire Tests of Door Assemblies
 - 7. NFPA 80 – Standard for Fire Doors and Windows

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1.04 SUBMITTALS

- A. In accordance with the procedures and requirements set forth in Section 01 33 00 – Submittal Procedures, submit the following:
 - 1. Manufacturer's product data.
 - 2. Complete layout and installation drawings and schedules with clearly marked dimensions. Indicate details of construction, profiles, gauges, reinforcing and location of doors and frames.
 - 3. Certify that shop applied primer is compatible with finish coats specified in Section 09 90 00 - Painting.
 - 4. Florida Product Approval for windloads shown on Drawings.

1.05 QUALITY ASSURANCE

- A. Comply with ANSI/SDI 100.
- B. Locations where fire-rated door and frame assemblies are required, provide assemblies which comply with NFPA 80 and have been tested and labeled in accordance with ASTM E152 by agency acceptable to governing authorities.
- C. Provide certificate or label for fire-rated doors which exceed sizes tested from a independent testing and inspection agency. Certificate or label shall indicate that door and frame assembly conforms to the requirements of the design.
- D. Provide stairwell doors which have temperature rise rating of 450 degrees F maximum in 30 minutes of fire exposure.

1.06 DELIVERY, STORAGE AND HANDLING

- A. Deliver products boxed or crated suitable for storage.
- B. Store products under cover, raised above ground level, and stacked to prevent warping and damage.
- C. Replace items damaged during delivery, storage, or handling.

PART 2 – PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Subject to compliance with the Specifications, provide products from one of the following manufacturers or equal:

1. Curries Company, Mason City, Iowa
2. Amweld Building Products, Inc.
3. Steelcraft, Cincinnati, Ohio

2.02 MATERIALS

- A. Steel Sheets: Commercial quality hot or cold rolled. Galvanize sheet steel in accordance with ASTM A525, commercial quality, A60 zinc coating, mill phosphatized.
- B. Anchorages: Galvanized steel, minimum 18 gauge.
- C. Fasteners and Inserts: Galvanized units standard with manufacturer.
- D. Primer: Rust-inhibitive coating, suitable to receive finish coatings specified in Section 09 90 00 - Painting.

2.03 FABRICATION, GENERAL

- A. Shop-fabricate assemblies to greatest extent possible.
- B. Fabricate exterior and interior doors, frames and louvers from hot-dip galvanized steel.
- C. Where exposed screws and fasteners are used, provide countersunk, flat Phillips-head fasteners.
- D. Fabricate exterior, vestibule and other doors indicated to be insulated in the schedule with foam in place insulation. Door and frame assembly shall have a maximum calculated core U-Value of 0.10 BTU per hour per square foot per degree F in accordance with ASTM C518.
- E. Comply with ANSI/DHI A115 series specifications for door and frame hardware preparation. Prepare door and frame using final hardware schedule and templates from hardware supplier.
- F. Shop Painting
 1. Clean surfaces thoroughly before beginning painting operations, removing rust, scale, oil, grease and other contaminants.
 2. Apply primer evenly to provide full protection of all exposed surfaces.

2.04 STEEL (HOLLOW METAL) DOORS

- A. Provide doors of size and style indicated.

1. Exterior Doors: SDI-100, Grade III, extra heavy-duty, Model 4, seamless, 16 gauge for doors less than four feet wide and 14 gauge for doors greater than four feet wide.
 2. Interior Doors: SDI 100, Grade II, heavy-duty, Model 3, seamless, 18 gauge for doors less than four feet wide and 16 gauge for doors greater than four feet wide.
- B. Top and bottom closures on all doors and a weather tight cap on all exterior doors.
- C. Glass lite kits shall be provided to accommodate glass shown or specified. Frame material shall be 20 gauge (minimum) cold rolled steel with mitered corners.

2.05 STEEL (HOLLOW METAL) DOOR FRAMES

- A. Fabricate door frames with mitered and welded corners.
- B. Provide concealed fastenings, unless otherwise indicated.
- C. Provide galvanized plaster guards or mortar boxes at back of finish hardware cutouts.
- D. Drill frames to receive three silencers on strike jamb of side swinging doors, and two silencers on heads of double doors, unless doors are to receive weatherstripping.
- E. Provide a minimum of three jamb anchors per jamb for doors 96 inches or less in height and one additional anchor for each additional 24 inches of height.

PART 3 – EXECUTION

3.01 INSTALLATION

- A. All doors and frames specified herein shall be neatly installed in designated locations indicated on Drawings.
- B. Install frames in accordance with SDI-105 and as herein specified.
- C. Install doors in accordance with SDI-100 and as herein specified.
- D. Install fire-rated doors and frames in accordance with NFPA 80.
- E. Coordinate cutouts and reinforcements with door hardware to be provided.
- F. Coordinate raceways through doors with security wiring.

3.02 PROTECTION AND CLEANING

- A. Provide protection against stains, dirt or damage to the finished installation. Adjust doors for proper operation.
- B. Immediately after erection and prior to finish painting, remove rusted or damaged prime coat and apply touch-up primer compatible with original primer and final coats.

END OF SECTION

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SECTION 08 63 00
TRANSLUCENT SKYLIGHT ASSEMBLIES

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. Section Includes: Translucent skylight assemblies, including:
1. Removable, insulated translucent skylight panel system including aluminum framing, battens, closures, trim and flashings.

1.02 REFERENCES

- A. General: Standards listed by reference, including revisions by issuing authority, form a part of this specification section to extent indicated. Standards listed are identified by issuing authority, authority abbreviation, designation number, title or other designation established by issuing authority. Standards subsequently referenced herein are referred to by issuing authority abbreviation and standard designation.
- B. American Society for Testing and Materials (ASTM):
1. ASTM C509 – Standard Specification for Elastomeric Cellular Preformed Gasket and Sealing Material
 2. ASTM C864 – Dense Elastomeric Compression Seal Gaskets, Setting Blocks and Spacers
 3. ASTM E283 – Test Method for Rate of Air Leakage Through Exterior Windows, Curtain Walls and Doors
 4. ASTM E330 – Structural Performance of Exterior Windows, Curtainwall, and Doors by Uniformed Static Air Pressure Difference
 5. ASTM E331 – Test Method for Water Penetration of Exterior Windows, Curtain Walls and Door by Uniform Static Air Pressure Difference
- C. Aluminum Association (AA)
1. AA Specifications for Aluminum Structures.
- D. American Architectural Manufacturers Association (AAMA)
1. AAMA 501 – Methods for Test for Metal Curtain Walls.

2. AAMA 603-98 – Voluntary Specification, Performance Requirements and Test Procedures for High Performance Organic Coatings on Aluminum Extrusions and Panels.
3. AAM 2604-98 – Voluntary Specification for High Performance Organic Coatings on Architectural Extrusions and Panels.
4. AAMA 611-98 – Specification for Anodized Architectural Aluminum.

1.03 SYSTEM DESCRIPTION

- A. Performance Requirements: Provide translucent skylight assembly system which has been manufactured, fabricated and installed to withstand from dead, live, and all other loads required by the current Building Code of the State or Commonwealth in which the project is located.
- B. and performance criteria stated by manufacturer without defects, damage or failure.
- C. Removable Structural Skylight Requirements
 1. Structural framing to be designed to meet the requirements of the current Building Code of the State of North Carolina. System design and calculations must also be furnished in accordance with the Aluminum Association "Specifications for Aluminum Structures" and sealed by a Professional Engineer registered in the State or Commonwealth in which the project is located.
 2. Framing system shall be designed to be removable without disassembly of the skylight system.
 3. Superstructure shall be pre-fabricated of extruded aluminum alloy 6005-T5 or 6061-T6 tubular box beams. Ferrous metals shall not be allowed. All parts shall be pre-assembled at the factory and knocked down for shipment to jobsite.
 4. Panels shall be as specified herein.
 5. Finish on exposed structure shall be as specified herein.

1.04 SUBMITTALS

- A. General: Submit listed submittals in accordance with Conditions of the Contract and Section 01 33 00 – Submittal Procedures.
- B. Product Data: Submit product data. Submit test results showing compliance with requirements specified under Performance Requirements paragraph herein. Include both published data and specific data prepared for this project.

- C. Shop Drawings: Submit shop drawings showing layout, profiles, and product components, including anchorage, accessories, finish colors, patterns and textures.
1. Submit shop drawings for approval prior to fabrication. Include detailed plans, elevations, and details of framing members, translucent glazing materials, sealants, fasteners, anchors, and thicknesses and types of formed flashing and closures and relationship with adjacent materials. Indicate maximum horizontal and vertical forces at rafters. Show method of removal in drawings. Provide additional framing and hardware as required to ensure removal of skylight is possible from the roof.
 2. Submit shop drawings and design calculations, showing design loads and stresses on translucent wall system. Calculations shall be signed and sealed by a Professional Engineer registered in the State of North Carolina.
- D. Samples – Submit selection and verification samples for finishes, colors and textures.
1. Aluminum Finish: Submit color charts or range samples for initial color selection. Submit finished sample of color selected for use on metal coupons. Translucent Glazing Materials: Submit a verification sample, 12" (305 mm) square of the specified translucent glazing material specified.
- E. Quality Assurance Submittals: Submit the following:
1. Design Data: Complete structural calculations.
 2. Test Reports: Manufacturer shall submit certified test reports, independently verified, for the skylight system. Reports shall verify that the materials will meet or exceed all performance requirements of this specification. Previously completed test reports will be acceptable if for the current manufacturer of the translucent panel system manufacturer and indicative of the product used proposed for use on this project. Required Test Reports are:
 - a. Flame Spread and Smoke Developed (ASTM E-84 by UL 790)
 - b. Burn Extent (ASTM D-635)
 - c. Color Difference (ASTM D-2244)
 - d. Erosion Resistance (ASTM D-4060)
 - e. Impact Strength (UL 972)
 - f. Tensile Bond Strength (ASTM C-297 after aging by ASTM D-1037)
 - g. Shear Bond Strength (ASTM D-1002 after five (5) separate conditions)

- h. Beam Bending Strength (ASTM E-72)
- i. Insulation "U" Factor (NFRC-100)
- j. Class A Burning Brand (ASTM E-108)

F. Closeout Submittals: Submit the following:

- 1. Operation and Maintenance Data: Operation and maintenance data for installed products. Include methods for maintaining installed products, and precautions against cleaning materials and methods detrimental to finishes and performance. Include documents showing removal, storage, and reinstallation requirements and instructions.
- 2. Warranty: Warranty documents specified herein.

1.05 QUALITY ASSURANCE

A. Qualifications

- 1. Installer Qualifications: Installer experienced in performing work of this Section who has specialized in installation of work similar to that required for this project.
 - a. Installer: Manufacturer of translucent skylight assembly system, or his authorized installer, shall install system.
- 2. Manufacturer Qualifications: Manufacturer capable of providing field service representation during construction and prequalifying acceptable installer.
- 3. Manufacturer: Systems shall be manufactured by a firm with a minimum of ten years of experience in the fabrication and installation of translucent skylight systems.

B. Source Quality: Obtain translucent skylight assembly materials from a single manufacturer.

1.06 DELIVERY, STORAGE & HANDLING

- A. Deliver materials in manufacturer's original, unopened, undamaged containers with identification labels intact. Sequence deliveries to avoid delays but minimize onsite storage.
- B. Store materials protected from exposure to harmful weather conditions and at temperature and humidity conditions recommended by manufacturer.
 - 1. Store and handle in strict compliance with manufacturer's instructions and recommendations, including storing panels on the long edge several inches above

ground, blocked and under cover to prevent warping. Protect from damage from sunlight, weather, excessive temperatures and construction operations.

1.07 PROJECT CONDITIONS

- A. Field Measurements: Verify actual measurements/openings by field measurements before fabrication; show recorded measurements on shop drawings. Coordinate field measurements and fabrication schedule with construction progress to avoid construction delays.
 - 1. Measurements: When practical, take accurate field measurements before preparation of shop drawings and fabrication. Do not delay job progress; work from "guaranteed dimensions" and allow for field trimming of perimeter flashing if taking field measurements before fabrication is not possible.

1.08 WARRANTY

- A. Manufacturer's Warranty: Submit, for Owner's acceptance, manufacturer's standard warranty document executed by authorized company official.
 - 1. System Warranty: Provide written warranty signed by manufacturer, agreeing to repair or replace work which exhibits defects in materials or workmanship. Defects are defined to include leakage of water, abnormal aging or deterioration, or failure to perform as required.
 - a. Warranty Period: 5 years from date of substantial completion.
 - 2. Translucent Glazing Material Warranty: Provide written warranty signed by manufacturer, agreeing to repair or replace glazing materials which exhibit defects in materials or workmanship. Defects are defined to include fiberbloom, or more than 8.0 Delta E units of discoloration.
 - a. Warranty Period: 10 years from date of manufacture.
 - 3. The face sheet manufacturer shall warrant the exterior face sheet against reinforcing fiber exposure, due to weathering, for a period of twenty (20) years. Warranty from any other party in this regard is not acceptable.

PART 2 – PRODUCTS

2.01 TRANSLUCENT WALL ASSEMBLIES

- A. Manufacturers:
 - 1. Kalwall Corporation

2. Structures Unlimited, Inc.
3. Major Industries (Kingspan)

2.02 MANUFACTURED UNITS

A. Panel Construction:

1. Provide double-faced, insulated, translucent fiberglass sandwich panels complying with the following:
 - a. Thickness: 2 3/4" (70 mm)
 - b. Grid Size: 12" x 24" (305 x 61 mm) (Designer to verify)
 - c. Grid Pattern: Rectangular (Designer to verify)
 - d. Light Transmission: 23 % max. (Designer to verify)
 - e. Exterior Sheet: 0.070" thick; White as selected from manufacturer's standard colors. To be uniform in strength, impenetrable by hand held pencil and repel an impact equal to 70 ft. lbs., without fracture or tear, when impacted by a 3 1/4" diameter, 5 lb. Free falling ball per UL 972
 - f. Interior Sheet: 0.045" thick UL listed; White as selected from manufacturer's standard colors
 - g. Solar Heat Gain Coefficient: 0.30 (Designer to verify)
 - h. U-Factor: 0.53 (Designer to verify)
2. Fabricate panels as a true sandwich panel of flat fiberglass sheet bonded to a grid core of mechanically interlocking aluminum I-beams, laminated under a controlled process of heat and pressure.
 - a. Adhesive bonding line shall be straight, cover the entire width of the I-beam and have neat, sharp edge.
 - b. White spots at intersections of muntins and mullions shall not exceed 4 for each 50 sq ft (4.65 m2) of panel, nor be more than 3/64" (1.19 mm) in width.
3. Panel Performance:
 - a. Deflection: Standard panels shall deflect no more than 1.9" at 30 PSF in 10'-0" span without a supporting frame by ASTM E-72.

- b. Support Strength: Removable skylight system shall meet the fall through requirements of OSHA 1910.23 as demonstrated by testing in accordance with ASTM E-661, hereby not requiring supplemental screens or railings.
- 4. Skylight system shall pass Class A Roof Burning Brand Test by ASTM E-108.

B. Components and Accessories

- 1. Structure: Extruded aluminum alloy 6063-T5 or 6063-T6 box beams. System shall be of a Rigid Frame design.
- 2. Grid Core: Aluminum I-beams, minimum 7/16" (11.1 mm) width, fabricated of extruded aluminum alloy 6063-T6 with provision for mechanical interlocking of muntin/mullion and perimeter which prevents high and low intersections which do not allow full bonding surface to contact with face material.
- 3. Translucent Facing: Fiberglass panels manufactured with uniform color, free of ridges, wrinkles, clusters of air bubbles and pinholes, with the following characteristics:
 - a. Flammability for Interior Face Sheet: Flamespread no greater than 20 and smoke developed no greater than 200 per ASTM E84. Burn extent no greater than 1" (25.4 mm) per ASTM D635.
 - b. The exterior face shall have a permanent glass erosion barrier embedded beneath the surface to provide maximum long-term resistance to reinforcing fiber exposure. Sacrificial surface films or coatings are not acceptable erosion barrier. Exterior face surface loss shall not exceed .7 mils and 40 mgs when tested in accordance with ASTM D4060-90 employing CS17 abrasive wheels at a head load of 500 grams for 1000 cycles.
 - c. Weatherability of Exterior Face Sheet: Not more than 3.0 units of color difference Delta E per ASTM D2244 after 5 years outdoor weathering in South Florida at 5 degrees facing south per ASTM D2244. Fabricate from colorfast resin.
 - d. Strength of Exterior Face Sheet: Uniform in strength and repel an impact equal to 60 ft-lb per Free Falling Ball test per UL 972.
- 4. Battens and Perimeter Closure Systems: Extruded aluminum alloy 6063-T6 or 6063-T5, for screw clamp-tight closure system. Fasten to panels with Type 304 self-tapping stainless steel screws. Receiving channels for screws shall be continuous, with length of each member extruded as part of the member.
 - a. Thermally broken panel and clamping system.

5. Flexible Sealing Tape: Manufacturer's standard sealing tape, pre-applied to closure system at factory under controlled conditions.
6. Laminate Adhesive
 - a. Heat and pressure resin type adhesive engineered for structural sandwich panel use, with minimum 25-years field use. Adhesive shall pass testing requirements specified by the International Code Council "Acceptance Criteria for Sandwich Panel Adhesives".
 - b. Minimum tensile strength of 750 psi when the panel assembly is tested by ASTM C-297 after two (2) exposures to six (6) cycles each of the aging conditions prescribed by ASTM D-1037.
 - c. Minimum shear strength of the panel adhesive by ASTM D-1002 after exposure to four (4) separate conditions:
 - 1) 50% Relative Humidity at 68°F: 540 psi
 - 2) 182°F: 100 psi
 - 3) Accelerated Aging by ASTM D-1037 at Room Temperature: 800 psi
 - 4) Accelerated Aging by ASTM D-1037 at 182°F: 250 psi

2.03 FINISHES (FACTORY)

- A. Aluminum Finishes: Provide the following finish for interior and exterior exposed aluminum surfaces:
 1. All exposed aluminum to have architectural corrosion resistant finish complying with AAMA 2604. Color to be selected by Owner from manufacturer's standards.

PART 3 – EXECUTION

3.01 MANUFACTURER'S INSTRUCTIONS

- A. Compliance: Comply with manufacturer's product data, including product technical bulletins, and manufacturer's shop drawings for installation.

3.02 EXAMINATION

- A. Site Verification of Conditions: Verify substrate conditions which have been previously installed under other Sections are acceptable for product installation in accordance with manufacturer's instructions. Take field dimensions and examine conditions of substrates, supports, and other conditions under which this work is to be performed and notify

Contractor, in writing, of circumstances detrimental to the proper completion of the work. Do not proceed with work until unsatisfactory conditions are corrected.

3.03 INSTALLATION

A. Translucent Skylight Assembly Installation

1. Match profiles, sizes and spacings indicated on approved shop drawings. Ensure that weep and condensation control system operates properly.
2. Coordinate installation with adjacent work such as roofing, sheet metal and other work to ensure creation of a complete weatherproof assembly. Anchor work securely to supporting structure but allow for differential and thermal movement.
3. Isolate between aluminum and dissimilar metals with a protective coating or plastic strip to prevent electrolytic corrosion.

3.04 ADJUSTING

- #### **A. Adjusting:** During installation, remove labels, part number markings, sealant smears, handprints and construction dirt from all components. Touch up damaged coatings and finishes and repair minor damage to eliminate all evidence of repair. Remove and replace work which cannot be satisfactorily repaired.

3.05 CLEANING

- #### **A. Cleaning:** Remove temporary coverings and protection of adjacent work areas. Repair or replace damaged installed products. Clean installed products in accordance with manufacturer's instructions prior to owner's acceptance. Remove construction debris from project site and legally dispose of debris.
1. Clean exposed surfaces including metal and glass using non-abrasive materials and methods recommended by manufacturer of material or product being cleaned. Remove and replace work that cannot be successfully cleaned.
 2. Reclean as necessary to prevent damage.

3.06 PROTECTION

- #### **A. Protection:** Protect installed product and finish surfaces from damage during construction.
1. Protect completed work from damage and deterioration and inspect immediately before final acceptance of project.

END OF SECTION

SECTION 08 71 00
FINISH HARDWARE

PART 1 – GENERAL

1.1 THE REQUIREMENT

- A. Furnish all labor, materials, equipment and appliances required for the complete execution of Work as shown on Drawings and specified herein.

1.2 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 08 11 13 – Steel Doors and Frames

1.3 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

- A. Without limiting the generality of these specifications, the Work shall conform to the applicable requirements of the following documents:
 - 1. ANSI/BHMA 156

1.4 SUBMITTALS

- A. In accordance with the procedures and requirements set forth in Section 01 33 00 – Submittal Procedures, submit the following:
 - 1. Manufacturers data for each item of hardware. Include installation and maintenance instructions.
 - 2. Furnish templates to fabricators of other work which is to receive hardware.
 - 3. Hardware schedule organized into "hardware sets," indicating complete designation of every item required for each door or opening. Furnish initial draft of schedule at the earliest possible date, in order to facilitate the fabrication of other work (such as hollow metal frames) which may be critical in the project construction schedule. Furnish final draft of schedule after samples, manufacturer's data sheets, coordination with shop drawings for other work, delivery schedules and similar information has been completed and accepted.
 - 4. Prepare a keying schedule in consultation with the Owner.

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1.5 QUALITY ASSURANCE

- A. Provide materials, assemblies, equipment and services from a single source for each category except that locksets, latchsets and cylinders must originate from the same manufacturer.
- B. Replace any item of finish hardware which cannot be installed or will not function properly.
- C. Provide hardware complying with NFPA 80 and UL labeled for fire rated openings.
- D. Furnish templates or information to door and frame manufacturer. Coordinate between the manufacturers where two or more articles of hardware are to be mounted on the same door. Verify all dimensions, new and existing.
- E. Coordinate hardware with other work. Furnish hardware items of proper design for use on doors and frames of the thicknesses, profile, swing, security and similar requirements indicated, as necessary for proper installation and function.

1.6 DELIVERY, STORAGE AND HANDLING

- A. Handle, store, distribute, protect and install hardware in accordance with manufacturer's instructions or recommendations. Deliver packaged materials in original containers with seals unbroken and labels intact.
- B. Properly mark or label, so each piece of hardware is readily identifiable with the approved hardware schedule. Tag each change key or otherwise identifying the door of which its cylinder is intended. Where double cylinder functions are used or where it is not obvious which is the key side of a door, appropriate instructions shall be included with the lock and hardware schedule.
- C. Provide secure storage area for hardware.

PART 2 – PRODUCTS

2.1 MATERIALS AND FABRICATION

- A. Hand of Door
 - 1. Drawings show swing or hand of each door leaf (left, right, reverse bevel, etc.).
Furnish hardware for proper installation and operation of door.
- B. Manufacturer's Name Plate

1. Do not use manufacturer's products which have name or trade name displayed in a visible location (omit removable nameplates), except in conjunction with required UL labels.

C. Base Metals

1. Produce hardware units of the basic metal and forming method indicated, using manufacturer's non-corrosive metal alloy, composition, temper and hardness but in no case of lesser quality material than specified.

D. Fasteners

1. Manufacture hardware to conform to published templates, generally prepared for machine screw installation. Do not provide hardware which has been prepared for self-tapping sheet metal screws, except as specifically indicated.
2. Furnish stainless steel fasteners for installation with each hardware item. Exposed finish (under any condition) to match hardware finish or surfaces of adjacent work. Match the finish of adjacent work as closely as possible, including surfaces to receive painted finish.
3. Provide fasteners which are compatible with unit fastened and the substrate, and which will not cause corrosion or deterioration of finish hardware, base material or fastener.

E. Tools for Maintenance

1. Furnish a complete set of specialized tools as needed for Owner's continued adjustment, maintenance, removal and replacement of builder's hardware.

F. Hardware Finishes

1. Stainless steel, US32D unless otherwise noted.
2. Closers shall have a USP finish unless otherwise noted.

G. Field Checks

1. Make periodic checks during installation of finish hardware to ascertain the correctness of the installation. After completion of the work, certify in writing, that all items of finish hardware have been installed, adjusted and are functioning in accordance with Specification requirements.

2.2 DESCRIPTION OF PRODUCTS

A. Hinges

1. Stainless steel full mortise concealed oil impregnated ball bearing type, five knuckle with non-rising pins for interior doors, and non-removable and non-rising pins for exterior doors. Tips shall be flat.
2. Sizes and weights of hinges:
 - a. Doors up to 36 inches – 4-1/2 inches regular weight.
 - b. Doors 36 inches to 40 inches – 5 inches regular weight.
 - c. Doors 40 inches to 48 inches – 5 inches heavy weight.
 - d. Fire Rated Doors up to 36 inches – 5 inches regular weight.
3. Provide three hinges per door leaf up to and including 90 inches and one additional hinge for each 30 inches of additional height.
4. Acceptable Manufacturers: Stanley Hardware, Hager Hardware

B. Locksets and Latchsets

1. Stainless steel, heavy-duty mortise type conforming to ANSI A156.13 Series 1000, Grade 1.
2. Wrought steel box strikes.
3. Stainless steel deadbolt with 1" throw approval.
4. 2 3/4 inch back set, 3/4 inch throw, two-piece anti-friction latchbolt.
5. Non-ferrous critical internal parts.
6. Cylinders shall be manufactured to conform to grand master key program.
7. Trim Design: LWM with wrought escutcheon by Corbin\Russwin or equal lever with return. Provide knurling on all levers leading into hazardous rooms and electrical rooms.
8. Acceptable Manufacturers: Yale, Corbin\Russwin, Schlage

C. Keys and Keying

1. Provide construction keyed, removable core master key system as directed by the Owner.

2. Furnish ten core removal keys and a quantity of master keys as directed by the Owner, not to exceed ten each per group. Furnish a minimum of 15 change keys per cylinder.
3. Furnish cylinders to match Owner's existing master key system.
4. Provide a key schedule showing all key numbers and spaces to which each permits entry. The schedule and key cabinet, along with key gathering envelopes containing keys for each lock endorsed with lock number and space designation, shall be turned over to the Owner. Install keys with proper tags in the key cabinet. Establish a construction master key, and apply to locks and cylinders, except for closets, within major spaces. Locks for closets shall be shipped unlocked and the keys delivered to the Owner with the balance of the keys.
5. Acceptable Manufacturers: Yale, Corbin\Russwin, Schlage

D. Panic Hardware

1. Heavy duty push bar exit device, U.L. labeled, with corrosive resistant construction.
2. ANSI A156.3, Grade 1.
3. Exterior trim to closely match locksets.
4. Single/active doors: mortise type.
5. Double doors: concealed vertical rod.
6. ANSI Function 08.
7. Acceptable manufacturer's: Von-Duprin, Adams Rite Manufacturing Company, Corbin/Russwin

E. Closers

1. Cast iron case with seamless one-piece forged steel spring tub.
2. Heavy duty forged steel arm.
3. Non-sized fully adjustable from size 1-6.
4. Backcheck intensity and location valves.
5. Delayed action closing.
6. Full metal cover.

7. Mechanical hold open device, except at fire rated doors.
8. ANSI 156.4, Grade 1.
9. Conforms to ADA 5 lbf. maximum door opening force requirement for non-fire rated interior doors.
10. Provide mounting brackets, and fasteners required for proper attachment.
11. Provide closers at fire rated doors.
12. Acceptable manufacturers: Corbin/Russwin, LCN, Norton

F. Overhead Door Holder

1. Heavy duty bronze, surface mounted with positive grip holder.
2. Track: extruded bronze.
3. Degree of opening: 85 – 110.
4. Finish: Satin Chrome Plated.
5. Acceptable manufacturers: Corbin/Russwin, Glynn-Johnson, Norton.

G. Door Stops and Bumpers

1. Finish: Satin chrome plated.
2. Floor mounted door stops.
 - a. Acceptable manufacturers and products: H.B. Ives 444, Hager Hardware Model 267F, and Glynn-Johnson Model FB36.
3. Wall bumpers
 - a. Acceptable manufacturers and products: H.B. Ives Model 407, Hager Hardware Model 234W, and Glynn-Johnson Model 60C.

H. Flush Bolts

1. U.L. listed.
2. Forged brass construction, 1/2" diameter flattened bolt tip, 12" long rod for doors 7'-4" tall or less. Provide longer rod for taller doors to keep lever about six foot above floor.

3. Provide flush bolts top and bottom of door.
4. Fit standard ANSI door preparation.
5. Acceptable manufacturers: Glynn-Johnson, Hager Hardware, and H.B. Ives.

I. Push Plates and Pulls

1. Push and pull plates: 4"x16"x0.050" stainless steel.
2. Pulls: through bolted, 1" diameter, 2 1/2" projection, 12" centers, stainless steel.
3. Acceptable manufacturers: H.B. Ives, Hager Hardware, and Builders Brass Works.

J. Coordinator

1. U.L. labeled and tested for 100,000 cycles.
2. Stop mounted, provide filler strips to fully cover stop.
3. Adjustable holding power and override feature.
4. Acceptable manufacturers: Glynn-Johnson, Hager Hardware, and H.B. Ives.

K. Kickplates

1. Stainless steel, 0.050" thick, beveled 3 sides, 8" high, width 2 inches less than door width.
2. Acceptable manufacturers: H.B. Ives, Hager Hardware, and Builders Brass Works.

L. Silencers

1. Rubber silencers: 3 for each single door and 2 for each double doors.
2. Rubber Silencers at fiberglass door locations shall be self-adhesive type.
3. Acceptable manufacturers and products: (Hollow metal doors and frames): Glynn-Johnson Models 64 or 65, Hager Hardware Models 308D or 307D, H.B. Ives Models 20 or 21.
4. Acceptable manufacturers and products: (Fiberglass doors and frames): H. B. Ives Model SR66 or equal.

M. Thresholds

1. Extruded aluminum saddle type and fiberglass for opening with fiberglass door and frames. Provide with stainless steel fasteners. Six inches wide or as shown on drawings.
2. Acceptable manufacturers: Pemko, National Guard Products, Incorporated, and Zero International. Fiberglass threshold by fiberglass door and frame manufacturer.

N. Door Bottom Seal

1. Extruded aluminum with neoprene seal.
2. Acceptable manufacturers and products: Pemko Model 57, Zero International Model 328 and National Guard Products, Inc. Model 96.

O. Weatherstripping

1. Extruded aluminum with neoprene seal.
2. U.L. Labeled.
3. Acceptable manufacturers and products: Pemko Model 294, National Guard Products, Inc. Model 190, and Zero International Model 328.

P. Knox Box

1. Furnish a Knox Box for emergency entry access mounted to main gate or as directed by the local fire official. Knox Box shall be Model required by fire official complete with spare key to unlock doors on site.

PART 3 – EXECUTION

3.1 GENERAL

A. Templates

1. After the hardware schedule is approved furnish to the various manufacturers, required blueprint templates for fabrication purposes. Templates shall be made available not more than ten (10) days after receipt of the approved hardware schedule.

B. Packaging and Marking

1. Ship hardware with proper non-corrosive fastenings for secure application. Each package of hardware shall be legibly marked indicating the part of the work for which it is intended. Markings shall correspond with the item numbers shown on

the approved hardware schedule. Keys shall be tagged within each package set and plainly marked on the face of the envelope with the key control number, door designation and all identification as necessary.

3.2 INSTALLATION

- A. Install hardware in a manner which will eliminate cracks on surfaces.
- B. Mount hardware units at heights recommended in "Recommended Locations for Builders Hardware" by BHMA, except as otherwise indicated or required to comply with governing regulations.
- C. Install each hardware item in compliance with the manufacturer's instructions and recommendations. Do not install surface-mounted items until finishes have been completed on the substrate.
- D. Set units level, plumb and true to line and location. Adjust and reinforce the attachment substrate as is necessary for proper installation and operation.
- E. Drill and countersink units which are not factory-prepared for anchorage fasteners. Space fasteners and anchors in accordance with factory standards.
- F. Cut and fit thresholds and floor covers to profile of door frames, with mitered corners and hair-line joints. Join units with concealed welds or concealed mechanical joints. Cut smooth openings for spindles, bolts and similar items, if any.
- G. Screw thresholds to substrate with No. 10 or larger screws, of the proper type for permanent anchorage and of bronze or stainless steel which will not corrode in contact with the threshold metal.
- H. Set thresholds in a bed of either butyl rubber sealant or polyisobutylene mastic sealant to completely fill concealed voids and exclude moisture. Do not plug drainage holes or block weeps. Remove excess sealant.

3.3 ADJUST AND CLEAN

- A. Adjust and check each operating item of hardware and each door to ensure proper operation or function. Lubricate moving parts as recommended by manufacturer. Replace units which cannot be adjusted to operate freely and smoothly as intended for the application.
- B. Final Adjustment
 - 1. One week prior to acceptance or occupancy make a final check and adjustment of all hardware items. Clean and relubricate operating items as necessary to restore

proper function and finish of hardware and doors. Adjust door control devices and compensate for final operation of heating and ventilating equipment.

- C. Instruct Owner personnel in proper adjustment and maintenance of hardware and hardware finishes, during the final adjustment of hardware.

3.4 HARDWARE SETS

- A. The door hardware sets on the Drawings indicates functional and general requirements. Items shall be quality and finish as specified. Hardware set identification refers to set numbers indicated on the Drawings. Provide hardware required to meet Code requirements. Consult Drawings for set number required.
- B. Coordinate hardware with security diagrams shown on Drawings and security installer. Provide door hardware, power transfers and strikes. Remainder of hardware by security installer.
- C. Hardware shall be as follows:

Table 1: Hardware Sets

Set	Items	Set	Items
1	1. Not Used	9	1. Not Used
2	1. Hinges 2. Entrance Lockset 3. Overhead Door Closer Holder (each leaf) 4. Flush Bolts 5. Coordinator 6. Kickplate 7. Threshold 8. Door Bottom Seal 9. Weatherstripping 10. Astragal w/Weatherstripping	10	1. Hinges 2. Classroom Lockset 3. Door Closer (each leaf) 4. Flush Bolts 5. Coordinator 6. Kickplates (each leaf)
3	1. Hinges 2. Entrance Lock Set 3. Door Closer 4. Kickplate 5. Threshold 6. Door Bottom Seal 7. Weatherstripping	11	1. Hinges 2. Classroom lockset 3. Door Closer/stop 4. Kickplate 5. Wallbumper 6. Threshold 7. Door Bottom Seal 8. Smoke Seal (jamb)
4	1. Hinges 2. Panic Hardware 3. Kickplate 4. Silencers 5. Door closer/holder	12	1. Not Used
5	1. Hinges 2. Classroom Lockset 3. Kickplate 4. Overhead stop 5. Silencers	13	1. Hinges 2. Classroom Lockset 3. Door Closer 4. Kickplate 5. Silencers
6	1. Hinges 2. Panic Hardware 3. Door Closer 4. Kickplate 5. Smoke seal (Jamb) 6. Silencers	14	1. Hinges 2. Panic Hardware 3. Door Closer 4. Kickplate 5. Weatherstripping 6. Threshold 7. Door Bottom Seal
7	1. Not Used	15	1. Hinges 2. Panic Hardware 3. Door Closer (each leaf) 4. Coordinator 5. Automatic Flush Bolts 6. Kick Plate 7. Weatherstripping 8. Threshold 9. Door Bottom Seal 10. Astragal w/Weatherstripping
8	8. Not used		

END OF SECTION

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SECTION 08 80 00
GLASS AND GLAZING

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. Furnish all labor, materials, equipment and appliances required for the complete execution of Work as shown on Drawings and specified herein.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 08 11 13 – Steel Doors and Frames

1.03 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

- A. Without limiting the requirements of these specifications, the Work shall conform to the applicable requirements of the following documents:
 - 1. CPSC 16 CFR1201 "Safety Standard for Architectural Glazing Materials."
 - 2. ANSI Z97.1 "Performance Specifications and Methods of Test for Safety Glazing Material Used in Buildings."
 - 3. North American Glazing Association "Glazing Manual."
 - 4. Underwriters' Laboratories "Building Materials Directory."

1.04 SUBMITTALS

- A. In accordance with the procedures and requirements set forth in Section 01 33 00 – Submittal Procedures, submit the following:
 - 1. Sample of each type of glass and color chart.
 - 2. Complete layout and installation drawings and schedules with clearly marked dimensions.
 - 3. Manufacturer's technical descriptions and reports for glass and glazing.

1.05 JOB CONDITIONS

- A. Check openings to verify that frames are plumb and true, square and secure.
- B. Take field dimensions for cutting glass and fabricating units.

- C. Do not install glazing when ambient temperature is less than 50 degrees F.

1.06 DELIVERY, STORAGE AND HANDLING

- A. Deliver materials in the manufacturer's original unopened labeled containers, clearly marked with their name and brand. Transport large panes of glass in vertical position with spacers to prevent contact between panes and edges.
- B. Store glass in a dry, well ventilated location at a constant temperature, maintained above dew point. Handling shall be kept to a minimum. Protect glass from soiling, condensation or moisture of any kind.

PART 2 – PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Subject to compliance with the Specifications provide products manufactured by one of the following:
 - 1. PPG Industries
 - 2. Libby – Owens – Ford
 - 3. Cardinal IG
 - 4. Oldcastle Building Envelope

2.02 MATERIALS

- A. Primary glass shall meet the requirements of ASTM C1036-90. Heat treated glass shall meet the requirements of ASTM C1048-90.
- B. Tempered glass shall be plate or float glass tempered by a special heat process and 1/4-inch thick or as noted on Drawings. Tempered glass shall meet the requirements of ANSI Z97.1 and Consumer Product Safety Commission 16 CFR 1201. Tempered glass shall be used for all applications, unless otherwise noted.
- C. Insulating glass shall be Low-E preassembled units of glass enclosing a hermetically sealed dehydrated air space and certified through the Insulating Glass Certification Council (IGCC) in accordance with ASTM E-2190, E-2188. Glass shall be made from tempered glass, or heat-strengthened glass where recommended by manufacturer for application indicated. The unit shall consist of a tinted 1/4" thick exterior light, 1/2" air space and 1/4" thick clear interior light. Sealing system shall consist of metal spacer with bent or soldered corners, butyl primary and silicone secondary seal. Desiccant shall be manufacturer's standard. Exterior pane shall be tinted and color shall be selected by the Owner from manufacturer's full range of colors. Exterior glass shall be insulated.

- D. Fire rated glass shall be FireLite Plus® as manufactured by Nippon Electric Glass Company, Ltd., and distributed by Technical Glass Products or equal glass shall be 5/16" thick. Provide glass fire rated tested for fire rated assembly (doors, windows, or walls) shown in accordance with UL and NFPA requirements. Provide glass that additionally meets the requirements of ANSI Z97.1 and CPSC 16CFR1201 (Cat 1 and II). Glass shall be premium grade ground and polished both sides. Permanently label each piece of glass.
- E. Glazing materials shall be a resilient, nonhardening glazing compound of either a polysulfide or a silicone type. Materials shall not contain any solvents and shall be 100% solids. Oil base putty shall not be used. Glazing compounds shall not be thinned with chlorinated solvents or benzene related compounds. Glazing tape may be used where, and as, recommended by the manufacturer. The color of all exposed glazing materials shall harmonize with the window units.
- F. Setting blocks and spacer shims shall be a non-staining material as recommended by the glass manufacturer.

PART 3 – EXECUTION

3.01 GENERAL

- A. Determine glass sizes by measuring the frames to receive the glass at the site. Comply with the manufacturer's specified tolerances for each type of glass including cutting tolerance, minimum edge clearance, minimum face clearance, and cover on glass.
- B. The edges of all tempered and insulating glass shall be protected from damage and edges shall not be modified in any way after the glass leaves the factory. Nipping of any glass to reduce size shall not be permitted.
- C. Deliver glass with manufacturer's labels showing type, thickness and quality of material (and U.L. label as required). These labels shall not be removed until the glass is set and final approval has been secured.

3.02 INSTALLATION

- A. Sheet glass shall be cut and set with waves running horizontally.
- B. All glass shall be set in such manner as to avoid possibility of breakage.
- C. Rabbets shall be thoroughly cleaned and shall have been prime coated before glass is set.

- D. Glass shall be well bedded and back glazed and all surplus compound and markings shall be carefully removed from doors, sash and adjoining work, while still fresh. Compound shall be finished in true, even lines, neatly and smooth faced. Set glass in strict accordance with the manufacturer's printed directions.
- E. All glass when set and glazed shall be free from rattle and be watertight.
- F. Glazing molds shall be removed and replaced in their correct locations in such a manner as not to mar molding or the screws securing same.
- G. Install fire rated glass in strict accordance with manufacturer's requirements to meet fire rated assembly shown on Drawings.

3.03 PROTECTION AND CLEANING

- A. Before and after installation, all work shall be properly protected against damage.
- B. On completion and prior to turning the project over to the Owner, all metal work and glass shall be cleaned and left in perfect condition. Glass shall be washed outside and inside.

END OF SECTION

SECTION 08 90 00

LOUVERS

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. Furnish all labor, materials, equipment, and appliances required for the complete execution of additions, modifications, alterations, to existing buildings and new construction work as shown on the Drawings and specified under the several sections of the Specifications.
- B. Principal items of work include:
 - 1. Fixed type, stormproof louvers and frames.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 01 33 00 – Submittal Procedures

1.03 REFERENCE CODES, SPECIFICATIONS, AND STANDARDS

- A. Without limiting the generality of these Specifications, work shall conform to the applicable requirements of the following documents. All referenced Specifications, codes, and standards refer to the most current issue available at the time of the Bid.
 - 1. All work shall comply with the current Building Code of the State or Commonwealth in which the project is located.
 - 2. and the requirements of all other authorities having jurisdiction.
 - 3. All units shall conform to AA-Aluminum Standards and Data, latest edition.
 - 4. Louvers shall bear the AMCA Seal with ratings in accordance with AMCA Standard 500 which applies to air performance ratings and water penetration ratings.
 - 5. All louvers, fasteners and supports shall be designed to meet a wind loading in accordance with the local building codes but shall not be less than 25 pounds per square foot.

1.04 SUBMITTALS

- A. In accordance with the procedures and requirements set forth in the General Conditions and Section 01 33 00 – Submittal Procedures, the Contractor shall submit the following:

1. Samples
 2. Shop Drawings
- B. Samples shall include:
1. Color and finish samples for each finish type required.
- C. Shop Drawings shall include but not be limited to:
1. Complete detail drawings showing materials, methods of fabrication and clearly indicating all dimensions.
 2. Detailed installation drawings showing all methods of attachment.

1.05 DELIVERY, STORAGE AND HANDLING

- A. Brace and support units to prevent deformation during delivery.
- B. Factory wrap units with approved materials to protect finish during delivery and storage.
- C. Handle units with care to prevent bending or scratching.

PART 2 – PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Subject to compliance with the Specifications, provide products manufactured by the following:
 1. Construction Specialties, Inc.
 2. Penn, Inc.
 3. Airolite Company, Marietta, Ohio
 4. Ruskin, Philips Industries, Inc.

2.02 FABRICATION

- A. Extruded aluminum 6063-T52 alloy, extruded within commercial tolerances and free of defects, minimum .081 inches thick with reinforcing bosses. All corners of frames shall be reinforced and welded.
- B. Hardware and fasteners shall be of Type 316 stainless steel placed through nylon bushings.

- C. The louver installation shall consist of a fixed exterior louver with frame depth of 6-inches.
- D. The fixed louver blades shall be spaced equally not to exceed 4.5" and a section thickness of .125-inches (frames and blades).
- E. Louver assemblies which are to be placed in openings exceeding 5 feet in width shall have slidable interlocked heavy gauge extruded aluminum mullions at mid span of integral tongue and groove construction.
- F. Coordinate louver sizes and free area requirements with the HVAC work.
- G. Provide 1" insulated blanked off sections as required to fill gaps around HVAC equipment, plenums, and ductwork. Finish of blank-off panels shall match louver.
- H. Bird screens shall be 1/2-inch square FRP or aluminum mesh P.V.C. coated, placed in removable .081-inch thick folded aluminum frames standard with the manufacturer.

2.03 FINISH

- A. Extruded aluminum louvers frames and blades to receive baked on Kynar based coating with a 20 year finish warranty.
- B. Interior louvers to receive alumilite finish 204-R1 as produced by the Aluminum Company of America, or equal.

PART 3 – EXECUTION

3.01 INSTALLATION

- A. Anchor louver frames using stainless steel bolts into holes drilled and tapped in channel or angle subframes and suspended lintels, or with strap anchors to masonry in accordance with the manufacturer's approved directions.
- B. Isolate aluminum from contact with masonry or dissimilar metals with heavy coat of bituminous paint or neoprene gaskets.
- C. Mount bird screens on inside face with clips, machine screwed into frames.
- D. All frames shall be installed with aluminum (or compatible) screws, bolts, anchors, etc., in such a manner that the frames are removable.

3.02 CUTTING AND FITTING

- A. Do all cutting and fitting required for the installation in a neat manner.

3.03 CLEANING

- A. Upon completion remove any and all protective coatings, clean off all parts of the work and leave entire installation in orderly condition.

END OF SECTION

¹SECTION 09 90 00

PAINTING

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. Furnish labor, materials, equipment and appliances required for complete execution of Work shown on Drawings and Specified herein.
- B. Section Includes:
 - 1. Paint Materials
 - 2. Shop Painting
 - 3. Field Painting
 - a. Surface Preparation
 - b. Piping and Equipment Identification
 - c. Schedule of Colors
 - d. Work in Confined Spaces
 - e. OSHA Safety Colors

1.02 RELATED SECTIONS

- A. Section 40 05 97 – Piping and Equipment Identification Systems
- B. Section 07 90 00 – Joint Fillers, Sealants, and Caulking

1.03 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

- A. Without limiting the generality of these specifications, the Work shall conform to the applicable requirements of the following documents:
 - 1. SSPC – The Society for Protective Coatings Standards
 - a. SSPC-Vis 1 – Pictorial Surface Preparation Standards for Painting Steel Structures
 - b. SSPC-SP2 – Hand Tool Cleaning

- c. SSPC-SP3 – Power Tool Cleaning
 - d. SSPC-SP5/NACE 1 – White Metal Blast Cleaning
 - e. SSPC-SP6/NACE 3 – Commercial Blast Cleaning
 - f. SSPC-SP7/NACE 4 – Brush-off Blast Cleaning
 - g. SSPC-SP10/NACE 2 – Near-White Metal Blast
 - h. SSPC-SP11 – Power Tool Cleaning to Bare Metal
 - i. SSPC-SP13/NACE6 – Surface Preparation of Concrete
- 2. ICRI – International Concrete Repair Institute
 - 3. NACE – National Association of Corrosion Engineers
 - 4. NAFP – The National Association of Pipe Fabricators
 - 5. ASTM D1737 – Test Method for Elongation of Attached Organic Coatings with Cylindrical Mandrel Apparatus
 - 6. ASTM B117 – Method of Salt Spray (Fog) Testing
 - 7. ASTM D4060 – Test Method for Abrasion Resistance of Organic Coating by the Taber Abraser
 - 8. ASTM D3359 – Method for Measuring Adhesion by Tape Test

1.04 SUBMITTALS

- A. In accordance with the procedures and requirements set forth in Section 01 33 00 – Submittal Procedures, submit the following:
 - 1. Manufacturer's literature and Material Safety Data Sheets for each product.
 - 2. Painting schedule identifying surface preparation and paint systems proposed. Cross reference with Tables 1 and 2. Provide the name of the paint manufacturer, and name, address, and telephone number of manufacturer's representative who will inspect the work. Submit schedule for approval as soon as possible following the Award of Contract, so approved schedule may be used to identify colors and specify shop paint systems for fabricated items. Manufacturer shall substitute paint system with equal performance where required for VOC compliance.
 - 3. Contractor shall submit Q.C. Inspection plan describing all tests and inspections task to be performed. Include copy of daily log showing environmental conditions

measurements and frequency. Copy of completed log shall be provided at completion of work.

1.05 SYSTEM DESCRIPTION

- A. Work shall include surface preparation, paint application, inspection of painted surfaces and corrective action required, protection of adjacent surfaces, cleanup and appurtenant work required for the proper painting of all surfaces to be painted. Surfaces to be painted are designated within the Painting Schedule and may include new and existing piping, miscellaneous metals, equipment, buildings, exterior fiberglass, exposed electrical conduit and appurtenances.
- B. Perform Work in strict accordance with manufacturer's published recommendations and instructions, unless the Engineer stipulates that deviations will be for the benefit of the project.
- C. Paint surfaces which are customarily painted, whether indicated to be painted or not, with painting system applied to similar surfaces, areas and environments, and as approved by Engineer.
- D. Submerged ferrous metal, piping, and internal pump surfaces within potable water facilities or potable water distribution systems shall be painted with NSF 61/600 approved coatings.
- E. Piping and equipment shall receive color coding and identification. Equipment shall be the same color as the piping system.

1.06 QUALITY ASSURANCE

- A. Painting operations shall be accomplished by skilled craftsman and licensed by the state/commonwealth to perform painting work.
- B. Provide a letter indicating that the painting applicator has five years of experience, and 5 references which show previously successful application of the specified or comparable painting systems. Include the name, address, and the telephone number for the Owner of each installation for which the painting applicator provided services.
- C. Contractor shall coordinate Q.C Inspections.
- D. Notify Owner and Engineer at completion of surface preparation, priming application and final cure to allow inspection by Owner and Engineer or their Third-Party Inspector.

1.07 STORAGE AND DELIVERY

- A. Bring materials to the job site in the original sealed and labeled containers.

- B. Container label to include manufacturer's name, type of paint, brand name, lot number, brand code, coverage, surface preparation, drying time, cleanup requirements, color designation, and instructions for mixing and reducing.
- C. Store paint materials at minimum ambient temperature of 45 degrees F (7 degrees C) and a maximum of 90 degrees F (32 degrees C), in ventilated area, and as required by manufacturer's instructions.

PART 2 – MATERIALS

2.01 GENERAL INFORMATION

- A. The term "paint" is defined as both paints and coatings including emulsions, enamels, stains, varnishes, sealers, and other coatings whether organic or inorganic and whether used as prime, intermediate, or finish coats.
- B. Purchase paint from an approved manufacturer. Manufacturer shall assign a representative to inspect application of their product both in the shop and field. The manufacturer's representative shall submit a report to the Engineer at the completion the Work identifying products used and verifying that surfaces were properly prepared, products were properly applied, and the paint systems were proper for the exposure and service.
- C. Provide primers and intermediate coats produced by same manufacturer as finish coat. Use only thinners approved by paint manufacturer, and only within manufacturer's recommended limits.
- D. Ensure compatibility of total paint system for each substrate. Test shop primed equipment delivered to the site for compatibility with final paint system. Provide an acceptable barrier coat or totally remove shop applied paint system when incompatible with system specified, and repaint with specified paint system.
- E. Use painting materials suitable for the intended use and recommended by paint manufacturer for the intended use.
- F. Require that personnel perform work in strict accordance with the latest requirements of OSHA Safety and Health Standards for construction. Meet or exceed requirements of regulatory agencies having jurisdiction and the manufacturer's published instructions and recommendations. Maintain a copy of all Material Safety Data Sheets at the job site of each product being used prior to commencement of work. Provide and require that personnel use protective and safety equipment in or about the project site. Provide respiratory devices, eye and face protection, ventilation, ear protection, illumination and other safety devices required to provide a safe work environment.

2.02 ACCEPTABLE MANUFACTURERS

- A. Subject to compliance with the Specifications, provide products from one of the following manufacturers:
 - 1. Tnemec Company Inc.
 - 2. PPG
 - 3. CARBOLINE
 - 4. Sherwin-Williams
 - 5. International Paints (Akzo Nobel)

PART 3 – EXECUTION

3.01 SHOP PAINTING

- A. Shop prime fabricated steel and equipment with at least one shop coat of prime paint compatible with finish paint system specified. Prepare surface to be shop painted in strict accordance with paint manufacturer's recommendations and as specified. Finish coats may be shop applied, if approved by the Engineer. Package, store and protect shop painted items until they are incorporated into Work. Repair painted surfaces damaged during handling, transporting, storage, or installation to provide a painting system equal to the original painting received at the shop.
- B. Identify surface preparation and shop paints on Shop Drawings. Verify compatibility with field applied paints.
- C. Coordinate shop painting and field coating to ensure item is delivered and field coating occurs within recoat window of shop painted system requirements.

3.02 SURFACE PREPARATION

- A. General
 - 1. Surfaces to be painted shall be clean and dry, and free of dust, rust, scale, and foreign matter. No solvent cleaning, power or hand tool cleaning shall be permitted unless approved by the Engineer.
 - 2. Protect or remove, during painting operations, hardware, accessories, machined surfaces, nameplates, lighting fixtures, and similar items not intended to be painted prior to cleaning and painting. Reposition items removed upon completion of painting operations.

3. Examine surfaces to be coated to determine that surfaces are suitable for specified surface preparation and painting. Report to Engineer surfaces found to be unsuitable in writing. Do not start surface preparation until unsuitable surfaces have been corrected. Starting surface preparation precludes subsequent claim that such surfaces were unsuitable for the specified surface preparation or painting.
4. Surface preparation shall be in accordance with specifications and manufacturer's recommendations. Provide additional surface preparation, and fill coats where manufacturer recommends additional surface preparation, in addition to requirements of specification.
5. Touch-up shop or field applied coatings damaged by surface preparation or any other activity, with the same shop or field applied coating; even to the extent of applying an entire coat when required to correct damage prior to application of the next coating. Touchup coats are in addition to the specified applied systems, and not considered a field coat.
6. Protect motors and other equipment during blasting operation to ensure blasting material is not blown into motors or other equipment. Inspect motors and other equipment after blasting operations and certify that no damage occurred, or where damage occurred, the proper remedial action was taken.
7. Field paint shop painted equipment in compliance with Color Coding and as approved by Engineer.

B. Metal Surface Preparation

1. Prepare all welds to a minimum NACE weld preparation level "C" per NACE Standard SP0178. Provide additional weld preparation where required by the coating manufacturer. Contractor shall provide NACE SP0178 weld mold visual aids on site for evaluation of all weld preparation.
2. Conform to current The Society for Protective Coatings Standards (SSPC) Specifications for metal surface preparation. Use SSPC-Vis-1 pictorial standards or NACE visual standards TM-01-70 or TM-01-75 to determine cleanliness of abrasive blast cleaned steel.
3. Perform blast cleaning operations for metal when following conditions exist:
 - a. Moisture is not present on the surface.
 - b. Relative humidity is below 80%.
 - c. Ambient and surface temperatures are 5°F or greater than the dew point temperature.

- d. Painting or drying of paint is not being performed in the area.
 - e. Equipment is in good operating condition.
 - f. Proper ventilation, illumination, and other safety procedures and equipment are being provided and followed.
- 4. Abrasive blast ferrous metals to be shop primed, or component mechanical equipment in accordance with SSPC-SP5, White Metal Blast.
 - 5. Abrasive blast field prepared ferrous metals in accordance with SSPC-SP10, Near White Metal Blast, where metal is to be submerged, in a corrosive environment, or in severe service. Provide a 3.0 mil minimum angular anchor profile unless recommended otherwise by the coating manufacturer in writing.
 - 6. Abrasive blast field prepared ferrous metals in accordance with SSPC-SP6 Commercial Blast, where metal is to be used in mild or moderate service, or non-corrosive environment or weathering exposure. Provide a 1.5 mil minimum angular anchor profile unless recommended otherwise by the coating manufacturer in writing.
 - 7. Clean nonferrous metals, copper, or galvanized metal surfaces in accordance to SSPC-SP1, Solvent Cleaning, or give one coat of metal passivator or metal conditioner compatible with the complete paint system. Galvanized metal shall be prepared in accordance with SSPC SP-16. Abrasive blast clean to increase mechanical adhesion in accordance with ASTM D6386, Standard Practice for Preparation of Zinc (Hot-Dip Galvanized) Coated Iron and Steel Product and Hardware Surfaces for Painting when required by coating manufacturer. Provide a 1.5 mil minimum angular anchor profile unless recommended otherwise by the coating manufacturer in writing.
 - 8. Abrasive blast clean internal and external ductile iron pipe surfaces prior to coating in accordance with NAPF 500-03-04, Surface Preparations Standard for Abrasive Blast Cleaning of Ductile Iron Pipe. Abrasive blast clean internal and external cast ductile iron and cast-iron fitting surfaces in accordance with NAPF-03-05.
 - 9. Prime cleaned metals immediately after cleaning to prevent rusting.
 - 10. Clean rusted metals down to bright metal by abrasive blasting and immediately field primed.

C. Concrete Surface Preparation

- 1. Cure concrete a minimum of 28 days at 75° F before surface preparation, and painting begins. Allow more time at lower temperatures if specified by paint manufacturer.

2. Test concrete for pH and salts using test methods recommended by the paint manufacturer. A minimum of one test per 1000 square feet of area to be coated shall be performed unless approved otherwise by Engineer. Do not begin surface preparation, or painting until acceptable to manufacturer.
3. Moisture content of concrete and masonry surfaces shall conform to manufacturer's recommended limits, and as listed in SSPC-SP13/NACE 6 Section 6 Acceptance Criteria Table 1. Floor surfaces to be coated shall be tested in accordance with ASTM F1869 – Standard Test Method for Measuring Moisture Vapor Emission Rate of Concrete Subfloor Using Anhydrous Calcium Chloride or as required by the coating manufacturer. Moisture vapor transmission shall not exceed three pounds per 1,000 square feet in a 24-hour period or less if specified by Coating Manufacturer. Vertical and horizontal overhead surfaces shall be tested in accordance with ASTM F2170 – Standard Test Method for Determining Relative Humidity in Concrete using in situ Probes (relative humidity shall not exceed 80% or as required by the coating manufacturer) or with ASTM D4263 – Standard Test Method for Indicating Moisture in Concrete by the Plastic Sheet Test Method (test results shall be no moisture present). Engineer or Coating Manufacturer Representative shall specify all test locations. A minimum of one test per 1000 square feet of area to be coated shall be performed unless approved otherwise by Engineer.
4. Prepare concrete surfaces to receive coatings in accordance with NACE 6/SSPC-13 – Joint Surface Preparation Standards and ICRI Technical Guidelines. Remove contaminants, open bugholes, surface voids, air pockets, and other subsurface irregularities using abrasive blasting, shot blasting, water jetting or mechanical abrading. Use dry, oil-free air for blasting operations. Surface texture after blasting shall achieve profile as required by manufacturer or where not defined by manufacturer, profile shall be a minimum ICRI-CSP 5 surface profile. Remove residual abrasives, dust, and loose particles by vacuuming or other approved method.
5. Surface defects, such as hollow areas, bugholes, honeycombs, and voids shall be filled with polymeric or waterborne epoxy cementitious filler compatible with painting system. Complete fill coats may be used in addition to specified painting system and as approved by the Engineer. Fins, form marks, and all protrusions or rough edges shall be removed.
6. Repair existing concrete surfaces which are deteriorated to the point that surface preparation exposes aggregate with fill coats or patching mortar as recommended by paint manufacturer and as directed by the Engineer.
7. Clean concrete of all dust, form oils, curing compounds, oil, tar, laitance, efflorescence, loose mortar, and other foreign materials before paints are applied.

8. To ease coating around outside corners, provide $\frac{3}{4}$ -inch chamfered edges on all new concrete outside corners and grind existing concrete outside corners to a minimum radius of $\frac{3}{4}$ -inch.
9. Unless recommended otherwise by the coating manufacturer, provide $\frac{1}{4}$ " deep by $\frac{1}{4}$ " wide tool cut terminations at 1-inch maximum from all coating edges for anchorage. Provide terminations around all equipment, piping, openings, gates, top and bottom of walls, stop locations of each day's work and overlap onto previously completed work. Transition coating 3-inches onto interior lining of piping except where coating compatibility concerns are noted by coating manufacturer.
10. Apply epoxy or polymeric filler compatible with painting system to all inside corners of areas to be coated with a margin trowel to form a continuous 45-degree cant cove across corners with a minimum dimension of 1.5-inch. Roughen or prepare cured filler as recommended by coating manufacturer for proper coating adhesion.
11. All equipment grouting shall be installed and cured prior to starting coating work. Coating shall be applied over grout up to the edges of all equipment, gates and uninterrupted piping unless specifically noted otherwise.

D. Wood

1. Clean wood surfaces free of all foreign matter, with cracks and nail holes and other defects properly filled and smoothed. Remove sap and resin by scraping and wipe clean with rags dampened with mineral spirits.
2. Saturate end grain, cut wood, knots, and pitch pockets with an appropriate sealer before priming.
3. Prime and backprime wood trim before setting in place.
4. After prime coat has dried, fill nailholes, cracks, open joints, and other small holes with approved spackling putty. Lightly sand wood trim prior to applying second coat of paint.

E. Castings

1. Prepare castings for painting by applying a brush or a knife-applied filler. Fillers are not to be used to conceal cracks, gasholes, or excessive porosity.
2. Apply one coat of primer with a minimum thickness of 1.2 mils in addition to coats specified. Allow sufficient drying time before further handling.

F. Masonry

1. Cure for a minimum of 30 days prior to paint application.
2. Clean masonry surfaces free from all dust, dirt, oil, grease, loose mortar, chalky deposits, efflorescence, and other foreign materials.
3. Test masonry for moisture content. Use test method recommended by paint manufacturer. Do not begin painting until moisture content is acceptable to manufacturer.

G. Gypsum Drywall

1. Sand joint compound with sandpaper to provide a smooth flat surface. Avoid sanding of adjacent drywall paper.
2. Remove dust, dirt, and other contaminants.

H. Previously-Painted Surfaces

1. Totally remove existing paint when: surface is to be submerged in a severe environment, paint is less than 75% intact, brittle, eroded or has underfilm rusting.
2. Surfaces which are greater than 75% intact require removal of failed paints and then spot primed. Spot priming is in addition to coats specified.
3. Remove surface contamination such as oil, grease, loose paint, mill scale, dirt, foreign matter, rust, mold, mildew, mortar, efflorescence, and sealers.
4. Clean and dull glossy surfaces prior to painting in accordance with the manufacturer's recommendations.
5. Check existing paints for compatibility with new paint system. If incompatible, totally remove existing paint system or apply a barrier coat recommended by the paint manufacturer. Remove existing paints of undetermined origin. Prepare a test patch of approximately 3 square feet over existing paint. Allow test patch to dry thoroughly and test for adhesion. If proper adhesion is not achieved remove existing paint and repaint.

3.03 APPLICATION OF PAINT

- A. Apply paint by experienced painters with brushes or other applicators approved by the Engineer, and paint manufacturer.
- B. Apply paint without runs, sags, thin spots, or unacceptable marks.
- C. Apply at rate specified by the manufacturer to achieve at least the minimum dry mil thickness specified. Apply additional coats, if necessary, to obtain thickness.

- D. Special attention shall be given to nuts, bolts, edges, angles, flanges, welds, etc., where insufficient film thicknesses are likely. Stripe paint outside corners and edges in accordance with SSPC PA Guide 11. Stripe painting shall be in addition to coats specified.
- E. Perform thinning in strict accordance with the manufacturer's instructions, and with the full knowledge and approval of the Engineer and paint manufacturer.
- F. Allow paint to dry a minimum of twenty-four hours between application of any two coats of paint on a particular surface, unless shorter time periods are a requirement by the manufacturer. Longer drying times may be required for abnormal conditions as defined by the Engineer and paint manufacturer. Do not exceed manufacturer's recommended drying time between coats.
- G. Suspend painting when any of the following conditions exist:
 - 1. Rainy or excessively damp weather.
 - 2. Relative humidity exceeds 85%.
 - 3. General air temperature cannot be maintained at 50°F or above through the drying period, except on approval by the Engineer and paint manufacturer.
 - 4. Relative humidity will exceed 85% or air temperature will drop below 40°F within 18 hours after application of paint.
 - 5. Surface temperature of item is within 5 degrees of dewpoint.
 - 6. Dew or moisture condensation are anticipated.
 - 7. Surface temperature exceeds the manufacturer's recommendations.
- H. Where application of coating across concrete control joints or expansion joints has the potential to crack, turn coating into joints and caulk joints with a sealant compatible with coating rated for the intended service per Section 07 90 00 – Joint Fillers, Sealants, Caulking.

3.04 INSPECTION

- A. Each field coat of paint will be inspected and approved by the Engineer or the Engineer's authorized representative before succeeding coat is applied. Tint successive coats so that no two coats for a given surface are exactly the same color. Tick-mark surfaces to receive black paint in white between coats.
- B. Use magnetic dry film thickness gauges and wet film thickness gauges for quality control. Furnish magnetic dry film thickness gauge for use by the Engineer.

- C. Coatings shall pass a holiday detector test.
- D. Determination of Film Thickness: Randomly selected areas, each of at least 107.5 contiguous square feet, totaling at least 5% of the entire control area shall be tested. Within this area, at least 5 squares, each of 7.75 square inches, shall be randomly selected. Three readings shall be taken in each square, from which the mean film thickness shall be calculated. No more than 20 percent of the mean film thickness measurements shall be below the specified thickness. No single measurement shall be below 80 percent of the specified film thickness. Total dry film thickness greater than twice the specified film thickness shall not be acceptable. Areas where the measured dry film thickness exceeds twice that specified shall be completely redone unless otherwise approved by the Engineer. When measured dry film thickness is less than that specified additional coats shall be applied as required.
- E. Holiday Testing: Holiday test painted ferrous metal surfaces which will be submerged in water or other liquids, or surfaces which are enclosed in a vapor space in such structures. Mark areas which contain holidays. Repair or repaint in accordance with paint manufacturer's printed instructions and retest.
 - 1. Dry Film Thickness Exceeding 20 Mils: For surfaces having a total dry film thickness exceeding 20 mils: Pulse-type holiday detector such as Tinker & Rasor Model AP-W, D.E. Stearns Co. Model 14/20, shall be used. The unit shall be adjusted to operate at the voltage required to cause a spark jump across an air gap equal to twice the specified coating thickness.
 - 2. Dry Film Thickness of 20 Mils or Less: For surfaces having a total dry film thickness of 20 mils or less: Tinker & Rasor Model M1 non-destructive type holiday detector, K-D Bird Dog, shall be used. The unit shall operate at less than 75-volts. For thicknesses between 10 and 20 mils, a non-sudsing type wetting agent, such as Kodak Photo-Flow, shall be added to the water prior to wetting the detector sponge.
- F. Paint manufacturer's NACE certified representative shall provide their services as required by the Engineer. Services shall include, but not be limited to, inspecting existing paint, determination of best means of surface preparation, inspection of completed work, and final inspection of painted work 11 months after the job is completed.

3.05 PROTECTION OF ADJACENT PAINT AND FINISHED SURFACES

- A. Use covers, masking tape, other method when protection is necessary, or requested by Owner or Engineer. Remove unwanted paint carefully without damage to finished paint or surface. If damage does occur, repair the entire surface adjacent to and including the damaged area without visible lapmarks and without additional cost to the Owner.
- B. Take all necessary precautions to contain dispersion of abrasive blasting debris and paint to the limits of the work. Take into account the effect of wind and other factors

which may cause dispersion of the abrasive blasting debris and paint. Suspend painting operations when abrasive blasting debris or paint cannot be properly confined. Assume all responsibilities and cost associated with damage to adjacent structures, vehicles, or surfaces caused by the surface preparation and painting operations.

3.06 PIPING AND EQUIPMENT IDENTIFICATION

- A. Piping and equipment identification shall be in accordance with Section 40 05 97 – Piping and Equipment Identification Systems.

3.07 SCHEDULE OF COLORS

- A. Match colors indicated. Piping and equipment colors are indicated in Section 40 05 97 – Piping and Equipment Identification Systems. Colors which are not indicated shall be selected from the manufacturer's full range of colors by the Engineer. No variation shall be made in colors without the Engineer's approval. Color names and numbers shall be identified according to the appropriate color chart issued by the manufacturer of the particular product in question.

3.08 WORK IN CONFINED SPACES

- A. Provide and maintain safe working conditions for all employees. Supply fresh air continuously to confined spaces through the combined use of existing openings, forceddraft fans and temporary ducts to the outside, or direct air supply to individual workers. Exhaust paint fumes to the outside from the lowest level in the contained space. Provide explosionproof electrical fans, if in contact with fumes. No smoking or open fires will be permitted in, or near, confined spaces where painting is being done. Follow OSHA, state/commonwealth, and local regulations at all times.

3.09 OSHA SAFETY COLORS

- A. Paint wall around wall-mounted breathing or fire apparatus with the appropriate safety red color; area not to exceed 2 feet wide by 3 feet high, unless apparatus covers the area. Fire apparatus include fire hoses, extinguisher, and hydrants.
- B. Paint hazardous areas and objects in accordance with OSHA regulations.

3.10 VOC REGULATIONS

- A. Provide paint systems in accordance with local, state, and federal regulations. Where paint systems shown in schedule do not comply, substitute equal products with VOC limits which comply with local, state, and federal regulations.

Table 1: Painting Schedule

Surface	Application	Painting System and No. of Coats	Product Reference (Table 2)	Total Min. Dry Film Thickness (Mils)
Concrete and Masonry				
Interior masonry and concrete walls, columns, beams, and ceilings	All new structures	1 coat sealer 2 coats acrylic epoxy	101 116	75-85 sq.ft./gal. 4-6/coat
Interior masonry and concrete walls, columns, beams, and ceilings in chemical rooms		1 coat sealer 2 coats epoxy polyamide	117 102	60-80 sq.ft./gal. 4-6/coat
Exterior masonry cavity walls on cavity face of inner wythe	All new structures	Dampproofing	See Section 07 11 00	
Exterior below grade if interior is dry	Accessible areas (e.g. pipe galleries, pump rooms, basements, etc.)	Waterproofing	See Section 07 13 50	
Submerged or occasional contact with potable or raw water	Water retaining side of new wall surfaces where opposite side of wall is interior and dry and where indicated "epoxy waterproofing" on drawing	2 coats NSF 61/600 approved epoxy polyamide Provide filler as required and recommended by manufacturer	105	4-6/coat
Containment Liner ¹	Interior and exterior secondary containment floors, tank supports and walls	2 coats high solids epoxy coating	See Section 09 97 00	
Metals				
Interior and exterior nonsubmerged (gloss)	All new blowers, pumps, motors and mechanical equipment, piping, etc.	1 coat epoxy polyamide primer	104	4-6
		1 coat epoxy polyamide	102	4-6
		1 coat aliphatic polyurethane	115	3-5
Interior insulated		1 coat acrylic latex	103	4
Submerged or occasional contact with potable or raw water	All metal piping, mechanical equipment, etc.	2 coats NSF 61/600 approved epoxy polyamide	105	4-6/coat
Steel doors, windows and door frames, steel stairs, monorails, structural steel, misc. metals (steel), galvanized lintels,		1 coat epoxy polyamide	102	5-8
		1 coat aliphatic polyurethane	115	3-4
Aluminum surfaces in contact with concrete		2 coats coal tar	107	26
Other				
Interior: Tar-dipped piping where color is required		1 coats epoxy resin sealer 1 coats epoxy polyamide	112 102	2-3/coat 5-8/coat
PVC Piping		1 coat epoxy polyamide	102	5-8
		1 coat aliphatic polyurethane	115	3-4

Ref.	System	Purpose	Product			
			Tnemec Series	PPG	CARBOLINE	Sherwin-Williams
101	Acrylic filler	Primer-sealer	130-6601	BLOXFIL 400BF	Sanitile 100	Pro-Industrial Heavy Duty Block Filler
102	Epoxy polyamide	Finish coat semi-gloss or gloss	N69	AMERLOCK 600 (SEMI-GLOSS)	Carboguard 890	Macropoxy 646
103	Acrylic latex	Sealer	1028/1029	PITT TECH PLUS	Carbocrylic 3359DTM	DTM Acrylic Primer/Finish
104	Epoxy Polyamide – metal	Primer	66	AMERCOAT 600	Carboguard 893SG	Macropoxy 646
105	Epoxy polyamide	Primer/Finish	21	AMERLOCK 2 VOC	Carboguard 61/891VOC	Macropoxy 646 PW
106	Coal tar epoxy	Finish high-coat build	46H-413	AMERCOAT 78HB	Bitumastic 300M	Hi-Mil Sher Tar Epoxy
107	Coal tar	Sealer	46-465	AMERCOAT 78HB	Bitumastic 300M	Hi-Mil Sher Tar Epoxy
108	Alkyd-medium oil	Finish coat	2H	HP INDUSTRIAL ALKYD 4308	Carbocoat 8215	Industrial Enamel
109	Alkyd-long oil	Finish coat	1029	HP INDUSTRIAL ALKYD 4308	Carbocoat 8215	Industrial Enamel
110	Epoxy polyamide	Primer	66-1211	AMERCOAT 600	Carboguard 893SG	Macropoxy 646
112	Epoxy polyamide	Sealer	66-1211	AMERLOCK SEALER	Carboguard 893SG	Macropoxy 920 Pre-Prime
113	Urethane	Barrier coat	530	AMERLOCK SEALER	Rustbond	-
114	Polyamine Epoxy	Intermediate coat	27	AMERLOCK 600	Carboguard 893SG	-
115	Aliphatic Polyurethane	Finish coat	1094 or 1095	PITTHANE ULTRA SERIES	Carbothane 134HG	Acrolon 218HS
116	Acrylic epoxy	Finish coat	113 or 114	AQUAPON WB EP	Sanitile 255	Pro-Industrial Water-Based Catalyzed Epoxy
117	Epoxy block filler	Sealer	1254	AMERLOCK 400BF	Sanitile 500	Kem Cati-Coat HS Epoxy Filler
118	Catalyzed epoxy	Finish coat	84	AMERLOCK 2/400	Carboguard 890	Macropoxy 646
119	High solids epoxy	Finish coat	104	AMERLOCK 240	Carboguard 890	Dura-Plate 235
120	Epoxy	Top coat	N69	AMERLOCK 240	Carboguard 890	-

Table 2: Product Listing

END OF SECTION

SECTION 09 97 00
SPECIAL COATINGS

PART 1 – GENERAL

1.01 THE REQUIREMENTS

- A. The Contractor shall furnish and install special coating systems in accordance with the Contract Documents.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 03 35 00 – Concrete Finishes
- B. Section 04 20 00 – Unit Masonry
- C. Section 05 12 00 – Structural Steel
- D. Section 05 50 00 – Metal Fabrications

1.03 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

- A. Without limiting the generality of other requirements of these specifications, all work hereunder shall conform to the applicable requirements of the reference portions of the following documents, to the extent that the requirements therein are not in conflict with the provisions of this Section.

- 1. Codes and Standards
 - a. NSF (National Sanitation Foundation) Standard 61

1.04 SUBMITTALS

- A. Shop Drawings shall be submitted in accordance with Section 01 33 00 – Submittal Procedures.
- B. Submit manufacturer's product data and installation instructions.
- C. Submit Material Data Sheets for each coating product provided.
- D. The manufacturer shall submit certification that coating product is proper for the exposure and service.
- E. Submit manufacturer's standard color chart for each coating product supplied.

- F. Submit manufacturer's representative name, address and telephone number who will inspect work.
- G. Submit manufacturer's Certification that coating products which may come in contact with potable water shall meet National Sanitation Foundation (NSF) Standard 61
- H. Submit letter from manufacturer stating that secondary containment lining is compatible with chemicals to be stored in area.

1.05 SERVICES OF MANUFACTURER'S REPRESENTATIVE

- A. The Contractor shall provide the services of a qualified manufacturer's technical representative who shall adequately supervise the surface preparation and application of the coating products.
- B. The manufacturer's technical representative shall submit to the Engineer a report, at the completion of the work, identifying the products used and verifying that surfaces were properly applied, and that the paint systems were proper for the exposure and surface.

1.06 QUALITY ASSURANCE

- A. Products shall be manufactured by company specializing in manufacturing the products specified in this Section with a minimum of five continuous years of experience of performance of similar applications in wastewater treatment plants or water treatment plants.
- B. Applicator shall be specialized in performing work of this Section with minimum five continuous years of experience and approved by the manufacturer.

PART 2 – PRODUCTS

2.01 CONTAINMENT LININGS

- A. Secondary containment areas shall be coated with a chemical resistant flake filled coating. Provide total coating thickness, not including filler, DFT of 40 -50 mils. Provide one of the following:
 - 1. Tnemec Products: Fill voids with Series 489, Intermediate Coat shall be Series 1402, and Top Coat of Series 1430.
 - 2. Carboline Products: Fill voids with Series 800 Patching Mortar. Primer to be Dudick Primer 27. Top coats - two coats of Plasite 4100.
 - 3. Sherwin Williams Products: Fill voids with Magnalux 1500PF, Primer Magnalux 1100, and a top coat of Magnalux 2100 FF

- B. Where chemicals are not compatible with coating specified provide a substitute product compatible with chemicals stored.
- C. Surface preparation shall be in accordance with the manufacturer's requirements and Specification 09 90 00.

PART 3 – EXECUTION

3.01 SURFACE PREPARATION

- A. Surfaces to receive coating shall be clean and free of dirt, oil, grease, and other foreign materials.
- B. Concrete and masonry surfaces shall cure for 28 days minimum prior to coating. Moisture content of concrete and masonry surfaces shall not exceed manufacturer's recommended limits.

3.02 APPLICATION

- A. All methods, procedures of mixing, application and curing of the coating material shall be accomplished in strict accordance with manufacturer's printed instructions and recommendations.
- B. Provide radius inside corners, ease outside corners, and terminate coatings in accordance with manufacturer's recommendations and instructions.

END OF SECTION

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SECTION 10 14 00
IDENTIFYING DEVICES

PART 1 – GENERAL

1.1 THE REQUIREMENT

- A. Furnish all labor, materials, equipment and appliances required for the complete execution of the Work as shown on the Drawings and specified herein.
- B. Principal items of work include:
 - 1. Plastic room name and number signs.
 - 2. Safety signs
 - 3. Building name or number

1.2 SUBMITTALS

- A. In accordance with the procedures and requirements set forth in Section 01 33 00 – Submittal Procedures, submit the following:
 - 1. Color and finish samples for all nameplates, signs and building name letters.
 - 2. Shop Drawings shall include, but not be limited to:
 - a. Complete details for all signs and building name letters giving sizes and styles of lettering and colors.
 - b. Complete schedules for all nameplates, signs, and building name letters giving location, message, letter, size, color, and method of attachment.
 - c. Details of fabrication and attachment of all items.

1.3 DELIVERY, STORAGE AND HANDLING

- A. Deliver all materials in unopened, unbroken and undamaged original packaging bearing the manufacturer's label and identification for installation.
- B. Handle all materials with care to prevent defacement of any nature.

PART 2 – PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

- A. Subject to compliance with the Specifications, provide products from one of the following manufacturers:
1. Interior Room, ADA Signs, and Site Signage
 - a. Mohawk Sign Systems
 - b. Innerface Architectural Signage Incorporated
 - c. Gemini Incorporated
 - d. Or equal
 2. Exterior and Interior Scheduled Signage
 - a. Seton Corporation
 - b. Safety Sign a division of Brimar Industries, Inc.
 - c. Emedco
 - d. Or equal

2.2 MATERIALS

- A. Signs
1. Interior room signs shall be self-extinguishing plastic with raised letters meeting the requirements of the American with Disabilities Act; total thickness minimum of 0.125 inch; rounded corners. Signs shall be 8"x8" or as indicated on Drawings with room name above and room number below.
 - a. Character size and style shall be 5/8 inch high minimum upper case Helvetica. Spacing and proportions of letters shall be in strict accordance with the Americans with Disabilities Act. Use names indicated on Room Finish Schedule.
 - b. Colors shall be as selected by the Owner from the manufacturer standard colors.
 2. Signs shown in Drawings shall be 0.040" minimum aluminum with vinyl lettering and numbering.

3. The building signage shall be 12" high laser cut aluminum letters with Helvetica Font. Each building shall receive the building name generally following naming in title block with 4 digit number as assigned by Fire Marshal.

2.3 ACCESSORIES

- A. Exterior and Interior Mounting Hardware: Stainless steel screws.
- B. Interior Room Name and Signs in Administrative Areas: Tape Adhesive: Double sided tape, permanent adhesive.

2.4 FABRICATION

- A. All items specified herein to be factory fabricated to the extent practicable.
- B. Provide all attachments and anchors necessary for concealed installments for door numbers, room name plates, and bulletin boards.

PART 3 – EXECUTION

3.1 INSTALLATION

- A. All materials specified herein shall be installed in compliance with the approved manufacturer's printed specifications. Mounting devices, bolts, screws, nuts and the like shall be of high strength aluminum or stainless steel. The final location of each sign shall be as determined by the Engineer.
- B. Plastic door numbers and room name plates shall be attached stainless steel oval Phillips head screw at each corner.
 1. Submit a schedule of door numbers and name plates to the Engineer for approval.
 2. Install door and name plates after final field finish has been applied and thoroughly dried.

3.2 ADJUSTMENT AND CLEANING

- A. After completion of project, remove all protective devices, touch up as necessary and clean all exposed surfaces with a mild solution of detergent and warm water. Leave all surfaces in a neat and clean condition.

3.3 SCHEDULES

- A. Fire-related signs provide each sign with wording and pictogram. Signs shall have red background and white letters and pictogram. (ADA Compliant.)

Wording	Size	
NOT AN EXIT	7x10	4
FIRE EXTINGUISHER	7x10	At each Fire Extinguisher
FIRE EXIT (stair)	7x10	4

- B. Caution signs shall have a yellow background with the word CAUTION 2 inches high with black letters and yellow background centered above wording below in black letters. Each sign shall be provided with pictogram showing figure in compliance with sign (i.e. a figure wearing glasses). See Drawings
- C. Safety Signs. Signs shall comply with ANSI Z 535 requirements. See Drawings.

END OF SECTION

SECTION 10 43 16
FIRST AID CABINETS

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. Furnish and install first aid cabinets as shown on the Drawings and as specified herein. Coordinate work in this Section with painting and marking as specified in Section 09 90 00 – Painting. Certain equipment items will be field located by Owner, if not otherwise shown on the Drawings.

1.02 SUBMITTALS

- A. Submit Shop Drawings, Operation and Maintenance Instructions, and other information as specified for all items of equipment in this Section in accordance with Section 46 00 00 – Equipment General Provisions and Section 01 33 00 – Submittal Procedures. Shop Drawings shall also include complete erection, installation, and adjustment instructions and recommendations.

1.03 MANUFACTURERS

- A. The materials covered by these Specifications are intended to be standard equipment of proven reliability and as manufactured by reputable manufacturers having experience in the production of such equipment. The equipment furnished shall be designed, constructed, and installed in accordance with the best practices and methods and shall operate satisfactorily when installed as shown on the Drawings and operated per manufacturers' recommendations.

PART 2 – PRODUCTS

2.01 FIRST AID CABINET

- A. The first aid cabinets shall be a Global Industrial First Aid Kit, 2 Shelf Steel Cabinet, ANSI Compliant, 50-75 Person, Item# T9FB2024169, or equal. One first aid cabinet shall be provided in each new building. Mounting brackets for masonry mounting shall be provided. Cabinets shall be field located as directed by the Engineer.

PART 3 – EXECUTION

3.01 INSTALLATION

- A. First aid cabinets shall be installed where shown on the Drawings or as directed by the Engineer. Where required by OSHA regulations, the background of the mounting location shall be painted the appropriate color.

END OF SECTION

SECTION 10 44 16
FIRE EXTINGUISHERS

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. Furnish and install fire extinguishers as shown on the Drawings and specified herein.

1.02 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

- A. Without limiting the generality of these Specifications, the Work shall conform to the applicable requirements of the following documents:
 - 1. NFPA 10 – Portable Fire Extinguishers

1.03 SUBMITTALS

- A. In accordance with the procedures and requirements set forth in Section 01 33 00 – Submittal Procedures, submit the following:
 - 1. Complete detail and installation drawings for Fire Extinguisher Cabinets.
 - 2. Manufacturer's data sheets and verification of U.L. ratings.

PART 2 – PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Subject to compliance with the Specifications provide products from one of the following manufacturers:
 - 1. Kidde Fire Extinguisher Company
 - 2. Ansul Fire Protection
 - 3. Potter – Roemer
 - 4. J. L. Industries

2.02 MATERIALS

- A. Dry Chemical (DC) Fire Extinguishers

1. Provide where indicated on Drawings, 10 lb. capacity, hand portable, with wall mount, tri-class dry chemical type, with Underwriters' Laboratories rating of 4-A: 60 BC.

B. Carbon Dioxide (CO2) Fire Extinguishers

1. Provide three (3) 10 lb. capacity, portable carbon dioxide type with wall mounts, having Underwriters' Laboratories rating of 10-BC. Provide in electrical rooms.

PART 3 – EXECUTION

3.01 INSTALLATION

- A. Fire extinguishers shall be installed where directed by the Engineer and as shown on Drawings. Locations shall be in accordance with NFPA 10.
- B. Wall mounts for extinguishers shall be securely mounted to masonry with lag bolts and shields.
- C. Fire extinguishers shall be installed so that the top of the fire extinguisher is not more than 5 feet above the floor.

END OF SECTION

SECTION 10 73 16

CANOPIES

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. Work in this Section includes furnishing and installation of extruded aluminum, post supported canopies and hanger rod canopies with perimeter gutter.
- B. Coordination Items and Considerations
 - 1. Concrete footings for post supported canopies. Footing styrofoam block outs and/or anchor rods shall be provided by manufacturer to be installed as part of concrete work.
 - 2. Flashing.
 - 3. Water drainage away from canopy.
 - 4. Coordination of all electrical fixtures and conduits or other items that are planned to be attached to the canopy.

1.02 QUALITY ASSURANCE

- A. Products meeting these specifications established standard of quality required as manufactured by a manufacturer with a minimum of 10 years of experience manufacturing and designing canopy systems.

1.03 SHOP DRAWINGS

- A. Confirm dimensions prior to preparation of shop drawings when possible.
- B. Supply manufacturer's standard literature and specifications for canopies.
- C. Submit shop drawings and structural calculations. Shop drawings shall include plan dimensions, elevations, and details, including drainage, connections, and means of anchoring posts. Shop drawings and structural calculations shall be sealed by a currently licensed Professional Engineer in the State or Commonwealth in which the project is located.
- D. Coordinate and show location and approved attachment methods for electrical fixtures, lightning protection, and conduits and other items that require attachment to the canopy on the Shop Drawings.

1.04 PERFORMANCE REQUIREMENTS

- A. Canopy must be designed for gravity loads, collateral loads, wind, seismic, snow, and live load requirements of the governing building code.
- B. Canopy must be designed to support additional accessories (electrical conduits and fixtures, etc.) attached to canopy system (posts, beams, ceiling, fascia, etc.).
- C. Electrical accessories including but not limited to lighting, switches and associated electrical conduits shall be coordinated with the canopy manufacturer. Attachment points shall not penetrate roof system or water conveying systems (wet columns and beams).
- D. Process control panels, electrical panels, etc. and associated conduits shall be provided with a support system independent of the canopy system.

1.05 DELIVER, STORAGE, HANDLING

- A. Deliver and store all canopy components in protected areas.

PART 2 – PRODUCTS

2.01 MANUFACTURERS

- A. Mapes Industries, Inc.
- B. Peachtree Protective Covers, Inc., Hiram, Georgia.
- C. Dittmer Architectural Aluminum, Winter Springs, Florida.
- D. AVAdeck, Houston, Texas.
- E. E.L. Burns Company
- F. Mitchell Metals
- G. MASA Architectural Canopies
- H. Or approved equal.

2.02 MATERIALS

- A. Decking, beams, posts, and fascia shall be extruded aluminum, alloy 6063-T6, in profile and thickness indicated.
- B. Decking shall be extruded and shall be at least 0.078" thick.

- C. Thickness of metal comprising posts shall be 0.125" minimum. Thickness of metal comprising beams shall be 0.125" minimum.
- D. Fascia shall be standard 6" extruded members with a minimum metal thickness of 0.0625".
- E. All bolts and fasteners shall be stainless steel and sized by designer of canopy system.

2.03 FINISHES

- A. Finish shall be Clear Anodized.

2.04 FABRICATION

- A. Welding shall follow AWS 1.2.
- B. Connections between posts and beams shall be designed to resist a minimum force of 350 lb.
- C. Decking shall be designed with interlocking extruded aluminum members with mechanical fasteners field applied to provide structural integrity for the completed assembly.
- D. Concealed drainage. Water shall drain from covered surfaces into integral gutter beam and be directed to ground level discharge via one or more designated support posts or downspout for cantilevered canopies.
- E. Lighting kits for support of lighting systems shown on Electrical Drawings.

PART 3 – EXECUTION

3.01 INSPECTION

- A. Confirm that surrounding area is ready for the canopy installation.
- B. Installer shall confirm dimensions and elevations to be as shown on drawings provided by manufacturer.
- C. Erection shall be performed by an approved installer and scheduled after all concrete, masonry and roofing in the area is completed.

3.02 INSTALLATION

- A. Installation shall be in strict accordance with manufacturer's erection drawings. Particular attention should be given to protecting the finish during handling and erection. Canopy shall be erected true to line, level, and plumb.

- B. Do not install items to the canopy system which have not been coordinated and approved by the canopy manufacturer.
- C. After installation, entire system shall be left in a clean condition.

END OF SECTION

SECTION 22 05 00
COMMON RESULTS FOR PLUMBING

PART 1 – GENERAL

1.1 SUMMARY

A. Related Documents:

1. Drawings and general provisions of the Subcontract apply to this Section.
2. Review these documents for coordination with additional requirements and information that apply to work under this Section.

B. Section Includes:

1. Furnish services, skilled and common labor, and apparatus and materials required for the complete installation as shown and within the intent of the drawings and/or these Specifications.
2. Requirements of this Section apply to Division 22 Sections.

C. Related Sections:

Division 01 – General Conditions

1. Section 01 75 00 – Checkout and Startup Procedures
2. Section 26 05 00 – Basic Electrical Requirements
3. Division 09 Sections on paints and coatings

1.2 REFERENCES

A. General:

1. The following documents form part of the Specifications to the extent stated. Where differences exist between codes and standards, the one affording the greatest protection shall apply. Unless otherwise noted, the referenced standard edition is the current one at the time of commencement of the Work.

B. Refer to Division 01– General Conditions for the list of applicable regulatory requirements.

- 1.

- C. These Division 22 specifications define the statutory, administrative, procedural, and technical requirements of the mechanical and controls modifications, replacements, and/or upgrades products and services to be provided on this Subcontract.
- D. Provide plumbing work as indicated on the Drawings and specified in Division 22 including:
1. Prepare coordination drawings, shop drawings, submittals, as-built drawings, and operating and maintenance instructions.
 2. Determine items and quantities required.
 3. Provide complete, continuous, operational, and functioning systems.
 4. Fully coordinate with work of other Sections, including field verification of elevations, dimensions, clearance, and access.
 5. Repair of all damage done to premises as a result of this installation and removal of debris left by those engaged in this installation.
 6. Rigging, hoisting, transportation, and associated work necessary for placement of equipment in the final location shown.
 7. Disassembly and re-assembly of equipment furnished under this Section, should this be required in order to move equipment into final location shown on the Drawings.
 8. Labor, materials, tools, appliances and equipment that are required to furnish and install the complete installation for this section of the work including that which is reasonably inferred.
 9. Cooperation with other crafts in putting the installation in place at a time when space required is accessible.
 10. Temporary scaffolding necessary for performance of the work in this Division.
 11. Cutting and core drilling required for work of Division 22, including locating of rebar or coordination of locating rebar with the General Contractor.
 12. Pipe sleeves for all holes in walls, floors, and ceilings, and cutting of floor slabs and slabs on grade.
 13. Waterproofing where necessary for installation under this Division.

14. Cooperation with and assistance to the Facilities Monitoring and Control System Contractor as required to provide a complete and functional plumbing system.
15. Counterflashing of roof penetrations for work of Division 22.
16. Sizes, and locations for installation of any curbs and pads for work of Division 22.
17. Temporary and permanent stands and supports for equipment requiring them including vibration isolation.
18. Temporary protection of existing installation.
19. Stenciling and equipment identification.
20. Firestopping of penetrations of ducts, piping, and conduits through walls, floors, and ceiling assemblies.
21. Temporary utilities as required to install work on Division 22 including lighting, water, gas, electricity, etc.
22. Fees, permits, inspections, taxes, and approach from agencies that have jurisdiction over installation of Division 22.
23. Participation in and coordination with the Commissioning process.
24. Warranty.

1.3 SUBMITTALS

- A. Submit under provisions of Division 01 – General Conditions.
- B. Product Data: Submit manufacturer's technical product specification sheets for each system component and device to be provided that includes data needed to prove compliance with this specification. Clearly indicate the exact model of each component to be provided.
- C. Shop Drawings: The Subcontractor shall submit for approval shop drawings prepared in accordance with Section 01 33 00 – Submittal Procedures and as required by other Sections of these specifications.
 1. Shop drawings shall be drawn to a scale of 1/4 inch = 1 foot (1:25) or larger, and shall include complete dimensions, locations, elevations, and clearances for plumbing, piping, ductwork, equipment, and valve numbers.
 - a. Prepare in Revit 2024 format or as otherwise directed.

- b. Identify equipment using designations shown on the Contract Documents or as directed by the Owner's Representative. Do not proceed with identifications without approval from the Owner's Representative.
- 2. All shop drawings shall clearly call out in bold letters and cloud symbols deviations from the specifications and contract documents, no matter how minor.

D. Coordination Drawings:

- 1. Obtain drawings from the structural, electrical, sprinkler, plumbing, sheet metal, concrete, steel, and dry wall trades.
- 2. Hold regular coordination sessions with trades until coordination issues are resolved.
- 3. Prepare separate composite coordination drawings to a scale of 1/4 inch = 1 foot (1:25) or larger, showing work of Divisions to demonstrate coordination, clearance, access, etc. between ductwork, equipment, temperature controls, cable trays, conduits, light fixtures, piping, plumbing, structural elements, architectural elements, etc. These drawings are to be the basis for the detailed shop drawings and need not be submitted, but are to be available for review upon request.
 - a. Prepare floor plans, elevations, and details to indicate penetrations in floors, walls, and ceilings and their relationship to other penetrations and installations.
 - b. Each trade is to adjust their shop drawings based on the outcome of coordination sessions.
- 4. Indicate locations where space is limited for installation and access and where sequencing and coordination of installations are of importance to the efficient flow of the Work.
- 5. Indicate scheduling, sequencing, movement, and positioning of large equipment into the building during construction.
- 6. Indicate the proposed locations, of piping, ductwork, equipment, and materials. Include the following:
 - a. Clearances for installing and maintaining insulation.
 - b. Clearances for servicing and maintaining equipment, including specific ceiling tile or ceiling access panel access and space for equipment disassembly required for periodic maintenance.
 - c. Equipment connections and support details.

- d. Fire-rated wall and floor penetrations.
 - e. Sizes and location of required concrete pads and bases.
 - f. Valve stem movement.
 - g. Sizes and locations of new and existing equipment support curbs on roof.
 - h. Sizes and locations of new openings, either sleeved, cut, or core-drilled, in new concrete construction unless specifically shown on the Structural Drawings.
- 7. Maintain one complete set of composite coordination drawings at the job site. Periodically update drawings based on actual field conditions.
 - 8. Submit final coordination drawings as part of record document requirements.
- E. Submit manufacturer's operation and maintenance manuals in compliance with Section 07 78 23 – Operation and Maintenance Data. Include a list of spare parts that the manufacturer recommends the Owner purchase.
 - F. Lateral Force Anchorage: Submit lateral force anchorage calculations and details of anchorage of components to building including backing design. Calculations shall be sealed by a Structural Engineer registered in the State or Commonwealth in which the project is located.
 - G. Record Documents: Upon completion of the work covered by this Contract, as directed, furnish as-built drawings as specified in Division 01. Include changes installed under this Contract which are not in accordance with the Contract Drawings. Note that these as-built drawings are to be based on the Contract Drawings. In addition, submit final copies of the Shop Drawings and Coordination Drawings.

1.4 QUALITY ASSURANCE

- A. Materials and Equipment: materials and equipment shall be new. Materials and equipment for which tests have been established by Underwriter's Laboratories, Inc. shall be approved by that body and shall bear its label of approval.
 - 1. The first named manufacturer and product is the basis of design. Other manufacturers and/or products are considered as substitutions.
- B. In lieu of listing by an approved testing laboratory, consideration will be given to certified test reports of an adequately equipped, recognized independent test laboratory competent to perform such testing indicating conformance to requirements of the applicable Underwriter's Laboratories, Inc. standards.

- C. Unless otherwise approved by the Project Manager, the materials to be furnished under this specification shall be the standard products of manufacturers regularly engaged in the production of such equipment equal to or superior to the material specified, and shall be the manufacturer's latest standard design that complies with the specification requirements.
- D. Approval of Materials:
 - 1. Division 01 – General Conditions requirements for Materials and Equipment and Submittals.
 - 2. A complete list of materials and equipment proposed shall be submitted to the Project Manager for approval. The list shall include for each item: the manufacturer, the manufacturer's catalog number, type or class, the rating, capacity, size, etc.
 - 3. Before installation of the equipment, the Subcontractor shall submit for approval detailed construction drawings for each item of fabricated equipment required for installation. Drawings shall be to scale and fully dimensioned and shall provide sufficient detail to clearly indicate the arrangement of equipment and its components.
 - 4. Installation of approved substituted equipment is the Subcontractor's responsibility, and changes required to work included under other divisions for installations of approved substituted equipment must be made to the satisfaction of the Owner's Representative and without change in contract price. Approval by the Owner's Representative of substituted equipment and/or dimension drawings does not waive these requirements.

1.5 START-UP TRAINING

- A. Prepare a formal training program for operating staff prior to the scheduled start-up date. The program will consist of the design, start-up, and operation of the mechanical, plumbing, fire protection, and building automation systems. Coordinate the training program with the production of the operation and maintenance manuals. Provide indexed binder and training materials to each participant.
- B. Provide 16 hours (unless specified otherwise) of on-site training in the operation and maintenance for installed system and major piece of equipment. Systems include boilers and heating hot water system, chillers and chilled water system, plumbing, fire protection, air supply and exhaust systems, air conditioning units, balancing, and Facilities Monitoring and Control System. Trainers shall be experienced, manufacturer-approved personnel.
 - 1. Schedule training for each system in advance with the Owner's Representative.
 - 2. Include travel, per diem and incidental costs for personnel under contract to the Subcontractor.

3. Operations and Maintenance data to be available for training sessions.

1.6 RULES AND REGULATIONS

- A. See Division 01.
- B. Provide work and materials in full accordance with the latest rules of the organizations listed in Division 01 and in other Sections of Division 22, and with prevailing rules and regulations pertaining to adequate protection and/or guarding of moving parts, or otherwise hazardous locations.
- C. Whenever the Drawings and Specifications require something which will violate the regulations, the regulations shall govern. Review the Drawings and Specifications, and request from the Owner's Representative clarification or revision of portion of the work in violation of the rules or regulations prior to installing the work. Necessary installation alteration required for compliance shall be made at no additional cost to the Owner.
- D. Whenever the Drawings and Specifications require larger sizes, or higher standards than are required by the regulations, the Drawings and Specifications shall govern.
- E. Strictly conform to the requirements of the National Fire Protection Association, National Electrical Code, International Building Codes, OSHA, Fire Marshal, and insurance underwriters' requirements. expenses required shall be borne under this Contract.

1.7 PROTECTION OF EQUIPMENT

- A. Protect, handle, and store products under provisions of Division 01.
- B. Assume responsibility for damage to of the work or premises before substantial completion. Should new or existing equipment become damaged, restore it to its original condition and finish before final acceptance. Damage incurred to the property or to the work of other Divisions, caused by this Division, shall be replaced or repaired by, and at the expense of, the Subcontractor to the satisfaction of the Owner's Representative. Exposed materials shall be clean at the time of acceptance of the project.

1.8 SCHEDULING AND SEQUENCING

- A. Cooperate with other trades in putting this installation in place at a time when space required is accessible, and in such a manner that other work in this space may be installed as shown on the Drawings. Schedule work and cooperate with the others to avoid delays, interferences, and unnecessary work, conforming to the construction schedule, making the installation when and where directed.
- B. Include labor and materials to install certain items furnished under this contract when required by the schedule. These items are part of this contract but may need to be installed only after completion of work under another contract which this contractor may or

may not be participating in. It is the responsibility of this contract to coordinate with others to ensure that preparations are made and ready to accept the installation of these items. These items include, but are not limited to:

1. Air inlets and outlet
 2. Temperature sensors.
 3. Monitoring and control panels.
 4. Sprinkler heads.
- C. If a discrepancy is discovered between engineering and architectural Drawings, whether with respect to a significant variance between location, variation in quantity, or violation of code requirements, notify Architect for clarification and do not proceed with the work affected until clarification has been made.
- D. Schedule work in advance with the Owner's Representative. No system shall be shut-down unless approved in writing.

1.9 TEMPORARY USE

- A. Should it become necessary to use the new portion of the system and the new equipment to warm or air condition part of the building before the completion of this work, the Owner reserves the right to make use of same at its own risk and expense, but the temporary use of the equipment shall not constitute an acceptance of the plant or part thereof in way. The Owner will bear the cost of fuel and electrical current for such temporary use of the equipment. If temporary use of new systems or equipment is solely for the benefit of the contractor, contractor shall bear the cost of fuel and electrical current for such temporary use.

1.10 WARRANTY

- A. Comply with Division 01 – General Conditions.
- B. Provide extended warranties where specifically required in subsequent sections of Division 22.

PART 2 – PRODUCTS

2.1 GENERAL

- A. In addition to material and equipment specified, provide incidental materials to effect a complete installation. Such incidental materials include solders, tapes, caulking, mastics, gaskets and similar items.

- B. Materials and equipment shall be uniform throughout the installation. Equipment of the same type shall be of the same manufacturer. materials and equipment shall be new.

2.2 MATERIALS AND SUBSTITUTIONS

- A. Comply with Division 01 – General Conditions.

PART 3 – EXECUTION

3.1 EXAMINATION OF SITE

- A. Examine the site and become familiar with conditions that may affect the work covered by this Division of the Specifications.
- B. Arrange to meet with the Owner's Representative at the job site before the work is started and discuss with them the various phases of the work and the procedure and preparation for testing and adjusting the systems.
- C. The general arrangement and location of piping ductwork, apparatus, etc., is shown on the Drawings or herein specified. Minor changes may be necessary to accommodate other work, new or existing, that may conflict with this work. Install this work in harmony with these trades and fully coordinate work.
- D. Visit the site of the work, take measurements, examine areas where work is to be performed and get such other information necessary for proper execution of the work. Ascertain and check conditions with the Drawings and Specifications, other trades, existing conditions and by what means the work is to be performed. No allowance shall subsequently be made for extra expense due to failure or neglect to make such examination and correlation. Where revisions or changes in the existing work are required to permit the installation of new work, they shall be made at no additional cost to the Owner. No allowance shall be subsequently made for error or omission.

3.2 ACCURACY OF DATA

- A. The Drawings indicate the general arrangement and location of piping, ducts, and equipment. Should it be necessary to deviate from arrangement or location indicated in order to meet architectural conditions or site conditions, or due to interference with other work, make such deviations as offsets, rises and drops in piping and ducts that may be necessary, whether shown or not, without extra expense to the Owner. Extreme accuracy of the data given herein and on the Drawings is not guaranteed. The Drawings and Specifications are for the assistance and guidance of this Section and exact locations, distances, and elevations shall be governed by actual site conditions.

3.3 COORDINATION ITEMS

A. Coordinate mechanical work with that of other trades in order to:

1. Avoid interferences between general construction, mechanical, electrical, structural and other specialty trades.
2. Maintain clearances and advise other trades of clearance requirements for operation, repair, removal and testing of mechanical equipment.
3. Indicate aisleways and accessways required on coordinated shop drawings for roof equipment area, mechanical equipment rooms, data and telecomm rooms, corridors, ceiling spaces, shafts, corridors, ceiling space, laboratories, etc.

B. Understanding of Work:

1. Study, examine, and compare of the contract documents, including drawings and specifications. The Subcontractor shall have a full understanding of how the work in this part is scheduled, phased, and installed with work of other trades.
2. Include in this installation piping, ductwork, devices, and equipment that are necessary for complete and operating systems as specified and as required.
3. Connect piping and ductwork from fixtures, outlets, and devices full size to the nearest suitable main or riser.
4. Certain installations may be presented as typical, and full details are not repeated for each case. Subcontractor shall provide complete installation as if full details apply to each and every case and make adjustments to typical details to suit each specific installation as part of the basic work.
5. Installation of work presented on the diagrams are applicable to the plans, and work depicted on the plans are applicable to the diagrams.
6. If there is a discrepancy in the drawings or specifications, the contractor shall figure the work based on the most stringent requirements to complete the installation and obtain clarification from the Architect before installation.

C. Sequence, coordinate, and integrate the various elements of mechanical systems, materials, and equipment. Comply with the following requirements:

1. Coordinate mechanical systems, equipment, and materials installation with other building components.
2. Verify dimensions by field measurements.

3. Arrange for chases, slots, and openings in other building components during progress of construction, to allow for mechanical installations.
4. Coordinate the installation of required supporting devices and sleeves to be set in poured-in-place concrete and other structural components, as they are constructed.
5. Sequence, coordinate, and integrate installations of mechanical materials and equipment for efficient flow of the Work. Give particular attention to large equipment requiring positioning prior to closing in the building.
6. Where mounting heights are not detailed or dimensioned, install systems, materials and equipment to provide the maximum headroom possible. Work shall be above ceilings or ceiling line.
7. Coordinate installation and connection of mechanical systems with exterior underground and overhead utilities and services. Comply with requirements of governing regulations, franchised service companies, and controlling agencies. Provide required connection for each service.
8. Install systems, materials, and equipment to conform with approved submittal data, including coordination drawings, to greatest extent possible. Conform to arrangements indicated by the Contract Documents, recognizing that portions of the Work are shown only in diagrammatic form. Coordinate with individual system requirements.
9. Install systems, materials, and equipment level and plumb, parallel and perpendicular to other building systems and components, where installed exposed in finished spaces.
10. Install mechanical equipment to facilitate servicing, maintenance, and repair or replacement of equipment components. As much as is practical, connect equipment for ease of disconnecting, with minimum of interference with other installations. Extend grease fittings to an accessible location.
11. Install systems, materials, and equipment giving right-of-way priority to systems required to be installed at a specified slope.
12. Coordinate with the locations of electrical panels and avoid installing piping and ductwork over them. Electrical panels are purposely located and have priority for location. The contractor is responsible for required piping and ductwork offsets to ensure that the panels are located as designed and for other conditions.
13. Perform system modification recommended by Test and Balance Agency after recommendations are accepted by the Owner's Representative.

3.4 WORKMANSHIP AND SUPERVISION

- A. Comply with of the following:
- B. General Requirements: Division 01 – General Conditions
- C. Special Requirements: .
 - 1. Measurements: Materials installed shall be to exact field measurements.
 - 2. The installation depicted on the Drawings is designed to fit tightly into work under other Sections or Divisions. It is the essence of this Contract that work be completely coordinated with other Sections or Divisions, and that locations of pipes and ducts be exactly determined in the field and cleared with other Sections or Divisions before the installation of these items is begun. No extra compensation will be made for failure to observe this clause.
 - 3. Adequate clearance for access to operable devices and automatic devices and for access to lubrication points shall be maintained in portions of the work including ductwork and piping installed on the roof. Tripping hazards shall be avoided.
 - 4. Provide architectural access doors where shown and where required for access to equipment and operable devices.
 - 5. Gauges, thermometers, and other indicating devices shall be installed so that they can be easily read from the floor.

3.5 MATERIAL DELIVERY AND STORAGE

- A. Comply with Section 01 65 00 – Product Delivery Requirements.
- B. Comply with Section 01 66 00 – Product Storage and Protection Requirements.

3.6 INSTALLATION

- A. Manufacturer's Directions: Follow manufacturer's directions covering points not shown on the drawings or specified herein. Manufacturer's directions do not take precedence over drawings and Specifications. Where these are in conflict with the drawings and Specifications, notify the Project Manager for clarification before installing the work.
- B. Carpentry, Cutting, Patching, and Core Drilling:
 - 1. Provide carpentry, cutting, patching, and core drilling required for installation of material and equipment specified in this Division.
 - 2. No penetrations shall be sleeved, cut, or core drilled through concrete construction without a submittal indicating exact locations and sizes and specific written

approval from the Owner's Representative or unless specifically shown on the Structural Drawings.

3. It is the Subcontractor's responsibility to accurately size and locate openings through the structure. The dimensions shown on the Structural Drawings are for general information only. Provide specific sizes, dimensions, requirements, etc.

C. Waterproof Construction:

1. Maintain waterproof integrity of penetrations of materials intended to be waterproof. Provide flashings at exterior roof penetrations. Caulk penetrations of foundation walls and floors watertight. Provide membrane clamps at penetrations of waterproof membranes.
2. Provide waterproof NEMA 3R enclosures for equipment or devices mounted outside or otherwise exposed to the weather.

D. Sleeves, Stubs, and Slab Penetrations: Section 22 05 29 – Hangers and Supports for Plumbing Piping and Equipment.

E. Painting of Mechanical Equipment and Hardware:

1. Comply with applicable Division 09 sections for paints and coatings.
2. Provide moisture resistant paint for exterior painting.
3. Colors shall be as shown on the drawings unless specified.
4. Comply with individual Sections for other equipment to be painted.
5. Repair damaged galvanizing, paint, or coatings. Use Z.R.C. (no known equal) cold galvanized compound for galvanized repairs.

F. Concrete Equipment Bases:

1. All equipment located on concrete floor inside the building or on grade outside the building, shall be mounted on a concrete base. The concrete base shall be four inches high and shall extend six inches beyond the edge of equipment base unless indicated otherwise on drawings.
2. Coordinate concrete bases: Concrete bases indicated on Architectural or Structural drawings are specified in other Divisions. Concrete bases not on Architectural or Structural drawings are requirements of this Division.

3.7 PIPING AND EQUIPMENT IDENTIFICATION

- A. Comply with Section 22 05 53 – Identification for Plumbing Piping and Equipment.

3.8 SHUTDOWN AND SCHEDULING

- A. Comply with Division 01.

3.9 PROTECTION OF EQUIPMENT

- A. Care shall be exercised during construction to avoid damage or disfigurement. Equipment shall be protected from dust and moisture prior to and during construction. The Subcontractor is cautioned that concrete finishing, painting, etc. in electrical rooms shall not proceed if unprotected equipment is installed.
- B. Where required or directed, construct temporary protection for equipment and installations for protection from dust and debris caused by construction.
- C. All protection shall be substantially constructed with the use of clean canvas, heavy plastic, visqueen and plywood as required, and made tight and dust proof as directed.
- D. The Subcontractor shall repair by spray or brush painting, after properly preparing the surface, scratches or defects in the finish of the equipment. Only identical paint furnished by the equipment manufacturer shall be used for such purposes.
- E. Failure of the Subcontractor to protect the equipment as outlined herein shall be grounds for rejection of the equipment and its installation.

3.10 INSPECTIONS

- A. Comply with Division 01.

3.11 REMOVED EQUIPMENT AND MATERIALS

- A. Comply with Division 01.

3.12 CLEANING

- A. Comply with Division 01.

3.13 LUBRICATION

- A. All lubrication points shall be accessible. Where this is impossible, provision shall be made for lubrication at an accessible location. Where oil is used, an oil level indicator and capped, vented filling connection shall be provided and firmly mounted in an accessible space and shall be connected to the bearing with pipe(s) as required. Where grease is used for lubricant, the pipe shall have a suitable lubricating fitting installed at

the accessible end. Equipment shall be thoroughly lubricated before operation and at time work is accepted.

3.14 SEALANTS

- A. See Division 07 Sections for sealing duct, pipe, and conduit penetrations through walls, partitions, and floors.
- B. Completely seal duct, pipe and conduit penetrations through rated and non-rated walls.

3.15 TESTS

- A. Upon completion of the mechanical construction work, perform tests and provide test reports as specified in this and other Sections.
 - 1. All tests shall be made in the presence of a representative of the Project Manager. The application or interruption of mechanical utilities shall be programmed and directed by the Project Manager.
 - 2. The Subcontractor shall submit to the Project Manager 3 copies of test results, certified in writing, witnessed, signed and dated, immediately upon completion of work. Unsatisfactory condition revealed by these test results, or unsatisfactory methods of tests and/or testing apparatus and instruments, shall be corrected by the Subcontractor to the satisfaction of the Project Manager.
 - 3. The Project Manager reserves the right to require that the Subcontractor perform and repeat tests that are deemed necessary to complete or check the tests or the certified records of the Subcontractor during the course of the work. Correct unsatisfactory portion of its work that is revealed by the tests or that may be due to progressive deterioration during this period, unless the item in question was a direct specification.

3.16 MAINTENANCE AND OPERATING INSTRUCTIONS AND TRAINING

- A. Refer to Division 01 – General Conditions for maintenance and operating instructions, and training requirements.
- B. At time of occupancy, arrange for manufacturer's representatives to instruct operating and maintenance personnel in the use of equipment requiring operating and maintenance. Arrange for personnel to be instructed at one time. Costs for this service shall be included in the Subcontract.
- C. Maintenance and operating instructions and training for Owner-furnished equipment will be provided by the equipment vendor. The Subcontractor shall be responsible for other equipment.

END OF SECTION

SECTION 22 05 29
HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT

PART 1 – GENERAL

1.01 SUMMARY

A. Related Documents:

1. Drawings and general provisions of the Subcontract apply to this Section.
2. Review these documents for coordination with additional requirements and information that apply to work under this Section.

B. Section Includes:

1. Pipe, duct, and equipment hangers and supports.
2. Anchors, equipment bases and supports.
3. Sleeves and seals.
4. Flashing, counter flashing and pipe stacks.
5. Firestopping.

C. Related Sections:

1. Division 01 – General Conditions.
2. Section 01 73 23 – Anchorage and Bracing of Non-Structural Components for seismic bracing of ductwork and piping.
3. Division 03 Section – Concrete.
4. Section 03 11 00 – Concrete Formwork.
5. Section 03 15 00 – Concrete Accessories.
6. Section 07 84 00 – Firestopping.
7. Section 07 90 00 – Joint Fillers, Sealants and Caulking.
8. Section 22 07 19 – Plumbing Piping Insulation.

03-28-2022

1.02 REFERENCES

A. General:

1. The following documents form part of the Specifications to the extent stated. Where differences exist between codes and standards, the one affording the greatest protection shall apply.
2. Unless otherwise noted, the referenced standard edition is the current one at the time of commencement of the Work.
3. Refer to Division 01 – General Conditions for the list of applicable regulatory requirements.
4. Refer to Section 22 05 00 – Common Results for Plumbing for codes and standards and other general requirements.

B. Code of Federal Regulations 29 CFR 1910.7:

1. Definitions and Requirements for a Nationally Recognized Testing Laboratory (NRTL).

C. National Fire Protection Association (NFPA)

1. NFPA-13 Installation of Sprinkler Systems
2. NFPA-14 Installation of Standpipe and Hose Systems

D. Sheet Metal and Air Conditioning Contractors' National Association, Inc. (SMACNA):

1. Seismic Restraint Manual: Guidelines for Mechanical Systems - latest edition for the support of ductwork.

E. Section 01 73 23 – Anchorage and Bracing of Non-Structural Components for seismic bracing of ductwork and piping.

F. UL Fire Resistance Directory, latest edition.

1.03 SUBMITTALS

- A. Submit under provisions of Section 22 05 00– Common Results for Plumbing - Review of Materials and Division 01 – General Conditions.
- B. Submit calculations showing compliance with Section 01 73 23 – Anchorage and Bracing of Non-Structural Components, for piece of equipment whether supported or braced from above or below.

- C. Submit calculations showing compliance with Section 01 73 23 – Anchorage and Bracing of Non-Structural Components for seismic bracing of ductwork and piping.
- D. Submit shop drawing of hanger and support spacing, framing and attachment methods.
- E. Submit firestopping systems for every application.

1.04 QUALITY ASSURANCE

- A. Comply with the following:
 - 1. Supports for Sprinkler Piping: NFPA 13.
 - 2. Supports for Standpipes: NFPA 14.
- B. Do not use black steel devices, components, fasteners, etc. within the Clean Room interstitial space or in related air flow path. Steel items shall be plated, galvanized, painted, or coated.

PART 2 – PRODUCTS

2.01 PIPE HANGERS AND SUPPORTS

- A. Hangers and supports in non-chemical areas shall be hot dipped galvanized steel. Hangers and supports in chemical areas shall be stainless steel 300 series.
- B. Hangers for Pipe Sizes ½ (12.7 mm) to 1-1/2 Inch (38 mm): Galvanized steel, adjustable swivel ring, UL listed, Grinnell Fig. 69 or equal. Use plastic coated hangers at all uninsulated copper piping.
- C. Hangers for Pipe Sizes 2 Inches (50.8 mm) and Cold Pipe Sizes 6 Inches (152.4 mm) and Over: Galvanized steel, adjustable, clevis, UL listed, Grinnell Fig. 260 or equal.
- D. Hangers for Hot Pipe Sizes 6 Inches (152.4 mm) and Over: Adjustable steel yoke, cast iron roll, double hanger.
- E. Trapeze Supports: 12 gauge channel complete with nuts, pipe clamps, pipe straps, and drive-in end caps. Furnish cushion strip on all uninsulated copper piping and; cast iron roll and stand for hot pipe sizes 6 inches and over.
- F. Pipe Supported Tight to Wall, Floor, or Ceiling: Superstrut A1200, Unistrut P1000, or equal, 12 gauge channel complete with pipe clamps, nuts, bolts, and end caps. Furnish cushion strip on all uninsulated copper piping. and adjustable steel yoke and cast iron roll for hot-pipe sizes 6 inches and over.

- G. Vertical Support: Galvanized Steel riser clamp, UL listed, Grinnell Fig. 261, Superstrut C720, or equal.
- H. Floor Support for Pipe Sizes to 4 Inches (101.6 mm) and Cold Pipe Sizes: Cast iron adjustable pipe saddle, locknut nipple, floor flange, and concrete pier or steel support.
- I. Floor Support for Hot Pipe Sizes 6 Inches (152.4 mm) and Over: Adjustable cast iron roll and stand, steel screws, and concrete pier or steel support.
- J. Shield for Insulated Piping 2 Inches and Smaller: 18-gauge (1.31 mm) galvanized steel shield over insulation in 180 degree segments, at least 12 inches (300 mm) long at pipe support.
- K. Pipe Shields: Pipe Shields Inc., FRI, or equal, pipe hanger shield with waterproofed calcium silicate insulation encased in a galvanized metal casing completely around the pipe. Provide insulation same thickness as pipe insulation. Furnish the following models:
 - 1. Chilled Water: A2000 with calcium silicate insulation extending 1 inch (25 mm) beyond the metal casing.
 - 2. All others: A1000.
- L. Concrete Anchors: In accordance with Section 03 15 00 – Concrete Accessories.

2.02 HANGER RODS

- A. Steel, threaded both ends, threaded one end, or continuously threaded.

2.03 ATTACHMENTS TO STRUCTURE

- A. Inserts for new formed concrete construction: Malleable iron case of galvanized steel shell and expander plug for threaded connection with lateral adjustment, top slot for reinforcing rods, lugs for attaching to forms; size inserts to suit threaded hanger rods. For Suspension from New Formed Concrete Structure: Grinnell Figure 282, Superstrut 452, or equal, UL listed for the rod sizes, Grinnell, Fig. 282, Superstrut 452, or equal.
- B. Connection to Existing Concrete Structure: Hilti Kwik-Bolt, Phillips or equal, wedge type expansion anchors. Powder-driven fasteners may be used only for flexible duct, metal duct up to 16 inches (400 mm) round (or rectangular equivalent), and for air inlet and outlet wire seismic braces, and only within the parameters of the fastener's ICBO report. Provide current ICBO report. Do not use powder-driven fasteners for pipes or conduits.
- C. For Suspension from New Formed Concrete Structure: B-Line B3014, Grinnell Figure 282, Superstrut 452, or equal, adjustable concrete insert.
- D. For Support on New Concrete: Galvanized steel headed bolts.

- E. Welded Connection to Steel Beams: B-Line B3083, Grinnell, Superstrut, or equal, steel welded beam attachment.
- F. Clamp Connection to Steel Beams: B-Line, Grinnell, Superstrut, or equal, beam clamp with retaining clip style as required by load.

2.04 SUPPORTS, BRACING, AND ACCESSORIES

- A. Miscellaneous Steel: Angles, channels, brackets, rods, clamps, etc., of new materials conforming to ASTM A36. Hot-dip galvanize steel parts after fabrication where used outdoors or inside the penthouse.
- B. Fasteners: Bolts and nuts, except as otherwise specified, shall conform to ASTM Standard Specifications for Low Carbon Steel Externally and Internally Threaded Standard Fasteners, Designation A307. Bolts shall have heavy hexagon heads, and nuts shall be of the hexagon heavy series. Bolts, washers, nuts, anchor bolts, screws and other hardware used outdoors or inside the penthouse shall be galvanized, and galvanized nuts shall have a free running fit. Provide bolts of ample size and strength for the purpose intended. Ferrous metal components below grade shall be stainless steel.
- C. Sheet Metal Screws: Plated, size 10 minimum.
- D. Pre-engineered duct and pipe bracing systems may be Mason Industries Seismic Sway Brace System or equal.

2.05 COUNTER FLASHING

- A. Metal Flashing: 26-gauge galvanized steel.
- B. Flexible Flashing: 47-mil thick sheet butyl; compatible with roofing.
- C. Caps: Steel, 16 gauge.

2.06 EQUIPMENT CURBS

- A. See Architectural and Structural Drawings for the design detail of the equipment curb.

2.07 SLEEVES

- A. Adjust-To-Crete, AMI Products, or equal, 24 gauge, electro-galvanized adjustable sleeve, up to 6" diameter. For 8 inches (200 mm) and larger, provide galvanized standard weight steel pipe sleeves
- B. Sleeves for Round Ductwork: Form with galvanized steel.
- C. Sleeves for Rectangular Ductwork: Form with galvanized steel or wood.

- D. Caulk: Acrylic sealant of quality specified in Section 07 90 00 – Joint Fillers, Sealants and Caulking.

2.08 FIREPROOFING OF FLOOR AND WALL PENETRATIONS

- A. Materials and installation shall comply with U.L. Fire Resistance Directory, for Through-Penetration for Firestop Devices, latest edition. See Section 07 84 00 – Firestopping.

2.09 FABRICATION

- A. Size sleeves large enough to allow for movement due to expansion and contraction. Provide for continuous insulation wrapping.
- B. Design hangers for installation without disengagement of supported pipe.

2.10 FINISH

- A. Prime-paint exposed steel hangers and supports. Hangers and supports located in crawl spaces, pipe shafts, and suspended ceiling spaces are not considered exposed.
 - 1. Steel in the Clean Room interstitial space is considered exposed.
- B. Hot-dip galvanized outdoors.
 - 1. Repair damage to galvanizing at welds, scratches, etc. using Z.R.C. (no known equal) cold galvanizing compound.

PART 3 – EXECUTION

3.01 ATTACHMENTS TO STRUCTURE

- A. Concrete Structure: Locate anchors from Edge condition and at a spacing to obtain maximum working loads specified in the applicable ICC report.
 - 1. See structural drawings for additional restrictions for locating anchors.
- B. Steel Structure: Attach at beam axis. Avoid eccentric loads wherever possible.
- C. Rating: Ultimate strength at least five times the imposed load.
- D. Submit for structural review pipe hanger locations, point loads and structural attachment details for pipes 6" and larger.
- E. Coordinate installation so that attachments to structure are made prior to fireproofing. If attachments must be made after fireproofing, then thoroughly clean area of fire proofing

before welded or bolted attachments are made and replace fireproofing as necessary. Fireproofing material shall match existing.

- F. Where point loads, imposed by work of Division 22, are greater than can safely be carried by the roof or deck, provide structural steel spreader beams tied to the building structure. Submit details of such spreader beams for approval.
- G. Inserts:
 - 1. Furnish inserts to Division 03 Sections – Concrete and Concrete Forming for placement in concrete form work.
 - 2. Furnish inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams.
 - 3. Furnish hooked rod to Division 03 Sections – Concrete and Concrete Forming for inserts carrying pipe larger than 4 inches (100 mm).
 - 4. Where concrete slabs form finished ceiling, furnish inserts to be flush with slab surface.
 - 5. Where inserts are omitted, submit an attachment plan to the Owner's Representative.

3.02 SUPPORTS, BRACING, AND ACCESSORIES

- A. Common support systems: This Section is responsible for the provision, coordination, calculations, and seismic bracing of support systems common to Division 22 work. Individual section shall provide their own horizontal support struts. Division 23 shall coordinate with other divisions of all aspects of hanger installation, horizontal strut installation, pipe/conduit/cable tray/etc. installation, seismic bracing installation, and so on.
- B. Set machines and devices dead level, except where pitch or slope is specified or shown. Securely fasten to the structure unless shown otherwise. Use dry pack cement grout to obtain complete contact between structure and equipment.
- C. This Section is responsible for the concrete work for the support of equipment provided by this Section. Coordinate locations with anchor bolts before concrete is placed.
- D. Pipe Hangers and Supports:
 - 1. Support horizontal piping as follows:

Pipe Size	Maximum Hanger Spacing	Hanger Diameter
1/2 to 1-1/4 inch (12.7 to 31.75 mm)	6 feet 6 inches (2 m)	3/8 inch (9.5 mm)
1-1/2 to 2-inch (38.1 to 50.8 mm)	10 feet (3 m)	3/8 inch (9.5 mm)
2-1/2 to 3-inch (63.5 to 76.2 mm)	10 feet (3 m)	1/2 inch (12.7 mm)
4 to 6-inch (101.6 to 152.4 mm)	10 feet (3 m)	5/8 inch (15.9 mm)
8 to 12-inch (203.2 to 304.8 mm)	14 feet (4.25 m)	7/8 inch (22.2 mm)
PVC (All sizes)	6 feet (1.8 m)	3/8 inch (9.5 mm)
C.I. Bell and Spigot (or No-Hub)	5 feet (1.5 m) at joints	3/8 inch (9.5 mm)

2. Install hangers to provide at least 1/2 inch (13 mm) space between finished covering and adjacent work.
3. Place a hanger within 12 inches (300 mm) of each horizontal elbow.
4. Use hangers with at least 1-1/2 inch (38 mm) vertical adjustment.
5. Support horizontal cast iron pipe adjacent to each hub, with 5 feet (1.5 m) maximum spacing between hangers.
6. Support vertical piping at every floor. Support vertical cast iron pipe at each floor at hub.
7. Where several pipes can be installed in parallel and at same elevation, provide multiple or trapeze hangers. Use specified pipe shields (if applicable). Trapeze size, and support size and spacing shall be governed by the cumulative weight of the supported piping. Maximum trapeze deflection shall be 1/240th of the span on a maximum stress of 15,000 psi (103.5 MPa), whichever is more stringent.
8. Support riser piping independently of connected horizontal piping.
9. Brace piping longitudinally and transversely as specified and indicated on the drawings. Support pipe from the building structure so that there is no apparent deflection in pipe runs. Fit piping with steel sway braces and anchors to prevent vibration and/or horizontal displacement under load when required. Do not support from, or brace to, ducts, other pipes, conduit, or materials except building structure. Piping or equipment shall be immobile and shall not be supported or hung by wire, rope, plumber's tape, plastic ties, or blocking of any kind. Vertical piping running between floors shall be additionally supported at mid points in a rigid and immobile fashion. Exposed or concealed piping which can be physically moved, and which is not properly supported will not be accepted, and additional support or

bracing will be required. Install seismic bracing as at locations as specified in the contract drawings.

10. Install and secure equipment with anchors and braces to floors, structural members and walls with sufficient backing, to prevent vibration and/or horizontal displacement under load and seismic force as hereinbefore specified. Follow manufacturer's recommendations for the installation of vibration isolators where required for equipment requiring such.

E. Equipment Bases and Supports:

1. Comply with Division 03 Sections – Concrete and Concrete Forming for concrete bases.
2. Provide templates, anchor bolts, and accessories for mounting and anchoring equipment.
3. Construct support of steel members. Brace and fasten with flanges bolted to structure. Level equipment installed on steel rails using shims to compensate for the deflection of the steel.
4. Provide rigid anchors for pipes after vibration-isolation components are installed.

F. Counter Flashing:

1. See Architectural Drawings for flashings.
2. Provide flexible flashing and metal counterflashing where piping and ductwork penetrate weatherproofed or waterproofed walls, floors, and roofs.
3. Counterflash vent and soil pipes projecting at least 3 inches (75 mm) above finished roof surface with lead worked at least 1 inch (25 mm) into hub, at least 8 inches (200 mm) clear on sides using 24 inches (600 mm) by 24 inches (600 mm) sheets. For pipes through outside walls, turn flanges back into wall and caulk, metal counterflash, and seal.
4. Counterflash floor drains in floors with topping over finished areas with lead, 10 inches (250 mm) clear on sides using at least 36 inches by (900 mm) 36 inches (900 mm) sheets. Fasten flashing to drain clamp device.
5. Seal floor, shower, mop sink, and drains watertight to adjacent materials.
6. Provide acoustical-lead flashing around ducts and pipes penetrating equipment rooms, installed in accordance with manufacturer's instructions for sound control.

7. Provide curbs for mechanical roof installations at least 14 inches (350 mm) high above roofing surface. Counterflash with flexible sheet and counterflash with sheet metal; seal watertight.

G. Sleeves:

1. Set sleeves in position in formwork. Provide reinforcing around sleeves.
2. Extend sleeves through floors 1 inch (25 mm) above finished floor level. Caulk sleeves full depth and provide floor plate.
3. Where piping or ductwork penetrates floor, ceiling, or wall, close-off space between pipe or duct and adjacent work with fire-stopping insulation and caulk airtight. Provide close-fitting metal collar or escutcheon covers at both sides of penetration.
4. Install chrome-plated steel escutcheons at finished surfaces.

END OF SECTION

SECTION 22 05 33
HEAT TRACING FOR PLUMBING PIPING

PART 1 – GENERAL

1.01 DESCRIPTION

- A. This Section describes the requirement for supplying, installing, and testing of the electric heat tracing system of the plumbing piping. Freeze protection shall be utilized for domestic water piping in areas subject to freezing temperatures. Ice and snow melting shall be utilized for gutters, downspouts, roof drain bodies and roof drain leaders exposed to snow and ice accumulation.
- B. A complete listing of all acronyms and abbreviations are included in Section 22 05 00 – Common Results for Plumbing.

1.02 RELATED WORK

- A. Division 01 – General Conditions.
- B. Section 01 33 00 – Submittal Procedures.
- C. Section 01 75 00 – Checkout and Startup Procedures.
- D. Section 22 05 00 – Common Results for Plumbing.
- E. Section 22 07 19 – Plumbing Piping Insulation.
- F. Section 26 05 19 – Low-Voltage Conductors and Cables.

1.03 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. The Institute of Electrical and Electronic Engineers (IEEE):
 - 1. 515.1-2012 – Standard for the Testing, Design, Installation, and Maintenance of Electrical Resistance Trace Heating for Commercial Applications
- C. International Code Council, (ICC):
 - 1. IPC-2012 – International Plumbing Code
- D. National Fire Protection Association (NFPA):

1. 70–2011 – National Electrical Code (NEC)

E. Underwriters' Laboratories, Inc. (UL):

1. 508-99 (R2013) – Standard for Industrial Control Equipment

1.04 SUBMITTALS

- A. Submittals, including number of required copies, shall be submitted in accordance with Section 01 33 00 – Submittal Procedures.
- B. Information and material submitted under this Section shall be marked “SUBMITTED UNDER SECTION 22 05 33 – HEAT TRACING FOR PLUMBING PIPING”, with applicable paragraph identification.
- C. Manufacturer's Literature and Data including: Full item description and optional features and accessories. Include dimensions, weights, materials, applications, standard compliance, model numbers, size, and capacity.
 1. Rated capacity.
 2. Length of cable.
 3. Cable spacing.
 4. Electrical power requirements.
 5. Controls.
 6. Enclosures.
 7. Accessories.
- D. The shop drawings shall include plans, sections, details, wiring diagrams, and attachments to other work. The wiring diagrams shall include power, signal, and control wiring.
- E. Field quality control test reports shall be submitted.
- F. Operation and Maintenance data in accordance with Paragraph 1.06.

1.05 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Ten years of experience in design, engineering, manufacture and support of specified system and components.
- B. Product Requirements:

1. Pipe or tank tracing cable assembly shall be factory assembled, immersed in water for a minimum of 12 hours, and then tested for insulation resistance, high potential breakdown and continuity before leaving the factory.
 2. Factory Mutual approved heating cable that has the same wattage per lineal foot (power output), throughout its entire length.
 3. UL Listed, thermostat and contactor panel.
 4. UL Listed Control/Monitor Panel.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

1.06 AS-BUILT DOCUMENTATION

- A. Submit manufacturer's literature and data updated to include submittal review comments, construction revisions and any equipment substitutions.
- B. Submit operation and maintenance data updated to include submittal review comments shall be inserted into a three-ring binder. All aspects of system operation and maintenance procedures, including piping isometrics, wiring diagrams of all circuits, a written description of system design, control logic, and sequence of operation shall be included in the operation and maintenance manual. The operations and maintenance manual shall include troubleshooting techniques and procedures for emergency situations. Notes on all special systems or devices such as damper and door closure interlocks shall be included. A List of recommended spare parts (manufacturer, model number, and quantity) shall be furnished. Information explaining any special knowledge or tools the owner will be required to employ shall be inserted into the As-Built documentation.

PART 2 – PRODUCTS

2.01 SELF-REGULATING PARALLEL RESISTANCE HEATING CABLES

- A. Self-regulating parallel resistance heating cables shall comply with IEEE 515.1.
- B. The heating element shall be a pair of parallel No. 16 AWG nickel coated stranded copper bus wires embedded in cross linked conductive polymer core, which varies heat output in response to temperature along its length. Cables shall be terminated with waterproof, factory assembled non heating leads with connects at one and seal the opposite end watertight. The cable shall be capable of crossing over itself without overheating.

- C. The electrical insulating jacket shall be flame-retardant polyolefin.
- D. The cable cover shall be tinned copper, stainless steel braid ,and polyolefin outer jacket with UV inhibitor.
- E. The maximum power on operating temperature shall be 65 degrees C (150 degrees F).
- F. The maximum power off exposure temperature shall be 85 degrees C (185 degrees F).
- G. The capacities and characteristics shall be:
 - 1. Maximum heat output 16.4 W/m (5.0 W/foot).
 - 2. Pipe Diameter: see plans.
 - 3. Number of parallel cables: per manufacturer.
 - 4. Spiral wrap pitch: per manufacturer.
 - 5. Volts: See ELEC plans.
 - 6. Phase: See ELEC plans.
 - 7. Hertz: 60 Hz.

2.02 CONTROLS

- A. Pipe mounting thermostats for Freeze protection shall have be a remote bulb unit with adjustable temperature range from minus 1 to 10 degrees C (34 to 50 degrees F). The thermostat shall be snap action, open-on-rise, single pole switch with minimum current rating adequate for the connected cable. The thermostat shall be remote bulb on capillary, resistance temperature device, or thermistor for direct sensing of pipe wall temperature. The control enclosure shall be corrosion resistant and waterproof.
- B. The enclosure shall be the NEMA 4X type.
- C. A minimum 30 amp contactor shall be provided to energize cable or close other contactors. Provide relay with contacts to indicate operational status, on/off, and for interface with central energy management and control system.

2.03 ACCESSORIES

- A. Cable Installation Accessories: Fiberglass tape, heat-conductive putty, cable ties, silicone end seals and splice kits, and installation clips all furnished by manufacturer, or as recommended in writing by manufacturer.
- B. Warning Labels: Shall comply with NFPA 70.

- C. Warning Tape: Continuously printed "Electrical Tracing"; vinyl, at least 0.08 mm (3 mils) thick, and with pressure-sensitive, permanent, waterproof, self-adhesive back.
 - 1. Width for Markers on Pipes with Outside Dimension, Including Insulation, Less Than 150 mm (6 inches): 19 mm (3/4 inch) minimum.
 - 2. Width for Markers on Pipes with Outside Dimension, Including Insulation, 150 mm (6 inches) or Larger: 38 mm (1-1/2 inches) minimum.

PART 3 – EXECUTION

3.01 GENERAL

- A. Inspect surfaces and substrates of electric heating cables for compliance with requirements of this specification. Ensure surfaces and pipes in contact with electric heating cables are free of burrs and sharp protrusions.
- B. Notify COR if the existing substrate conditions are unsuitable for application of heating cables in accordance with manufacturer's recommendations.
- C. If the installation of the heat tracing is unsatisfactory, then the Contractor shall correct the installation at no cost to the Owner.

3.02 INSTALLATION

- A. Electric heating cable shall be installed for the following applications:
 - 1. Freeze protection of plumbing piping: Self-regulating parallel-resistance heating cable.
- B. Electric heating cable shall be installed across expansion, construction, and control joints according to the manufacturer's recommendations using cable protection conduit and slack cable to allow for movement without damage to cable.
- C. The installation of electric heating cable for snow and ice melting on roofs, gutters and downspouts, and roof drain leaders shall be provided with clips furnished by the manufacturer that are compatible with roof, gutters and downspouts and roof drain leaders.
- D. Electric heating cable for pipe freeze protection shall be installed according to the following:
 - 1. Electric heating cables shall be installed after piping has been tested and before insulation is installed.
 - 2. Electric heat cables shall be installed according to IEEE 515.1

3. Insulation shall be installed or applied over piping with electric cables. Refer to Section 22 07 19 – Plumbing Piping Insulation.
 4. Warning tape shall be installed on pipe insulation where piping is equipped with electric heating cables.
- E. Field adjustable switches and circuit breaker trip ranges shall be set.
- F. Heating cables including leads shall be protected from damage.
- G. Equipment shall be grounded according to Section 26 05 19 – Low-Voltage Conductors and Cables.
- H. Wiring shall be connected according to Section 26 05 19 – Low-Voltage Conductors and Cables.

3.03 TESTS

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
1. Perform tests after cable installation but before application of coverings such as insulation, wall or ceiling construction, or concrete.
 2. Test cables for electrical continuity and insulation integrity before energizing.
 3. Test cables to verify rating and power input. Energize and measure voltage and current simultaneously.
- C. Repeat tests for continuity, insulation resistance, and input power after applying thermal insulation on pipe-mounted cables.
- D. If deficiency is found, Contractor shall correct all deficiencies at no cost to the Owner.
- E. Prepare test and inspection reports.

END OF SECTION

SECTION 22 07 19
PLUMBING PIPING INSULATION

PART 1 – GENERAL

1.01 SUMMARY

- A. Related Documents: Drawings and general provisions of the Subcontract apply to this Section.
 - 1. Review these documents for coordination with additional requirements and information that apply to work under this Section.
- B. Section Includes:
 - 1. Piping insulation.
 - 2. Jackets and accessories.
- C. Related Sections:
 - 1. Division 01 – General Conditions
 - 2. Section 09 90 00 – Painting for painting insulation jacket.
 - 3. Section 22 05 3 – Identification for Plumbing Piping and Equipment.

1.02 REFERENCES

- A. General:
 - 1. The following documents form part of the Specifications to the extent stated. Where differences exist between codes and standards, the one affording the greatest protection shall apply.
 - 2. Unless otherwise noted, the referenced standard edition is the current one at the time of commencement of the Work.
 - 3. Refer to Division 01 – General Conditions for the list of applicable regulatory requirements.
 - 4. Refer to Section 22 05 00 – Common Results for Plumbing for codes and standards, and other general requirements.
- B. ASTM International:

1. ASTM-B-209 – Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
2. ASTM-C-195 – Standard Specification for Mineral Fiber Thermal Insulating Cement
3. ASTM C 196 – Standard Specification for Expanded or Exfoliated Vermiculite Thermal Insulating Cement
4. ASTM-C-449 – Standard Specification for Mineral Fiber Hydraulic-Setting Thermal Insulating and Finishing Cement
5. ASTM-C-533 – Standard Specification for Calcium Silicate Block and Pipe Thermal Insulation
6. ASTM C534 / C534M – Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form
7. ASTM-C-547 – Standard Specification for Mineral Fiber Pipe Insulation
8. ASTM-C-552 – Standard Specification for Cellular Glass Thermal Insulation
9. ASTM C553 – Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications
10. ASTM-C-578– Standard Specification for Rigid, Cellular Polystyrene Thermal Insulation
11. ASTM-C-610 – Standard Specification for Molded Expanded Perlite Block and Pipe Thermal Insulation
12. ASTM-E-84 – Standard Test Method for Surface Burning Characteristics of Building Material.
13. ASTM C 450 – Standard Practice for Fabrication of Thermal Insulating Fitting Covers for NPS Piping, and Vessel Lagging
14. ASTM C 921 – Standard Practice for Determining the Properties of Jacketing Materials for Thermal Insulation
15. ASTM B 209 – Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
16. ASTM A666 – Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar

- C. Code of Federal Regulations 20-CFR-1910.7 Definitions and Requirements for A Nationally Recognized Testing Laboratory (NRTL)
- D. National Fire Protection Association NFPA-90A & NFPA-255 Surface Burning Characteristics of Building Materials
- E. Underwriters Laboratories UL-723 Surface Burning Characteristics of Building Materials

1.03 SUBMITTALS

- A. Submit under provisions of Section 22 05 00 – Common Results for Plumbing, Review of Materials and Division 01 – General Conditions.
- B. Subcontractor shall submit the product description, list of materials and thickness for each service, and at each location.
- C. LEED Submittals:
 - 1. Product Data for Credit EQ 4.1: For solvent cements and adhesive primers, including printed statement of VOC content.

1.04 QUALITY ASSURANCE

- A. Subcontractor shall assure applicator is a company specializing in piping insulation application with at least 3 years of relevant experience.
- B. Fire Hazard: Provide insulation, jackets, facings adhesives and accessories acceptable to the State Fire Marshall and meeting the requirements of NFPA 90A. Meet the following hazard classifications stated in accordance with U.L. Test Method of Fire Hazard - Classifications of Building Materials, No. 723:
 - 1. Flame-spread: Maximum 25.
 - 2. Fuel Contributed: Maximum 50.
 - 3. Smoke Developed: Maximum 50.

PART 2 – PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Manville Corporation, Certain-Teed, or Owens Corning Fiberglass.
- B. Armacell (Armaflex Cellucar Insulation) LLC.
- C. No substitutions.

2.02 INSULATION MATERIALS

- A. Mineral-Fiber Insulation: Glass fibers bonded with a thermosetting resin complying with the following:
1. Preformed Pipe Insulation: Comply with ASTM C 547, Type I, with factory-applied, all-purpose, vapor-retardant jacket.
 2. Blanket Insulation: Comply with ASTM C553, Type II, without facing.
 3. Fire-Resistant Adhesive: Comply with MIL-A-3316C in the following classes and grades:
 - a. Class I, Grade A for bonding glass cloth and tape to unfaced glass-fiber insulation, for sealing edges of glass-fiber insulation, and for bonding lagging cloth to unfaced glass-fiber insulation.
 - b. Class 2, Grade A for bonding glass-fiber insulation to metal surfaces.
 - c. For indoor applications, use adhesive that has a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 4. Vapor-Retarder Mastics: Fire and water-resistant, vapor-retarder mastic for indoor applications. Comply with MIL-C 19565C, Type II. See Paragraph 2.05 of this Section.
 5. Mineral-Fiber Insulating Cements: Comply with ASTM C 195.
 6. Expanded or Exfoliated Vermiculite Insulating Cements: Comply with ASTM C 196.
 7. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C 449/C 449M.
- B. Cellular-Glass Insulation: Inorganic, foamed or cellulated glass, annealed, rigid, hermetically sealed cells, incombustible.
1. Preformed Pipe Insulation, without Jacket: Comply with ASTM C 552, Type II, Class I.
 2. Preformed Pipe Insulation, with Jacket: Comply with ASTM C 552, Type II, Class 2.
 3. Cellular-Glass, Phenolic, Polyisocyanurate, and Polystyrene Adhesive: Solvent-based resin adhesive, with a service temperature range of minus 75 to plus 300 deg F. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

- C. Prefabricated Thermal Insulating Fitting Covers: Comply with ASTM C 450 for dimensions used in performing insulation to cover valves, elbows, tees, and flanges.

2.03 FIELD-APPLIED JACKETS

- A. General: ASTM C 921, Type I, unless otherwise indicated.
- B. Foil and Paper Jacket: Not acceptable.
- C. PVC Jacket: High-impact, ultraviolet-resistant PVC; 20 mils thick; roll stock ready for shop or field cutting and forming.
 - 1. Adhesive: As recommended by insulation material manufacturer.
 - 2. PVC Jacket Color: White
 - 3. PVC Jacket Color: Color-code piping jacket as determined by existing conditions.
 - 4. Not to be used for outdoors.
- D. Heavy PVC Fitting Covers: Factory-fabricated fitting covers manufactured from 30-mil (0.75 mm) thick, high-impact, ultraviolet-resistant PVC.
 - 1. Shapes: 45 and 90-degree, short and long-radius elbows, tees, valves, flanges, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories for the disabled.
 - 2. Adhesive: As recommended by insulation material manufacturer.
 - 3. Not to be used for outdoors.
- E. Aluminum Jacket: Aluminum roll stock, ready for shop or field cutting and forming to indicated sizes. Comply with ASTM B 209 (ASTM B 209M), 3003 alloy, H-14 temper.
 - 1. Finish and Thickness: Smooth finish, 0.010 (0.25 mm) inch thick.
 - 2. Moisture Barrier: 1-mil thick, heat-bonded polyethylene and kraft paper.
 - 3. Elbows: preformed 45 and 90-degree, short and long-radius elbows; same material, finish, and thickness as jacket.

2.04 ACCESSORIES AND ATTACHMENTS

- A. Bands: stainless steel ASTM A666, Type 304, 3/4 inch (20 mm) wide; 0.02 inch (0.050 mm) thick.

2.05 VAPOR RETARDANTS

- A. Mastics: Use materials as recommended by the insulation material manufacturer that are compatible with insulation materials, jackets, and substrates.
- B. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-C-19565C, Type II.
 - 1. For indoor applications, use mastics that have a low VOC content when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.06 SEALANTS

- A. Joint Sealants:
 - 1. For indoor applications, use mastics that have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

PART 3 – EXECUTION

3.01 EXAMINATION

- A. Examine substrates and conditions for compliance with requirements for installation and other conditions affecting performance of insulation application.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 PREPARATION

- A. Install materials after piping has been tested and approved.
- B. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

3.03 GENERAL APPLICATION REQUIREMENTS.

- A. Apply insulation materials, accessories, and finishes according to the manufacturer's written instructions; with smooth, straight, and even surfaces; and free of voids throughout the length of ducts and fittings.
- B. Refer to schedules at the end of this Section for material, form, jacket, and thickness required for each piping system insulation requirements.
- C. Use accessories compatible with insulation materials and suitable for the service. Use accessories that do not corrode, soften or otherwise attack insulation or jacket when in either wet or dry state.

- D. Apply insulation with longitudinal seams at top and bottom of horizontal pipe runs.
- E. Apply multiple layers of insulation with longitudinal and end seams staggered.
- F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.
- G. Seal joints and seams with vapor-retardant mastic on insulation indicated to receive a vapor retardant.
- H. Keep insulation materials dry during application and finishing.
- I. Apply insulation with tight longitudinal seams and end joints. Bond the seams and joints with adhesive recommended by the insulation material manufacturer.
- J. Apply insulation with the least number of joints practical.
- K. Apply insulation over fittings, valves, and specialties, with continuous thermal and vapor-retardant integrity, unless otherwise indicated. Refer to special instruction for applying insulation over fittings, valves, and specialties.
- L. Hangers and Anchors: Where vapor retardant is indicated, seal penetrations in insulation at hangers, supports, anchors, and other projections with vapor-retardant mastic.
 - 1. Apply insulation continuously through hangers and around anchor attachments.
 - 2. For insulation application where vapor retardants are indicated, extend insulation on anchor legs at least 12 inches (300 mm) from point of attachment to pipe and taper insulation ends. Seal tapered ends with a compound recommended by the insulation material manufacturer to maintain vapor retardant integrity.
 - 3. Install insert materials and apply insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by the insulation material manufacturer.
 - 4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect the jacket from tear or puncture by the hanger, support, and shield.
- M. Insulation Terminations: For insulation where vapor retardants are indicated, taper insulation ends. Seal tapered ends with a compound recommended by the insulation material manufacturer to maintain vapor retardant integrity.
- N. Apply adhesives and mastics at the manufacturer's recommended coverage rate.
- O. Apply insulation with integral jackets as follows:

1. Pull jacket tight and smooth.
 2. Circumferential Joints: Cover with 3 inches (75 mm) wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip and spaced 4-inches o.c.
 3. Longitudinal Seams: Overlap jacket seams at least 1 1/2 inches (38 mm). Apply insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 4-inches o.c.
 4. Exception: Do not staple longitudinal laps on insulation having a vapor retardant.
 5. Vapor-retardant mastics: Where vapor retardants are indicated, apply mastic on seams and joints and at ends adjacent to flanges, unions, valves, and fittings.
 6. At penetrations in jackets for thermometers and pressure gauges, fill and seal voids with vapor-retardant mastic.
- P. Roof Penetrations: Apply insulation for interior applications to a point even with top of roof flashing.
1. Seal penetrations with vapor-retardant mastic.
 2. Apply insulation for exterior applications tightly joined to interior insulation ends.
 3. Extend metal jacket for exterior insulation occurring outside of roof flashing at least 2-inches below the top of the roof flashing.
 4. Seal sheet metal jacket to roof flashing with vapor-retardant mastic.
- Q. Exterior Wall Penetrations: For penetration of below-grade exterior walls, terminate insulation flush with mechanical sleeve seal. Seal terminations with vapor-retardant mastic.
- R. Interior Wall and Partition Penetrations: Apply insulation continuously through walls and floors.
- S. Fire-Rated Wall and Partition Penetrations: Apply insulation continuously through penetrations of fire-rated walls and partitions
1. Firestopping and fire-resistive joint sealers are specified in Division 07 "Penetration Firestopping".
 2. Floor Penetrations: Apply insulation continuously through floor assembly.
 3. For insulation with vapor retardants, seal insulation with vapor-retardant mastic where floor supports penetrate vapor retardant.

3.04 MINERAL-FIBER INSULATION APPLICATION

- A. Apply insulation to straight pipes and tubes as follows;
 - 1. Secure each layer of preformed pipe insulation to pipe with wire, tape, or bands without deforming insulation materials.
 - 2. Where vapor retarders are indicated, seal longitudinal seams and end joints with vapor-retarder mastic. Apply vapor retarder to ends of insulation at intervals of 15 to 20-feet (4.5 to 6 m) to form a vapor retarder between pipe insulation segments.
 - 3. For insulation with factory-applied jackets, secure laps with outward clinches staples at 6 inches o.c.
 - 4. For insulation with factory-applied jackets with vapor retarders, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by the insulation material manufacturer and seal with vapor-retarder mastic.
- B. Apply Insulation to flanges as follows:
 - 1. Apply preformed pipe insulation to outer diameter of pipe flange.
 - 2. Make width of insulation segment the same as overall width of the flange and bolts, plus twice the thickness of the pipe insulation.
 - 3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with mineral-fiber blanket insulation.
 - 4. Apply canvas jacket material with manufacturer's recommended adhesive, overlapping seams at least 1 inch (25 mm), and seal joints with vapor-retarder mastic.
- C. Apply insulation to fittings and elbows as follows:
 - 1. Apply premolded insulation sections of the same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
 - 2. When premolded insulation elbows and fittings are not available, apply mitered sections of pipe insulation, or glass-fiber blanket insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire, tape, or bands.
 - 3. Cover fittings with heavy PVC covers. Overlap PVC covers on pipe insulation jackets at least 1 inch (25 mm) at each end. Secure fitting covers with manufacturer's attachments and accessories. Seal seams with tape and vapor-retarder mastic.
- D. Apply insulation to valves and specialties as follows:

1. Apply premolded insulation sections of the same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
2. When premolded insulation sections are not available, apply glass-fiber blanket insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation. For check valves, arrange insulation for access to strainer basket without disturbing insulation.
3. Apply insulation to flanges as specified for flange insulation application.
4. Use preformed heavy PVC fitting covers for valve sizes where available. Secure fitting covers with manufacturer's attachments and accessories. Seal seams with tape and vapor-retarder mastic.
5. For larger sizes where PVC fitting covers are not available, seal insulation with canvas jacket and sealing compound recommended by the insulation material manufacturer.

3.05 CELLULAR-GLASS INSULATION APPLICATION

A. Apply insulation to straight pipes and tubes as follows:

1. Secure each layer of insulation to pipe with bands without deforming insulation.
2. Where vapor retarders are indicated, seal longitudinal seams and end joints with vapor-retarder mastic.
3. For insulation with factory-applied jackets, secure laps with outward clinched staples at 6-inches o.c.
4. For insulation with factory-applied jackets with vapor retarders, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by the insulation material manufacturer and seal with vapor-retarder mastic.

B. Apply insulation to flanges as follows:

1. Apply preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation segment the same as overall width of the flange and bolts, plus twice the thickness of the pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of cellular-glass block insulation of the same thickness as pipe insulation
4. Apply insulation to fittings and elbows as follows:

5. Apply premolded insulation sections of the same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instruction.
 6. When premolded sections of insulation are not available, apply mitered sections of cellular-glass insulation. Secure insulation materials with bands.
 7. Cover fittings with heavy PVC fitting covers. Overlap PVC covers on pipe insulation jackets as least 1 inch (25 mm) at each end. Secure fitting covers with manufacturer's attachments and accessories. Seal seams with tape and vapor-retarder mastic.
- C. Apply insulation to valves and specialties as follows:
1. Apply premolded segments of cellular-glass insulation or glass-fiber blanket insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation. For check valves, arrange insulation for access to strainer basket without disturbing insulation.
 2. Apply insulation to flanges as specified for flange insulation application.
 3. Use preformed heavy PVC fitting covers for valve sizes where available. Secure fitting covers with manufacturer's attachments and accessories. Seal seams with tape and vapor-retarder mastic.
 4. For larger sizes where PVC fitting covers are not available, seal insulation with canvas jacket and sealing compound recommended by the insulation material manufacturer.

3.06 PREFORMED ELASTOMERIC CELLULAR THERMAL INSULATION APPLICATION

- A. Apply insulation to straight pipes and tubes as follows:
1. Install pipe insulation by slitting tubular sections and applying onto pipes. Seams and butt joints shall be adhered and sealed using Armaflex 520 adhesive
 2. All edges shall be clean-cut. Rough or jagged edges shall not be permitted.
- B. Apply insulation to valves, flanges and fittings as follows:
1. Insulate with the same insulation thickness as the adjacent piping. Seams and butt joints shall be adhered and sealed with Armaflex 520 adhesive.
 2. All edges shall be clean-cut. Rough or jagged edges shall not be permitted.
- C. Outdoor insulation shall be protected as follows:

1. Furnish PVC jacket and PVC fitting covers or aluminum jackets.
2. All jackets shall have the seams located on the bottom of the pipes.

3.07 FIELD-APPLIED JACKET APPLICATION

- A. Apply PVC jacket where indicated, with 1 inch (25 mm) overlap at longitudinal seams and end joints. Seal with manufacturer's recommended adhesive.
- B. Apply metal jacket where indicated, with 2-inch (50 mm) overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel band 12 inches (300 mm) o.c. and at end joints.
- C. Insulation and jacket for cold pipes shall include wicks to direct possible condensation to outside the jacket. The product shall be Knauf PermaWick or equal.
- D. Indoor, Concealed Applications: Insulated pipes conveying fluids above ambient temperature shall have standard jackets, with or without vapor barrier, factory-applied or field-applied. Insulate fittings, joints and valves with insulation of like material and thickness as adjoining pipe, and finish with glass cloth and adhesive. PVC jackets shall be used.
- E. Indoor, Exposed Applications: For pipe exposed in mechanical equipment rooms or in finished spaces, insulate as for concealed applications. Finish with canvas jacket; size for finish painting. PVC jackets shall be used.
- F. Exterior Applications: Provide vapor-barrier jackets. Cover with aluminum jacket with seams located on bottom side of horizontal piping. Insulate fittings, joints, and valves with insulation of like material and thickness as adjoining pipe and cover with aluminum jacket.
- G. Buried Piping: Provide factory-fabricated assembly with inner all-purpose service jacket with self-sealing lap, and asphalt-impregnated open-mesh glass fabric, with 0.001 inch thick aluminum foil sandwiched between three layers of bituminous compound; outer surface faced with a polyester film.

3.08 FINISHES

- A. Paint insulation as specified in Section 09 90 00 – Painting.
- B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.

3.09 PIPING SYSTEM APPLICATIONS

- A. Insulation materials and thicknesses are specified in schedules at the end of this Section.

B. Items Not Insulated: Unless otherwise indicated, do not apply insulation to the following systems, materials, and equipment.

1. Flexible connectors.
2. Vibration control devices.
3. Drainage piping located in crawl spaces, unless otherwise indicated.
4. Below-grade piping, unless otherwise indicated.
5. Chrome-plated pipes and fittings, unless potential for personal injury.
6. Air chambers, unions, strainers, check valves, plug valves, and flow regulators.

3.10 INSULATION APPLICATION SCHEDULE, GENERAL.

- A. Refer to insulation application schedules for required insulation materials, vapor retarders, and field-applied jackets.
- B. Application schedules identify piping system and indicate pipe size ranges and material, thickness, and jacket requirements.

3.11 EXTERIOR INSULATION APPLICATION SCHEDULE

- A. This application schedule is for aboveground insulation outside the building.
- B. Service: Domestic, Tepid, Industrial & Exposed Waste/Drain.
 1. Operating Temperature: 60 to 140 deg F (15 to 60 deg C).
 2. Insulation Material: preformed Mineral-fiber
 3. Insulation Thickness: Apply the following insulation thicknesses:
 - a. Copper pipe, All sizes: 1 inch (25 mm) Insulation
 - b. Polypropylene Pipe 1 inch (25 mm) Insulation
 4. Field-Applied Jacket: Aluminum
 5. Vapor Retarder Required: Yes
 6. Finish: As specified in Paragraph 3.08 of this Section.

3.12 ALTERNATE INSULATION APPLICATION

- A. Preformed elastomeric cellular insulation may be used as an alternative to the materials in Paragraphs 3.11.

END OF SECTION

SECTION 22 11 13

FACILITY WATER DISTRIBUTION PIPING

PART 1 – GENERAL

1.01 DESCRIPTION

- A. Domestic water systems, including piping, equipment and all necessary accessories as designated in this Section.
- B. A complete listing of all acronyms and abbreviations are included in Section 22 05 00 – Basic Plumbing Requirements.

1.02 RELATED WORK

- A. Division 01 – General Conditions
- B. Section 01 33 00 – Submittal Procedures
- C. Section 07 84 00 – Firestopping
- D. Section 07 90 00 – Joint Fillers, Sealants and Caulking
- E. Section 09 90 00 – Painting
- F. Section 01 73 23 – Anchorage and Bracing of Non-Structural Components
- G. Section 22 05 00 – Basic Plumbing Requirements
- H. Section 22 07 19 – Plumbing Piping Insulation

1.03 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. American Society of Mechanical Engineers (ASME):
 - 1. A13.1-2007 (R2013) – Scheme for Identification of Piping Systems
 - 2. ASME Boiler and Pressure Vessel Code
 - 3. BPVC Section IX-2015 Welding, Brazing, and Fusing Qualifications
- C. American Society of Sanitary Engineers (ASSE):

1. 1010-2004 – Performance Requirements for Water Hammer Arresters

D. American Society for Testing and Materials (ASTM):

1. C919-2012 – Standard Practice for Use of Sealants in Acoustical Applications
2. D1785-2012 – Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120
3. D2000-2012 – Standard Classification System for Rubber Products in Automotive Applications
4. D2564-2012 – Standard Specification for Solvent Cements for Poly (Vinyl Chloride) (PVC) Plastic Piping Systems
5. D2657-2007 – Standard Practice for Heat Fusion Joining of Polyolefin Pipe and Fittings
6. ASTM D 2765 – Test Methods for Determination of Gel Content and Swell Ratio of Crosslinked Ethylene Plastics.
7. ASTM D 6394 – Specification for Sulfone Plastics (SP).
8. ASTM E 84 – Standard Test Method for Surface Burning Characteristics of Building Materials.
9. ASTM E 119 – Standard Test Methods for Fire Tests of Building Construction and Materials.
10. ASTM E 814 – Standard Test Method for Fire Tests of Through-Penetration Fire Stops.
11. D2855-1996 (R2010) – Standard Practice for Making Solvent-Cemented Joints with Poly (Vinyl Chloride) (PVC) Pipe and Fittings
12. D4101-2014 – Standard Specification for Polypropylene Injection and Extrusion Materials
13. E1120-2008 – Standard Specification for Liquid Chlorine
14. E1229-2008 – Standard Specification for Calcium Hypochlorite
15. F2389-2010 – Standard Specification for Pressure-rated Polypropylene (PP) Piping Systems

16. F2620-2013 – Standard Practice for Heat Fusion Joining of Polyethylene Pipe and Fittings
 17. F2769-2014 – Standard Specification for Polyethylene of Raised Temperature (PE-RT) Plastic Hot and Cold-Water Tubing and Distribution Systems
- E. American Water Works Association (AWWA):
1. C203-2008 – Coal-Tar Protective Coatings and Linings for Steel Water Pipelines – Enamel and Tape – Hot Applied
 2. C651-2014 – Disinfecting Water Mains
- F. International Code Council (ICC):
1. IPC-2012 – International Plumbing Code
- G. Manufacturers Specification Society (MSS):
1. SP-58-2009 – Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application, and Installation
 2. SP-72-2010a – Ball Valves with Flanged or Butt-Welding Ends for General Service
 3. SP-110-2010 – Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends
- H. NSF International (NSF):
1. 14-2015 – Plastics Piping System Components and Related Materials
 2. 61-2014a – Drinking Water System Components – Health Effects
 3. 372-2011 – Drinking Water System Components – Lead Content
- I. Plumbing and Drainage Institute (PDI):
1. PDI-WH 201-2010 – Water Hammer Arrestors
- J. Department of Veterans Affairs:
1. H-18-8-2013 – Seismic Design Handbook

1.04 SUBMITTALS

- A. Submittals, including number of required copies, shall be submitted in accordance with Section 01 33 00 – Submittal Procedures.
- B. Information and material submitted under this Section shall be marked “SUBMITTED UNDER SECTION 22 11 13 – FACILITY WATER DISTRIBUTION PIPING”, with applicable paragraph identification.
- C. Manufacturer's Literature and Data including: Full item description and optional features and accessories. Include dimensions, weights, materials, applications, standard compliance, model numbers, size, and capacity.
 - 1. All items listed in Part 2 - Products.
- D. Complete operating and maintenance manuals including wiring diagrams, technical data sheets and information for ordering replacement parts:
 - 1. Include complete list indicating all components of the systems.
 - 2. Include complete diagrams of the internal wiring for each item of equipment.
 - 3. Diagrams shall have their terminals identified to facilitate installation, operation and maintenance.

1.05 QUALITY ASSURANCE

- A. A certificate shall be submitted prior to welding of steel piping showing the Welder's certification. The certificate shall be current and no more than one year old. Welder's qualifications shall be in accordance with ASME BPVC Section IX.
- B. All grooved joint couplings, fittings, valves, and specialties shall be the products of a single manufacturer. Grooving tools shall be by the same manufacturer as the groove components.
- C. All pipe, couplings, fittings, and specialties shall bear the identification of the manufacturer and any markings required by the applicable referenced standards.

1.06 SPARE PARTS

- A. For mechanical press-connect fittings, provide tools required for each pipe size used at the facility.

1.07 AS-BUILT DOCUMENTATION

- A. Submit manufacturer's literature and data updated to include submittal review comments and any equipment substitutions.
- B. Submit operation and maintenance data updated to include submittal review comments, substitutions and construction revisions shall be in electronic version on compact disc or DVD and inserted into a three ring binder. All aspects of system operation and maintenance procedures, including piping isometrics, wiring diagrams of all circuits, a written description of system design, control logic, and sequence of operation shall be included in the operation and maintenance manual. The operations and maintenance manual shall include troubleshooting techniques and procedures for emergency situations. Notes on all special systems or devices shall be included. A list of recommended spare parts (manufacturer, model number, and quantity) shall be furnished. Information explaining any special knowledge or tools the owner will be required to employ shall be inserted into the As-Built documentation.
- C. The installing contractor shall maintain as-built drawings of each completed phase for verification; and, shall provide the complete set at the time of final systems certification testing. As-built drawings are to be provided, and a copy of them in Auto-CAD version 2022 provided on compact disk or DVD. Should the installing contractor engage the testing company to provide as-built or any portion thereof, it shall not be deemed a conflict of interest or breach of the 'third party testing company' requirement.
- D. Certification documentation shall be provided to Owner's Representative 10 working days prior to submitting the request for final inspection. The documentation shall include all test results, the names of individuals performing work for the testing agency on this project, detailed procedures followed for all tests, and certificate if applicable that all results of tests were within limits specified. If a certificate is not available, all documentation shall be on the Certifier's letterhead.

PART 2 – PRODUCTS

2.01 MATERIALS

- A. Material or equipment containing a weighted average of greater than 0.25 percent lead are prohibited in any potable water system intended for human consumption and shall be certified in accordance with NSF 61 or NSF 372. Endpoint devices used to dispense water for drinking shall meet the requirements of NSF 61, Section 9.
- B. Plastic pipe, fittings, and solvent cement shall meet NSF 14 and shall be NSF listed for the service intended.

2.02 CPVC PIPE AND FITTINGS

- A. A. CPVC Schedule 80 Pipe: ASTM F441/F 441M.
 - 1. CPVC Schedule 80 Fittings: ASTM F439, socket, ASTM F437, threaded, ASTM F439, socket type or ASTM F437, threaded type.

2.03 TRAP PRIMER WATER PIPING

- A. Pipe: Copper tube, ASTM B88, type K, hard drawn.
- B. Fittings: Bronze castings conforming to ASME B16.18 Solder joints.
- C. Solder: ASTM B32 alloy type Sb5. Provide non-corrosive flux.

2.04 STRAINERS

- A. Provide on high pressure side of pressure reducing valves, on suction side of pumps, on inlet side of indicating and control instruments and equipment subject to sediment damage and where shown on drawings. Strainer element shall be removable without disconnection of piping.
- B. Water: Basket or "Y" type with easily removable cover and brass strainer basket.
- C. Body: Less than 3 inches, brass or bronze; 3 inches and greater, cast iron or semi-steel.

2.05 DIELECTRIC FITTINGS

- A. Provide dielectric couplings or unions between pipe of dissimilar metals and below grade and above metal piping.

2.06 STERILIZATION CHEMICALS

- A. Hypochlorite: ASTM E1120.
- B. Liquid Chlorine: ASTM E1229.

2.07 WATER HAMMER ARRESTER

- A. Closed copper tube chamber with permanently sealed 60 psig air charge above a Double O-ring piston. Two high heat Buna-N O-rings pressure packed and lubricated with FDA approved silicone compound. All units shall be designed in accordance with ASSE 1010. Access shall be provided where devices are concealed within partitions or above ceilings. Size and install in accordance with PDI-WH 201 requirements. Provide water hammer arrestors at:

1. All solenoid valves.
2. All groups of two or more flush valves.
3. All quick opening or closing valves.
4. All medical washing equipment.

2.08 SOLDER AND FLUX FOR POTABLE WATER SYSTEMS

- A. Solder and flux for water distribution systems intended for human consumption shall conform to NSF-61. Solder shall be certified to NSF-61.

PART 3 – EXECUTION

3.01 INSTALLATION

- A. General: Comply with the International Plumbing Code and the following:
 1. Install branch piping for water from the piping system and connect to all fixtures, valves, cocks, outlets, casework, cabinets and equipment, including those furnished by the Owner or specified in other sections.
 2. Pipe shall be round and straight. Cutting shall be done with proper tools. Pipe, except for plastic and glass, shall be reamed to remove burrs and a clean smooth finish restored to full pipe inside diameter.
 3. All pipe runs shall be laid out to avoid interference with other work/trades.
 4. Install union and shut-off valve on pressure piping at connections to equipment.
 5. Install chrome plated cast brass escutcheon with set screw at each wall, floor and ceiling penetration in exposed finished locations and within cabinets and millwork.
 6. Penetrations:
 - a. Firestopping: Where pipes pass through fire partitions, fire walls, smoke partitions, or floors, install a fire stop that provides an effective barrier against the spread of fire, smoke, and gases as specified in Section 07 84 00 – Firestopping. Completely fill and seal clearances between raceways and openings with the firestopping materials.
 - b. Waterproofing: At floor penetrations, completely seal clearances around the pipe and make watertight with sealant as specified in Section 07 90 00 –

Joint Fillers, Sealants and Caulking. Bio-based materials shall be utilized when possible.

- c. Acoustical sealant: Where pipes pass through sound rated walls, seal around the pipe penetration with an acoustical sealant that is compliant with ASTM C919.
- 7. Mechanical press-connect fitting connections shall be made in accordance with the manufacturer's installation instructions. The tubing shall be fully inserted into the fitting and the tubing marked at the shoulder of the fitting. The fitting alignment shall be checked against the mark on the tubing to assure the tubing is fully engaged (inserted) in the fitting. Ensure the tube is completely inserted to the fitting stop (appropriate depth) and squared with the fitting prior to applying the pressing jaws onto the fitting. The joints shall be pressed using the tool(s) approved by the manufacturer. Minimum distance between fittings shall be in accordance with the manufacturer's requirements. When the pressing cycle is complete, visually inspect the joint to ensure the tube has remained fully inserted, as evidenced by the visible insertion mark.

B. Domestic Water piping shall conform to the following:

- 1. Grade all lines to facilitate drainage. Provide drain valves at bottom of risers and all low points in system. Design domestic hot water circulating lines with no traps.
- 2. Connect branch lines at bottom of main serving fixtures below and pitch down so that main may be drained through fixture. Connect branch lines to top of main serving only fixtures located on floor above.

3.02 PIPING SCHEDULE

A. Aboveground Water-Service Piping NPS 3/4 to NPS 3 shall be the following:

- 1. CPVC, Schedule 80 pipe; CPVC, Schedule 80 socket fittings; and solvent-cemented joints.

3.03 TESTS

- A. General: Test system either in its entirety or in sections. Submit testing plan to Owner's Representative 10 working days prior to test date.
- B. Potable Water System: Test after installation of piping and domestic water heaters, but before piping is concealed, before covering is applied, and before plumbing fixtures are connected. Fill systems with water and maintain hydrostatic pressure of 150 psig gauge for two hours. No decrease in pressure is allowed. Provide a pressure gauge with a

shutoff and bleeder valve at the highest point of the piping being tested. Pressure gauge shall have 1 psig increments.

- C. All Other Piping Tests: Test new installed piping under 1-1/2 times actual operating conditions and prove tight.

3.04 STERILIZATION

- A. After tests have been successfully completed, thoroughly flush and sterilize the interior domestic water distribution system in accordance with AWWA C651.
- B. Use liquid chlorine or hypochlorite for sterilization.

3.05 DEMONSTRATION AND TRAINING

- A. Provide services of manufacturer's technical representative for four (4) hours to instruct Owner's Personnel in operation and maintenance of the system.

END OF SECTION

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SECTION 22 11 19
DOMESTIC WATER PIPING SPECIALTIES

PART 1 – GENERAL

1.01 SUMMARY

- A. This Section includes the following domestic water piping specialties:
 - 1. Vacuum breakers
 - 2. Backflow preventers
 - 3. Pressure reducing valve
 - 4. Strainers
 - 5. Drain valves
 - 6. Water hammer arresters
 - 7. Air vents
 - 8. Trap-seal primer valves
- B. Related Sections include the following:
 - 1. Section 22 05 19 – Meters and Gauges for Plumbing Piping for thermometers, pressure gauges, and flow meters in domestic water piping.

1.02 PERFORMANCE REQUIREMENTS

- A. Minimum Working Pressure for Domestic Water Piping Specialties: 125 psig, unless otherwise indicated.

1.03 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: Diagram power, signal, and control wiring.
- C. Field quality-control test reports.
- D. Operation and Maintenance Data: For domestic water piping specialties to include operation, and maintenance manuals.

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1.04 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. NSF Compliance:
 - 1. Comply with NSF 14, Plastics Piping Components and Related Materials, for plastic domestic water piping components.
 - 2. Comply with NSF 61, Drinking Water System Components – Health Effects; Sections 1 through 9.

PART 2 – PRODUCTS

2.01 VACUUM BREAKERS

- A. Pipe-Applied, Atmospheric-Type Vacuum Breakers:
 - 1. Manufacturers:
 - a. Conbraco Industries, Inc.
 - b. FEBCO; SPX Valves & Controls.
 - c. Watts Industries, Inc.; Water Products Div.
 - d. Zurn Plumbing Products Group; Wilkins Div.
 - 2. Standard: ASSE 1001.
 - 3. Size: NPS 1/4 to NPS 3, as required to match connected piping.
 - 4. Body: Bronze.
 - 5. Inlet and Outlet Connections: Threaded.
 - 6. Finish: Chrome plated.
- B. Hose-Connection Vacuum Breakers:
 - 1. Manufacturers:
 - a. Conbraco Industries, Inc.
 - b. MIFAB, Inc.

- c. Watts Industries, Inc.; Water Products Div.
 - d. Woodford Manufacturing Company.
 - e. Zurn Plumbing Products Group.
- 2. Standard: ASSE 1011.
- 3. Body: Bronze, nonremovable, with manual drain.
- 4. Outlet Connection: Garden-hose threaded complying with ASME B1.20.7.
- 5. Finish: Chrome or Rough bronze.
- C. Pressure Vacuum Breakers:
 - 1. Manufacturers:
 - a. Conbraco Industries, Inc.
 - b. FEBCO; SPX Valves & Controls.
 - c. Watts Industries, Inc.; Water Products Div.
 - d. Zurn Plumbing Products Group; Wilkins Div.
 - 2. Standard: ASSE 1020.
 - 3. Operation: Continuous-pressure applications.
 - 4. Pressure Loss: 5 psig maximum, through middle 1/3 of flow range.
 - 5. Accessories:
 - a. Valves: Ball type, on inlet.

2.02 BACKFLOW PREVENTERS

- A. Reduced-Pressure-Principle Backflow Preventers:
 - 1. Manufacturers:
 - a. Conbraco Industries, Inc.
 - b. FEBCO; SPX Valves & Controls.
 - c. Watts Industries, Inc.; Water Products Div.
 - d. Zurn Plumbing Products Group; Wilkins Div.

2. Standard: ASSE 1013.
3. Operation: Continuous-pressure applications.
4. Pressure Loss: 12 psig maximum, through middle 1/3 of flow range.
5. Body: Bronze for NPS 2 and smaller; cast iron with interior lining complying with AWWA C550 or that is FDA approved or steel with interior lining complying with AWWA C550 or that is FDA approved for NPS 2-1/2 and larger.
6. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.
7. Configuration: Designed for horizontal, straight through flow.
8. Accessories:
 - a. Valves: Ball type with threaded ends on inlet and outlet of NPS 2 and smaller; outside screw and yoke gate-type with flanged ends on inlet and outlet of NPS 2-1/2 and larger.
 - b. Air-Gap Fitting: ASME A112.1.2, matching backflow-preventer connection.

2.03 PRESSURE REDUCING VALVE

- A. Valve shall meet ASSE 1003
- B. Shall reduce incoming water pressure down to 25-75 PSI (adj). Max working pressure 300 PSI
- C. Body shall be cast bronze, copper or cast iron. Components shall be lead free and meet all NSF 60 requirements. Diaphragm shall be reinforced EPDM.
- D. System shall be serviceable inline with replaceable seats, strainers, and include a bypass.
- E. Valve shall be manufactured by WATTS (LFU5B), Apollo, Bell & Gossett, Zurn, or equal.

2.04 STRAINERS FOR DOMESTIC WATER PIPING

- A. Y-Pattern Strainers:
 1. Pressure Rating: 125 psig minimum, unless otherwise indicated.
 2. Body: Bronze for NPS 2 and smaller; cast iron with interior lining complying with AWWA C550 or FDA-approved, epoxy coating for NPS 2-1/2 and larger.
 3. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.
 4. Screen: Stainless steel with round perforations, unless otherwise indicated.

5. Perforation Size:
 - a. Strainers NPS 2 and Smaller: 0.020 inch.
 - b. Strainers NPS 2-1/2 to NPS 4: 0.045 inch.
 - c. Strainers NPS 5 and Larger: 0.10 inch.
6. Drain: Factory-installed, hose-end drain valve.

2.05 DRAIN VALVES

A. Ball-Valve-Type, Hose-End Drain Valves:

1. Standard: MSS SP-110 for standard-port, two-piece ball valves.
2. Pressure Rating: 400-psig minimum CWP.
3. Body: Copper alloy.
4. Ball: Chrome-plated brass.
5. Seats and Seals: Replaceable.
6. Handle: Vinyl-covered steel.
7. Inlet: Threaded or solder joint.
8. Outlet: Threaded, short nipple with garden-hose thread complying with ASME B1.20.7 and cap with brass chain.

2.06 WATER HAMMER ARRESTERS

A. Water Hammer Arresters:

1. Manufacturers:
 - a. Josam Company.
 - b. MIFAB, Inc.
 - c. PPP Inc.
 - d. Sioux Chief Manufacturing Company, Inc.
 - e. Tyler Pipe; Wade Div.
 - f. Watts Drainage Products Inc.
 - g. Zurn Plumbing Products Group.

2. Standard: ASSE 1010 or PDI-WH 201.
3. Type: Copper tube with piston.
4. Size: ASSE 1010, Sizes AA and A through F or PDI-WH 201, Sizes A through F.

2.07 AIR VENTS

A. Bolted-Construction Automatic Air Vents:

1. Body: Bronze.
2. Pressure Rating: 125-psig minimum pressure rating at 140 deg F.
3. Float: Replaceable, corrosion-resistant metal.
4. Mechanism and Seat: Stainless steel.
5. Inlet and Vent Outlet End Connections: Threaded.

B. Welded-Construction Automatic Air Vents:

1. Body: Stainless steel.
2. Pressure Rating: 150-psig minimum pressure rating.
3. Float: Replaceable, corrosion-resistant metal.
4. Mechanism and Seat: Stainless steel.
5. Inlet and Vent Outlet End Connections: Threaded.

2.08 TRAP-SEAL PRIMER VALVES

A. Supply-Type, Trap-Seal Primer Valves:

1. Manufacturers:
 - a. MIFAB, Inc.
 - b. PPP Inc.
 - c. Sioux Chief Manufacturing Company, Inc.
 - d. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
 - e. Watts Industries, Inc.; Water Products Div.
2. Standard: ASSE 1018.

3. Pressure Rating: 125 psig minimum.
4. Body: Bronze.
5. Inlet and Outlet Connections: NPS 1/2 threaded, union, or solder joint.
6. Gravity Drain Outlet Connection: NPS 1/2 threaded or solder joint.
7. Distribution box as required.
8. Finish: Chrome plated, or rough bronze for units used with pipe or tube that is not chrome finished.

PART 3 – EXECUTION

3.01 INSTALLATION

- A. Refer to Section 22 05 00 – Basic Plumbing Requirements for piping joining materials, joint construction, and basic installation requirements.
- B. Install backflow preventers in each water supply to mechanical equipment and systems and to other equipment and water systems that may be sources of contamination. Comply with authorities having jurisdiction.
 1. Install drain for backflow preventers with atmospheric-vent drain connection with air-gap fitting, fixed air-gap fitting, or equivalent positive pipe separation of at least two pipe diameters in drain piping and pipe to floor drain. Locate air-gap device attached to or under backflow preventer. Simple air breaks are not acceptable for this application.
 2. Do not install bypass piping around backflow preventers.
- C. Install balancing valves in locations where they can easily be adjusted.
- D. Install Y-pattern strainers for water on supply side of each control valve, water pressure-reducing valve, solenoid valve, and pump.
- E. Install outlet boxes recessed in wall. Install 2-by-4-inch (38-by-89-mm) fire-retardant-treated-wood blocking wall reinforcement between studs. Fire-retardant-treated-wood blocking is specified in Section 06 10 00 – Rough Carpentry.
- F. Install water hammer arresters in water piping according to PDI-WH 201 and drawings.
- G. Install air vents at high points of water piping. Install drain piping and discharge to floor drain.
- H. Install supply-type, trap-seal primer valves with outlet piping pitched down toward drain trap a minimum of 1 percent, and connect to floor-drain body, trap, or inlet fitting.

3.02 CONNECTIONS

- A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping and specialties.
- B. Ground equipment according to Section 26 05 26 – Grounding and Bonding for Electrical Systems.
- C. Connect wiring according to Section 26 05 19 – Low-Voltage Conductors and Cables.

3.03 LABELING AND IDENTIFYING

- A. Equipment Nameplates and Signs: Install engraved plastic-laminate equipment nameplate or sign on or near each of the following:
 - 1. Pressure vacuum breakers.
 - 2. Intermediate atmospheric-vent backflow preventers.
 - 3. Reduced-pressure-principle backflow preventers.
 - 4. Double-check backflow-prevention assemblies.
 - 5. Automatic balancing valves.
 - 6. Outlet boxes.
 - 7. Supply-type, trap-seal primer valves.
- B. Distinguish among multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations, in addition to identifying unit. Nameplates and signs are specified in Section 22 05 53 – Identification for Plumbing Piping and Equipment.

3.04 FIELD QUALITY CONTROL

- A. Perform the following tests and prepare test reports:
 - 1. Test each pressure vacuum breaker reduced-pressure-principle backflow preventer, double-check backflow-prevention assembly and vacuum breaker assembly according to authorities having jurisdiction and the device's reference standard.
- B. Remove and replace malfunctioning domestic water piping specialties and retest as specified above.

3.05 ADJUSTING

- A. Confirm flow rate and direction of flow for automatic balancing valves.

END OF SECTION

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SECTION 22 13 16
---SANITARY WASTE AND VENT PIPING

PART 1 – GENERAL

1.01 DESCRIPTION

- A. This Section pertains to sanitary sewer and vent systems, including piping, equipment and all necessary accessories as designated in this section.
- B. A complete listing of all acronyms and abbreviations are included in Section 22 05 00 – Common Results for Plumbing.

1.02 RELATED WORK

- A. Division 01 – General Conditions
- B. Section 01 33 00 – Submittal Procedures
- C. Section 07 84 00 – Firestopping: Penetrations in Rated Enclosures
- D. Section 07 90 00 – Joint Fillers, Sealants and Caulking: Sealant Products
- E. Section 09 90 00 – Painting: Preparation and Finish Painting and Identification of Piping Systems.
- F. Section 22 05 00 – Common Results for Plumbing: Pipe Hangers and Supports, Materials Identification.
- G. Section 22 07 19 – Plumbing Piping Insulation
- H. Section 26 05 26 – Grounding and Bonding for Electrical Systems

1.03 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. American Society of Mechanical Engineers (ASME):
 - 1. A13.1-2007 – Scheme for the Identification of Piping Systems
 - 2. A112.36.2M-1991(R 2012) – Cleanouts
 - 3. A112.6.3-2001 (R2007) – Standard for Floor and Trench Drains

4. B1.20.1-2013 – Pipe Threads, General Purpose (Inch)
 5. B16.1-2010 – Gray Iron Pipe Flanges and Flanged Fittings
 6. B16.4-2011 – Standard for Grey Iron Threaded Fittings Classes 125 and 250
 7. B16.21-2011 – Nonmetallic Flat Gaskets for Pipe Flanges
 8. B16.39-2009 – Malleable Iron Threaded Pipe Unions Classes 150, 250, and 300
 9. B18.2.1-2012 – Square, Hex, Heavy Hex, and Askew Head Bolts and Hex, Heavy Hex, Hex Flange, Lobed Head, and Lag Screws (Inch Series)
- C. American Society of Sanitary Engineers (ASSE):
1. 1079-2012 – Performance Requirements for Dielectric Pipe Unions
- D. American Society for Testing and Materials (ASTM):
1. A53/A53M-2012 – Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-coated, Welded and Seamless
 2. A74-2013a – Standard Specification for Cast Iron Soil Pipe and Fittings
 3. A888-2013a – Standard Specification for Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste, and Vent Piping Applications
 4. B32-2008 – Standard Specification for Solder Metal
 5. C564-2012 – Standard Specification for Rubber Gaskets for Cast Iron Soil Pipe and Fittings
 6. D1785-2012 – Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120
 7. D2321-2011 – Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications
 8. D2564-2012 – Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems
 9. D2665-2012 – Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Drain, Waste, and Vent Pipe and Fittings
 10. D2855-1996 (R 2010) – Standard Practice for Making Solvent-Cemented Joints with Poly(Vinyl Chloride) (PVC) Pipe and Fittings

11. D5926-2011 – Standard Specification for Poly(Vinyl Chloride) (PVC) Gaskets for Drain, Waste, and Vent (DWV), Sewer, Sanitary, and Storm Plumbing Systems
12. F402-2005 (R 2012) – Standard Practice for Safe Handling of Solvent Cements, Primers, and Cleaners Used for Joining Thermoplastic Pipe and Fittings
13. F477-2010 – Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe
14. F1545-1997 (R 2009) – Standard Specification for Plastic-Lined Ferrous Metal Pipe, Fittings, and Flanges

E. Cast Iron Soil Pipe Institute (CISPI):

1. 2006 – Cast Iron Soil Pipe and Fittings Handbook
2. 301-2012 – Standard Specification for Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste, and Vent Piping Applications
3. 310-2012 – Specification for Coupling for Use in Connection with Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste, and Vent Piping Applications

F. International Code Council (ICC):

1. IPC-2012 – International Plumbing Code

G. National Fire Protection Association (NFPA):

1. 70-2014 – National Electrical Code (NEC)

H. Underwriters' Laboratories, Inc. (UL):

1. 508-99 (R2013) – Standard for Industrial Control Equipment

1.04 SUBMITTALS

- A. Submittals, including number of required copies, shall be submitted in accordance with Section 01 33 00 – Submittal Procedures.
- B. Information and material submitted under this Section shall be marked “SUBMITTED UNDER SECTION 22 13 16 – SANITARY WASTE AND VENT PIPING”, with applicable paragraph identification.
- C. Manufacturer's Literature and Data including: Full item description and optional features and accessories. Include dimensions, weights, materials, applications, standard compliance, model numbers, size, and capacity.

1. Piping
 2. Floor Drains
 3. Cleanouts
 4. Trap Seal Protection
 5. Penetration Sleeves
 6. Pipe Fittings
 7. Traps
 8. Exposed Piping and Fittings
- D. Detailed shop drawing of clamping device and extensions when required in connection with the waterproofing membrane or the floor drain.

1.05 AS-BUILT DOCUMENTATION

- A. The installing contractor shall maintain as-built drawings of each completed phase for verification; and, shall provide the complete set at the time of final systems certification testing. As-built drawings are to be provided, and a copy of them on Auto-Cad version 2020 provided on compact disk or DVD. Should the installing contractor engage the testing company to provide as-built or any portion thereof, it shall not be deemed a conflict of interest or breach of the 'third party testing company' requirement.
- B. Certification documentation shall be provided prior to submitting the request for final inspection. The documentation shall include all test results, the names of individuals performing work for the testing agency on this project, detailed procedures followed for all tests, and a certification that all results of tests were within limits specified.

PART 2 – PRODUCTS

2.01 SANITARY WASTE, DRAIN, AND VENT PIPING

- A. Cast iron waste, drain, and vent pipe and fittings.
1. Cast iron waste, drain, and vent pipe and fittings shall be used for the following applications:
 - a. Pipe buried in or in contact with earth.
 - b. Sanitary pipe extensions to a distance of approximately 5 feet outside of the building.

- c. Interior waste and vent piping above grade.
- 2. Cast iron Pipe shall be bell and spigot or hubless (plain end or no-hub or hubless).
- 3. The material for all pipe and fittings shall be cast iron soil pipe and fittings and shall conform to the requirements of CISPI 301, ASTM A888, or ASTM A74.
- 4. Cast iron pipe and fittings shall be made from a minimum of 95 percent post-consumer recycled material.
- 5. Joints for hubless pipe and fittings shall conform to the manufacturer's installation instructions. Couplings for hubless joints shall conform to CISPI 310. Joints for hub and spigot pipe shall be installed with compression gaskets conforming to the requirements of ASTM C564.

B. Polyvinyl Chloride (PVC)

- 1. Polyvinyl chloride (PVC) pipe and fittings are permitted where the waste temperature is below 140 degrees F.
- 2. PVC piping and fittings shall NOT be used for the following applications:
 - a. Waste collected from steam condensate drains.
 - b. Spaces such as mechanical equipment rooms, kitchens, Sterile Processing Services, sterilizer areas, and areas designated for sleep.
 - c. Vertical waste and soil stacks serving more than two floors.
 - d. Exposed in mechanical equipment rooms.
 - e. Exposed inside of ceiling return plenums.
- 3. Polyvinyl chloride sanitary waste, drain, and vent pipe and fittings shall be solid core sewer piping conforming to ASTM D2665, sewer and drain series with ends for solvent cemented joints.
- 4. Fittings: PVC fittings shall be solvent welded socket type using solvent cement conforming to ASTM D2564.

2.02 EXPOSED WASTE PIPING

- A. Chrome plated brass piping of full iron pipe size shall be used in finished rooms for exposed waste piping connecting fixtures, casework, cabinets, equipment and reagent racks when not concealed by apron including those furnished by the Owner or specified in other sections.

1. The Pipe shall meet ASTM B43, regular weight.
 2. The Fittings shall conform to ASME B16.15 or ASTM D2665//.
 3. Nipples shall conform to ASTM B687, Chromium-plated.
 4. Unions shall be brass or bronze with chrome finish. Unions 65 mm (2-1/2 inches) and larger shall be flange type with approved gaskets.
- B. In unfinished Rooms such as mechanical Rooms and Kitchens, Chromeplated brass piping is not required. The pipe materials specified under the paragraph "Sanitary Waste, Drain, and Vent Piping" can be used. The sanitary pipe in unfinished rooms shall be painted as specified in Section 09 90 00 – Painting.

2.03 SPECIALTY PIPE FITTINGS

- A. Transition pipe couplings shall join piping with small differences in outside diameters or different materials. End connections shall be of the same size and compatible with the pipes being joined. The transition coupling shall be elastomeric, sleeve type reducing or transition pattern and include shear and corrosion resistant metal, tension band and tightening mechanism on each end. The transition coupling sleeve coupling shall be of the following material:
1. For cast iron soil pipes, the sleeve material shall be rubber conforming to ASTM C564.
 2. For PVC soil pipes, the sleeve material shall be elastomeric seal or PVC, conforming to ASTM F477 or ASTM D5926.
 3. For dissimilar pipes, the sleeve material shall be PVC conforming to ASTM D5926, or other material compatible with the pipe materials being joined.
- B. The dielectric fittings shall conform to ASSE 1079 with a pressure rating of 125 psig at a minimum temperature of 180 degrees F. The end connection shall be solder joint copper alloy and threaded ferrous.
- C. Dielectric flange insulating kits shall be of non-conducting materials for field assembly of companion flanges with a pressure rating of 150 psig. The gasket shall be neoprene or phenolic. The bolt sleeves shall be phenolic or polyethylene. The washers shall be phenolic with steel backing washers.
- D. The di-electric nipples shall be electroplated steel nipple complying with ASTM F1545 with a pressure rating of 300 psig at 225 degrees F. The end connection shall be male threaded. The lining shall be inert and noncorrosive propylene.

2.04 CLEANOUTS

- A. Cleanouts shall be the same size as the pipe, up to 4 inches; and not less than 4 inches for larger pipe. Cleanouts shall be easily accessible and shall be gastight and watertight. Minimum clearance of 24 inches shall be provided for clearing a clogged sanitary line.
- B. Floor cleanouts shall be gray iron housing with clamping device and round, secured, scoriated, gray iron cover conforming to ASME A112.36.2M. A gray iron ferrule with hubless, socket, inside calk or spigot connection and counter sunk, taper-thread, brass or bronze closure plug shall be included. The frame and cover material and finish shall be nickel-bronze copper alloy with a square shape. The cleanout shall be vertically adjustable for a minimum of 2 inches. When a waterproof membrane is used in the floor system, clamping collars shall be provided on the cleanouts. Cleanouts shall consist of wye fittings and eighth bends with brass or bronze screw plugs. Cleanouts in the resilient tile floors, quarry tile and ceramic tile floors shall be provided with square top covers recessed for tile insertion. In the carpeted areas, carpet cleanout markers shall be provided. Two-way cleanouts shall be provided where indicated on drawings and at every building exit. The loading classification for cleanouts in sidewalk areas or subject to vehicular traffic shall be heavy duty type.
- C. Cleanouts shall be provided at or near the base of the vertical stacks with the cleanout plug located approximately 24 inches above the floor. If there are no fixtures installed on the lowest floor, the cleanout shall be installed at the base of the stack. The cleanouts shall be extended to the wall access cover. Cleanout shall consist of sanitary tees. Nickelbronze square frame and stainless steel cover with minimum opening of 6 by 6 inches shall be furnished at each wall cleanout. Where the piping is concealed, a fixture trap or a fixture with integral trap, readily removable without disturbing concealed pipe, shall be accepted as a cleanout equivalent providing the opening to be used as a cleanout opening is the size required.

2.05 FLOOR DRAINS

- A. General Data: floor drain shall comply with ASME A112.6.3. A caulking flange, inside gasket, or hubless connection shall be provided for connection to cast iron pipe, screwed or no hub outlets for connection to steel pipe. The drain connection shall be bottom outlet. A membrane clamp and extensions shall be provided, if required, where installed in connection with waterproof membrane. Puncturing membrane other than for drain opening will not be permitted. Double drainage pattern floor drains shall have integral seepage pan for embedding into floor construction, and weep holes to provide adequate drainage from pan to drain pipe. For drains not installed in connection with a waterproof membrane, a flashing membrane, 24 inches square or another approved waterproof membrane shall be provided.
- B. FD-1: medium duty (non-traffic) floor drain shall comply with ASME A112.6.3. The floor drain shall be constructed of an epoxy coated cast iron body with medium duty nickel

bronze grate, double drainage pattern, clamping device, without sediment bucket but with secondary strainer in bottom for large debris. The grate shall be 6 inches minimum.

2.06 TRAPS

- A. Traps shall be provided on all sanitary branch waste connections from fixtures or equipment not provided with traps. Exposed brass shall be polished brass chromium plated with nipple and set screw escutcheons. Concealed traps may be rough cast brass or same material as the piping they are connected to. Slip joints are not permitted on sewer side of trap. Traps shall correspond to fittings on cast iron soil pipe or steel pipe respectively, and size shall be as required by connected service or fixture.

2.07 TRAP SEAL PROTECTION

- A. Trap Primer (TP-1): The trap seal primer system shall be electronic type conforming to ASSE 1044.
 - 1. The controller shall have a 24 hour programmable timer, solid state, 6 outlet zones, minimum adjustable run time of 1 minute for each zone, 12 hour program battery backup, manual switch for 120VAC power, 120VAC to 24VAC internal transformer, fuse protected circuitry, UL listed, 120VAC input-24VAC output, constructed of enameled steel or plastic.
 - 2. The cabinet shall be recessed mounting with a stainless steel cover.
 - 3. The solenoid valve shall have a brass body, suitable for potable water service, normally closed, 125 psig rated, 24VAC.
 - 4. The control wiring shall be copper in accordance with the National Electric Code (NFPA 70), Article 725 and not less than 18 gauge. All wiring shall be in conduit and in accordance with Division 26 of the Specifications.
 - 5. The vacuum breaker shall conform to ASSE 1001.
- B. Floor trap seals can be protected by a barrier type trap seal device. The device shall conform to ASSE 1072 and be installed in accordance with manufacturer requirements.
- C. Trap Primer (TP-2): The trap seal primer valve shall be hydraulic, supply type with a pressure rating of 125 psig and conforming to standard ASSE 1018.
 - 1. The inlet and outlet connections shall be NPS 1/2 inch
 - 2. The trap seal primer valve shall be fully automatic with an all brass or bronze body.
 - 3. The trap seal primer valve shall be activated by a drop in building water pressure, no adjustment required.

4. The trap seal primer valve shall include a manifold when serving two, three, or four traps.
5. The manifold shall be omitted when serving only one trap.

2.08 PENETRATION SLEEVES

- A. A sleeve flashing device shall be provided at points where pipes pass through membrane waterproofed floors or walls. The sleeve flashing device shall be manufactured, cast iron fitting with clamping device that forms a sleeve for the pipe floor penetration of the floor membrane. A galvanized steel pipe extension shall be included in the top of the fitting that will extend 2 inches above finished floor and galvanized steel pipe extension in the bottom of the fitting that will extend through the floor slab. A waterproof caulked joint shall be provided at the top hub.

PART 3 – EXECUTION

3.01 PIPE INSTALLATION

- A. Piping Schedule

Pipe Installation Schedule					
Service	Pressure Test	Pipe Material	Fittings	Joining Methods	Construction Standards
Above Grade Exterior Piping	10 ft of head, or 5 PSI	Cast Iron	Hubless or Hub & Spigot	CISPI 310, or ASTM C564	CISPI 301, ASTM A888, or ASTM A74
Interior and Below Grade Piping	10 ft of head, or 5 PSI	PVC	Sockets	Solvent Welded, ASTM D2564	ASTM D2665

- B. The pipe installation shall comply with the requirements of the International Plumbing Code (IPC) and these specifications.
- C. Branch piping shall be installed for waste from the respective piping systems and connect to all fixtures, valves, cocks, outlets, casework, cabinets and equipment, including those furnished by the Owner or specified in other Sections.
- D. Pipe shall be round and straight. Cutting shall be done with proper tools. Pipe shall be reamed to full size after cutting.

- E. All pipe runs shall be laid out to avoid interference with other work.
- F. The piping shall be installed above accessible ceilings where possible.
- G. The piping shall be installed to permit valve servicing or operation.
- H. The piping shall be installed free of sags and bends.
- I. Seismic restraint shall be installed where required by code.
- J. Changes in direction for soil and waste drainage and vent piping shall be made using appropriate branches, bends and long sweep bends. Sanitary tees and short sweep quarter bends may be used on vertical stacks if change in direction of flow is from horizontal to vertical. Long turn double wye branch and eighth bend fittings shall be used if two fixtures are installed back to back or side by side with common drain pipe. Straight tees, elbows, and crosses may be used on vent lines. Do not change direction of flow more than 90 degrees. Proper size of standard increaser and reducers shall be used if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.
- K. Buried soil and waste drainage and vent piping shall be laid beginning at the low point of each system. Piping shall be installed true to grades and alignment indicated with unbroken continuity of invert. Hub ends shall be placed upstream. Required gaskets shall be installed according to manufacturer's written instruction for use of lubricants, cements, and other installation requirements.
- L. Cast iron piping shall be installed according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings"
- M. Aboveground copper tubing shall be installed according to Copper Development Association's (CDA) "Copper Tube Handbook".
- N. Aboveground PVC piping shall be installed according to ASTM D2665. Underground PVC piping shall be installed according to ASTM D2321.
- O. If an installation is unsatisfactory to the COR, the Contractor shall correct the installation at no cost to the Owner.

3.02 JOINT CONSTRUCTION

- A. Hub and spigot, cast iron piping with gasket joints shall be joined in accordance with CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for compression joints.
- B. Hub and spigot, cast iron piping with calked joints shall be joined in accordance with CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for lead and oakum calked joints.

- C. Hubless or No-hub, cast iron piping shall be joined in accordance with CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless piping coupling joints.
- D. For threaded joints, thread pipe with tapered pipe threads according to ASME B1.20.1. The threads shall be cut full and clean using sharp disc cutters. Threaded pipe ends shall be reamed to remove burrs and restored to full pipe inside diameter. Pipe fittings and valves shall be joined as follows:
 - 1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is required by the pipe service.
 - 2. Pipe sections with damaged threads shall be replaced with new sections of pipe.
- E. Copper tube and fittings with soldered joints shall be joined according to ASTM B828. A water flushable, lead free flux conforming to ASTM B813 and a lead-free alloy solder conforming to ASTM B32 shall be used.
- F. For PVC piping, solvent cement joints shall be used for joints. All surfaces shall be cleaned and dry prior to applying the primer and solvent cement. Installation practices shall comply with ASTM F402. The joint shall conform to ASTM D2855 and ASTM D2665 appendixes.

3.03 SPECIALTY PIPE FITTINGS

- A. Transition coupling shall be installed at pipe joints with small differences in pipe outside diameters.
- B. Dielectric fittings shall be installed at connections of dissimilar metal piping and tubing.

3.04 PIPE HANGERS, SUPPORTS AND ACCESSORIES

- A. All piping shall be supported according to the International Plumbing Code (IPC), Section 22 05 00 – Common Results for Plumbing, and these specifications. Where conflicts arise between these the code and Section 22 05 00 – Common Results for Plumbing the most restrictive or the requirement that specifies supports with highest loading or shortest spacing shall apply.
- B. Hangers, supports, rods, inserts and accessories used for pipe supports shall be painted according to Section 09 90 00 – Painting. Electroplated copper hanger rods, hangers and accessories may be used with copper tubing.
- C. Horizontal piping and tubing shall be supported within 12 inches of each fitting or coupling.
- D. Horizontal cast iron piping shall be supported with the following maximum horizontal spacing and minimum hanger rod diameters:

1. NPS 1-1/2 inch to NPS 2 inch: 60 inches with 3/8-inch rod.
 2. NPS 3 inch: 60 inches with 1/2-inch rod.
 3. NPS 4 inch to NPS 5 inch: 60 inches with 5/8-inch rod.
 4. NPS 6 inch to NPS 8 inch: 60 inches with 3/4-inch rod.
 5. NPS 10 inch to NPS 12 inch: 60 inch with 7/8 inch rod.
- E. The maximum spacing for plastic pipe shall be 4 feet.
- F. Vertical piping and tubing shall be supported at the base, at each floor, and at intervals no greater than 15 feet.
- G. In addition to the requirements in Section 22 05 00 – Common Results for Plumbing shall have the following characteristics:
1. Solid or split unplated cast iron.
 2. All plates shall be provided with set screws.
 3. Height adjustable clevis type pipe hangers.
 4. Adjustable floor rests and base flanges shall be steel.
 5. Hanger rods shall be low carbon steel, fully threaded or threaded at each end with two removable nuts at each end for positioning rod and hanger and locking each in place.
 6. Riser clamps shall be malleable iron or steel.
 7. Rollers shall be cast iron.
 8. See Section 22 05 00 – Common Results for Plumbing, for requirements on insulated pipe protective shields at hanger supports.
- H. Miscellaneous materials shall be provided as specified, required, directed or as noted on the drawings for proper installation of hangers, supports and accessories. If the vertical distance exceeds 20 feet for cast iron pipe additional support shall be provided in the center of that span. All necessary auxiliary steel shall be provided to provide that support.
- I. Cast escutcheon with set screw shall be provided at each wall, floor and ceiling penetration in exposed finished locations and within cabinets and millwork.
- J. Penetrations:

1. Fire Stopping: Where pipes pass through fire partitions, fire walls, smoke partitions, or floors, a fire stop shall be installed that provides an effective barrier against the spread of fire, smoke and gases as specified in Section 07 84 00 – Firestopping. Clearances between raceways and openings shall be completely filled and sealed with the fire stopping materials.
 2. Water proofing: At floor penetrations, clearances shall be completely sealed around the pipe and make watertight with sealant as specified in Section 07 90 00 – Joint Fillers, Sealants and Caulking.
- K. Exhaust vents shall be extended separately through roof. Sanitary vents shall not connect to exhaust vents.

3.05 TESTS

- A. Sanitary waste and drain systems shall be tested either in its entirety or in sections.
- B. Waste System tests shall be conducted before trenches are backfilled or fixtures are connected. A water test or air test shall be conducted, as directed.
1. If entire system is tested for a water test, tightly close all openings in pipes except highest opening, and fill system with water to point of overflow. If the waste system is tested in sections, tightly plug each opening except highest opening of section under test, fill each section with water and test with at least a 10-foot head of water. In testing successive sections, test at least upper 10 feet of next preceding section so that each joint or pipe except upper most 10 feet of system has been submitted to a test of at least a 10-foot head of water. Water shall be kept in the system, or in portion under test, for at least 15 minutes before inspection starts. System shall then be tight at all joints.
 2. For an air test, an air pressure of 5 psig gauge shall be maintained for at least 15 minutes without leakage. A force pump and mercury column gauge shall be used for the air test.
 3. After installing all fixtures and equipment, open water supply so that all p-traps can be observed. For 15 minutes of operation, all p-traps shall be inspected for leaks and any leaks found shall be corrected.
 4. Final Tests: Either one of the following tests may be used.
 - a. Smoke Test: After fixtures are permanently connected and traps are filled with water, fill entire drainage and vent systems with smoke under pressure of 1 inch of water with a smoke machine. Chemical smoke is prohibited.
 - b. Peppermint Test: Introduce 2 ounces of peppermint into each line or stack.

END OF SECTION

SECTION 22 13 19
SANITARY WASTE PIPING SPECIALTIES

PART 1 – GENERAL

1.01 SUMMARY

- A. This Section includes the following sanitary drainage piping specialties:
 - 1. Cleanouts.
 - 2. Floor drains.
 - 3. Roof flashing assemblies.
 - 4. Through-penetration firestop assemblies.
 - 5. Miscellaneous sanitary drainage piping specialties.
 - 6. Flashing materials.
- B. Related Sections include the following:
 - 1. Section 22 14 13 – Facility Storm Drainage for trench drains for storm water, channel drainage systems for storm water, roof drains, and catch basins.
 - 2. Refer to Section 22 05 00 – Common Results for Plumbing for piping joining materials, joint construction, and basic installation requirements.

1.02 DEFINITIONS

- A. PVC: Polyvinyl chloride plastic.

1.03 SUBMITTALS

- A. Shop Drawings: Show fabrication and installation details for frost-resistant vent terminals.
- B. Field quality-control test reports.
- C. Operation and Maintenance Data: For drainage piping specialties to include in emergency, operation, and maintenance manuals.

1.04 QUALITY ASSURANCE

- A. Drainage piping specialties shall bear label, stamp, or other markings of specified testing agency.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- C. Comply with NSF 14, Plastics Piping Components and Related Materials, for plastic sanitary piping specialty components.

1.05 COORDINATION

- A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.
- B. Coordinate size and location of roof penetrations.

PART 2 – PRODUCTS

2.01 CLEANOUTS

- A. Cleanouts:
 - 1. Basis-of-Design Product: Subject to compliance with requirements, refer to table for area and provide the product indicated or a comparable product by one of the following:
 - a. Linoleum Floors: J.R. Smith Series 4140 – round top with insert
 - b. Carpeted Floors: J.R. Smith Series 4240-Y – round with carpet marker
 - c. Exterior: J. R. Smith 4240 – round with cast iron cover
 - d. Wall: J.R. Smith Series 4710
 - e. Quarry Floor: J.R. Smith Series 4053-PB – square bronze top
 - f. Ceramic Floor: J.R. Smith Series 4053-NB – square nickel bronze top
 - g. Concrete Floors: J. R. Smith Series 4100 – round galvanized cast iron top.
 - h. Truck/Loading Dock Areas: J. R. Smith Series 4231 – ductile iron top.
 - i. Josam Company; Josam Div.

- j. MIFAB, Inc.
 - k. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
 - l. Tyler Pipe; Wade Div.
 - m. Watts Drainage Products Inc.
 - n. Zurn Plumbing Products Group; Specification Drainage Operation.
- 2. Standard: ASME A112.36.2M for cast iron for cleanout test tee.
 - 3. Body Material: cast-iron as required to match connected piping.
 - 4. Closure: Countersunk or raised-head, brass plug.
 - 5. Closure Plug Size: Same as or not more than one size smaller than cleanout size.

2.02 FLOOR DRAINS AND FLOOR SINKS

A. Floor Drains and Floor Sinks:

- 1. Manufacturers:
 - a. Josam Company; Josam Div.
 - b. MIFAB, Inc.
 - c. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
 - d. Tyler Pipe; Wade Div.
 - e. Watts Drainage Products Inc.
 - f. Zurn Plumbing Products Group; Light Commercial Operation.
- 2. Standard: ASME A112.6.3.
- 3. Refer to schedule on drawings

2.03 ROOF FLASHING ASSEMBLIES

A. Roof Flashing Assemblies:

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Acorn Engineering Company; Elmdor/Stoneman Div.

- b. Thaler Metal Industries Ltd.
- B. Description: Manufactured assembly made of 6.0-lb/sq. ft., 0.0938-inch-thick, lead flashing collar and skirt extending at least 8 inches from pipe, with galvanized-steel boot reinforcement and counterflashing fitting.

2.04 MISCELLANEOUS SANITARY DRAINAGE PIPING SPECIALTIES

- A. Hub Drain:
 - 1. Description: Shop or field fabricate from ASTM A 74, Service class, hub-and-spigot, cast-iron, soil-pipe fittings. Include P-trap, hub-and-spigot riser section; and where required, increaser fitting joined with ASTM C 564, rubber gaskets.
 - 2. Size: as indicated on drawings.

PART 3 – EXECUTION

3.01 INSTALLATION

- A. Install cleanouts in aboveground piping and building drain piping according to the following, unless otherwise indicated:
 - 1. Size same as drainage piping up to NPS 4. Use NPS 4 for larger drainage piping unless larger cleanout is indicated.
 - 2. Locate at each change in direction of piping greater than 45 degrees.
 - 3. Locate at minimum intervals of 50 feet for piping NPS 4 and smaller and 100 feet for larger piping.
 - 4. Locate at base of each vertical soil and waste stack.
- B. For floor cleanouts for piping below floors, install cleanout deck plates with top flush with finished floor.
- C. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.
- D. Install floor drains at low points of surface areas to be drained. Set grates of drains flush with finished floor, unless otherwise indicated.
 - 1. Position floor drains for easy access and maintenance.
 - 2. Set floor drains below elevation of surrounding finished floor to allow floor drainage. Set with grates depressed according to the following drainage area radii:

- a. Radius, 30 Inches or Less: Equivalent to 1 percent slope, but not less than 1/4-inch total depression.
 - b. Radius, 30 to 60 Inches: Equivalent to 1 percent slope.
 - c. Radius, 60 Inches or Larger: Equivalent to 1 percent slope, but not greater than 1-inch total depression.
- 3. Install floor-drain flashing collar or flange so no leakage occurs between drain and adjoining flooring. Maintain integrity of waterproof membranes where penetrated.
- 4. Install individual traps for floor drains connected to sanitary building drain, unless otherwise indicated.
- E. Install roof flashing assemblies on sanitary stack vents and vent stacks that extend through roof.
- F. Install flashing fittings on sanitary stack vents and vent stacks that extend through roof.
- G. Assemble open drain fittings and install with top of hub 1 inch above floor.
- H. Install deep-seal traps on floor drains and other waste outlets, if indicated.
- I. Install floor-drain, trap-seal primer fittings on inlet to floor drains that require trap-seal primer connection.
 - 1. Exception: Fitting may be omitted if trap has trap-seal primer connection.
 - 2. Size: Same as floor drain inlet.
- J. Install air-gap fittings on draining-type backflow preventers and on indirect-waste piping discharge into sanitary drainage system.
- K. Install sleeve flashing device with each riser and stack passing through floors with waterproof membrane.
- L. Install wood-blocking reinforcement for wall-mounting-type specialties.
- M. Install traps on plumbing specialty drain outlets. Omit traps on indirect wastes unless trap is indicated.
- N. Install escutcheons at wall, floor, and ceiling penetrations in exposed finished locations and within cabinets and millwork. Use deep-pattern escutcheons if required to conceal protruding pipe fittings.

3.02 CONNECTIONS

- A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to equipment to allow service and maintenance.

3.03 FLASHING INSTALLATION

- A. Fabricate flashing from single piece unless large pans, sumps, or other drainage shapes are required. Join flashing according to the following if required:
 - 1. Lead Sheets: Burn joints of lead sheets 6.0-lb/sq. ft., 0.0938-inch thickness or thicker.
 - 2. Copper Sheets: Solder joints of copper sheets.
- B. Install sheet flashing on pipes, sleeves, and specialties passing through or embedded in floors and roofs with waterproof membrane.
- C. Set flashing on floors and roofs in solid coating of bituminous cement.
- D. Secure flashing into sleeve and specialty clamping ring or device.
- E. Install flashing for piping passing through roofs with counterflashing or commercially made flashing fittings, according to Section 07 60 00– Flashing and Sheet Metal.
- F. Extend flashing up vent pipe passing through roofs and turn down into pipe, or secure flashing into cast-iron sleeve having calking recess.
- G. Fabricate and install flashing and pans, sumps, and other drainage shapes.

3.04 PROTECTION

- A. Protect drains during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.
- B. Place plugs in ends of uncompleted piping at end of each day or when work stops.

END OF SECTION

SECTION 22 14 13
STORM DRAINAGE

PART 1 – GENERAL

1.01 DESCRIPTION

- A. This Section describes the requirements for storm drainage systems, including piping and all necessary accessories as designated in this Section.
- B. A complete listing of all acronyms and abbreviations are included in Section 22 05 00 – Common Results for Plumbing.

1.02 RELATED WORK

- A. Division 01 – General Conditions
- B. Section 01 33 00 – Submittal Procedures
- C. Section 07 84 00 – Firestopping: Penetrations in rated enclosures.
- D. Section 07 90 00 – Joint Fillers, Sealants and Caulking
- E. Section 09 90 00 – Painting: Preparation and finish painting and identification of piping systems.
- F. Section 22 05 00 – Common Results for Plumbing: Pipe Hangers and Supports, Materials Identification.
- G. Section 22 05 33 – Heat Tracing for Plumbing Piping
- H. Section 22 07 19 – Plumbing Piping Insulation

1.03 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. American Society of Mechanical Engineers (ASME):
 - 1. A112.6.4-2003 (R2012) – Roof, Deck, and Balcony Drains
 - 2. A13.1-2007 (R2013) – Scheme for Identification of Piping Systems

C. American Society of Sanitary Engineering (ASSE)

1. 1079-2012 – Performance Requirements for Dielectric Pipe Unions

D. American Society for Testing and Materials (ASTM):

1. C1173-2010 (R2014) – Standard Specification for Flexible Transition Couplings for Underground Piping Systems
2. D1785-2012 – Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80 and 120
3. D2000-2012 – Standard Classification System for Rubber Products in Automotive Applications
4. D2321-2014e1 – Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications
5. D2564-2012 – Standard Specification for Solvent Cements for Poly (Vinyl Chloride) (PVC) Plastic Piping Systems
6. D2665-2014 – Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Drain, Waste, and Vent Pipe and Fittings
7. D2855-1996 (R2010) – Standard Practice for Making Solvent-Cemented Joints with Poly (Vinyl Chloride) (PVC) Pipe and Fittings
8. D4101-2014 – Standard Specification for Polypropylene Injection and Extrusion Materials
9. D5926-2011 – Standard for Poly (Vinyl Chloride) (PVC) Gaskets for Drain, Waste, and Vent (DWV), Sewer, Sanitary, and Storm Plumbing Systems
10. F477-2014 – Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe
11. F656-2010 – Standard Specification for Primers for Use in Solvent Cement Joints of Poly (Vinyl Chloride) (PVC) Plastic Pipe and Fittings
12. F1545-2015 – Standard Specification for Plastic-Lined Ferrous Metal Pipe, Fittings, and Flanges

E. International Code Council (ICC):

1. IPC-2012 – International Plumbing Code

- F. Manufacturers Standardization Society of the Valve and Fittings Industry, Inc. (MSS):
1. SP-72-2010a – Ball Valves with Flanged or Butt-Welding Ends for General Service
 2. SP-110-2010 – Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends

1.04 SUBMITTALS

- A. Submittals, including number of required copies, shall be submitted in accordance with Section 01 33 00– Submittal Procedures.
- B. Information and material submitted under this Section shall be marked “SUBMITTED UNDER SECTION 22 14 13 – FACILITY STORM DRAINAGE”, with applicable paragraph identification.
- C. Manufacturer's Literature and Data including: Full item description and optional features and accessories. Include dimensions, weights, materials, applications, standard compliance, model numbers, size, and capacity.
1. Pipe and Fittings.
 2. Specialty Pipe Fittings.
 3. Cleanouts.
 4. Roof Drains.
 5. Expansion Joints.
 6. Downspout Nozzles.
 7. Sleeve Flashing Devices.
- D. Detailed shop drawing of clamping device and extensions when required in connection with the waterproofing membrane.

1.05 QUALITY ASSURANCE

1.06 BIO-BASED MATERIALS: FOR PRODUCTS DESIGNATED BY THE USDA’S BIO-PREFERRED PROGRAM, PROVIDE PRODUCTS THAT MEET OR EXCEED USDA RECOMMENDATIONS FOR BIO-BASED CONTENT, SO LONG AS PRODUCTS MEET ALL PERFORMANCE REQUIREMENTS IN THIS SPECIFICATIONS SECTION. FOR MORE

INFORMATION REGARDING THE PRODUCT CATEGORIES COVERED BY THE BIO-PREFERRED AS-BUILT DOCUMENTATION

- A. Submit manufacturer's literature and data updated to include submittal review comments and any equipment substitutions.
- B. Submit operation and maintenance data updated to include submittal review comments, substitutions and construction revisions shall be in electronic version on compact disc or DVD or inserted into a three ring binder. All aspects of system operation and maintenance procedures, including piping isometrics, wiring diagrams of all circuits, a written description of system design, control logic, and sequence of operation shall be included in the operation and maintenance manual. The operations and maintenance manual shall include troubleshooting techniques and procedures for emergency situations. Notes on all special systems or devices such as damper and door closure interlocks shall be included. A List of recommended spare parts (manufacturer, model number, and quantity) shall be furnished. Information explaining any special knowledge or tools the owner will be required to employ shall be inserted into the As-Built documentation.
- C. The installing contractor shall maintain as-built drawings of each completed phase for verification; and, shall provide the complete set at the time of final systems certification testing. As-built drawings are to be provided, and a copy of them in Auto-CAD version 2020 provided on compact disk or DVD. Should the installing contractor engage the testing company to provide as-built or any portion thereof, it shall not be deemed a conflict of interest or breach of the 'third party testing company' requirement.
- D. Certification documentation shall be provided to Owner's Representative 10 working days prior to submitting the request for final inspection. The documentation shall include all test results, the names of individuals performing work for the testing agency on this project, detailed procedures followed for all tests, and certification that all results of tests were within limits specified.

PART 2 – PRODUCTS

2.01 STORM WATER DRAIN PIPING

- A. Polyvinyl Chloride (PVC):
 - 1. PVC storm sewer pipe and fittings are permitted for single story structures except for mechanical equipment rooms and other areas containing air handling equipment or hot water generation equipment.
 - 2. PVC storm sewer pipe and fittings shall be schedule 40 solid core piping conforming to ASTM D1785 and ASTM D2665, Sewer and Drain Series, with ends for solvent cemented joints.

3. PVC joints shall be solvent welded socket type using solvent cement conforming to ASTM D2564 and adhesive primer conforming to ASTM F656. Bio-based materials shall be utilized when possible.
- B. Roof drain piping and body of drain in locations where the outdoor conditions are subject to freezing shall be insulated.

2.02 SPECIALTY PIPE FITTINGS

- A. Transition pipe couplings shall join piping with small differences in outside diameters or be of different materials. End connections shall be of the same size and compatible with the pipes being joined. The transition coupling shall be unshielded, elastomeric, sleeve type reducing or transition pattern conforming with ASTM C1173 and include shear ring and corrosion resistant metal tension band and tightening mechanism on each end. The transition coupling sleeve coupling shall be of the following material:
1. For cast iron soil pipes, the sleeve material shall be rubber conforming to ASTM C564.
 2. For PVC soil pipes, the sleeve material shall be elastomeric seal conforming to ASTM F477 or PVC conforming to ASTM D5926.
 3. dissimilar pipes, the sleeve material shall be PVC conforming to ASTM D5926, or other material compatible with the pipe materials being joined.
- B. Dielectric fittings shall conform to ASSE 1079 with a pressure rating of 150 psig at a minimum temperature of 180 degrees F. The end connection shall be solder joint copper alloy and threaded ferrous.
- C. Dielectric flanges shall conform to ASSE 1079 with a pressure rating of 150 psig. The flange shall be a factory fabricated, bolted, companion flange assembly. The end connection shall be threaded or solder-joint copper alloy and threaded ferrous.
- D. Dielectric flange insulating kits shall be of non-conducting materials for field assembly of companion flanges with a pressure rating of 150 psig. The gasket shall be neoprene or phenolic. The bolt sleeves shall be phenolic or polyethylene. The washers shall be phenolic with steel backing washers.
- E. Dielectric nipples shall be electroplated steel and shall conform with ASTM F1545 with a pressure ratings of 300 psig at 225 degrees F. The end connection shall be male threaded. The lining shall be inert and noncorrosive propylene. Bio-based materials shall be utilized when possible.

2.03 CLEANOUTS

- A. Cleanouts shall be the same size as the pipe, up to 4 inches; not less than 4 inches for larger pipe. Cleanouts shall be easily accessible and shall be gastight and watertight. A minimum clearance of 24 inches shall be provided for clearing a clogged storm sewer line.
- B. Floor cleanouts shall be gray iron housing with clamping device and round, secured, scoriated, gray iron cover conforming to ASME A112.36.2M. A gray iron ferrule with hubless, socket, inside caulk or spigot connection and counter sunk, taper-thread, brass or bronze closure plug shall be included. The frame and cover material and finish shall be nickel-bronze copper alloy with a square shape. The cleanout shall be vertically adjustable for a minimum of 2 inches. When a waterproof membrane is used in the floor system, clamping collars shall be provided on the cleanouts. Cleanouts shall consist of wye fittings and eighth bends with brass or bronze screw plugs. Cleanouts in the resilient tile floors, quarry tile and ceramic tile floors shall be provided with square top covers recessed for tile insertion. In the carpeted areas, carpet cleanout markers shall be provided. Two way cleanouts shall be provided where indicated on the drawings and at each building exit. The loading classification for cleanouts in sidewalk areas or subject to vehicular traffic shall be heavy duty.
- C. Cleanouts shall be provided at or near the base of the vertical stacks with the cleanout plug located approximately 24 inches above the floor. The cleanouts shall be extended to the wall access cover. Cleanout shall consist of sanitary tees. Nickel bronze square frame and stainless steel cover with minimum opening of 6 inch by 6 inch shall be provided at each wall cleanout.
- D. In horizontal runs above grade, cleanouts shall consist of cast brass tapered screw plug in fitting or caulked/no hub cast iron ferrule. Plain end (no-hub) piping in interstitial space or above ceiling may use plain end (no-hub) blind plug and clamp.

2.04 ROOF DRAINS AND CONNECTIONS

- A. Roof Drains: Roof Drains (RD) shall be cast iron with clamping device for making watertight connection and shall conform with ASME A112.6.4. Free openings through strainer shall be twice area of drain outlet. For roof drains not installed in connection with a waterproof membrane, a soft copper membrane shall be provided 12 inches in diameter greater than outside diameter of drain collar. An integral gravel stop shall be provided for drains installed on roofs having built up roofing covered with gravel or slag. Integral no-hub, soil pipe gasket or threaded outlet connection shall be provided.
 - 1. Flat Roofs: The roof drain shall have a beehive or dome shaped strainer with integral flange not less than 12 inches in diameter. For an insulated roof, a roof drain with an adjustable drainage collar shall be provided, which can be raised or lowered to meet required insulation heights, sump receiver and deck clamp. The

bottom section shall serve as roof drain during construction before insulation is installed.

2. Canopy Roofs: The roof drain shall have a beehive or dome shaped strainer with the integral flange no greater than 8 inches in diameter. For an insulated roof, the roof drain shall be provided with an adjustable drainage collar, which can be raised or lowered to meet the required insulation heights, sump receiver and deck clamp. Bottom section shall serve as roof drain during construction before insulation is installed.
 3. Promenade Decks: the roof drain shall be the same as for canopy roofs, except decks shall have flat, round, loose, non-slip, bronze grate set in square, non-slip, bronze frame.
 4. Portico Roofs and Gutters: Roof drains shall be horizontal angle type drain with flat bottom and horizontal outlet at the same elevation as the pipe to which it is connected. Strainer shall be removable angle grate type.
 5. Protective Roof Membrane Insulation Assembly: The roof drain shall have a perforated stainless steel extension filter, non-puncturing clamp ring, large sump with extra wide roof flange and deck clamp.
 - a. Non pedestrian Roofs: The roof drain shall have large polypropylene or aluminum locking dome.
 - b. Pedestrian Roof: The roof drain shall have a bronze promenade top 14 inches square, set in square secured frame support collar.
 6. Roof Drains, Overflow or Secondary (Emergency): Roof Drains identified as overflow or secondary (emergency) drains shall have a 2 inch water dam integral to the drain body.
 7. Roof drains in areas subject to freezing shall have heat tape and shall be insulated.
- B. Expansion Joints: Expansions joints shall be heavy cast iron with cast brass or PVC expansion sleeve having smooth bearing surface working freely against a packing ring held in place and under pressure of a bolted gland ring, forming a water and air tight flexible joint. Asbestos packing is prohibited.
- C. Interior Downspouts: An expansion joint shall be provided, specified above, at top of run on straight, vertical runs of downspout piping 40 feet long or greater.

2.05 DOWNSPOUT NOZZLE

- A. The downspout nozzle fitting shall be of brass, unfinished, with internal pipe thread or no-hub adaptor as required for connection to rain leader downspout. Wall flange shall act as escutcheon and support anchor.
- B. Downspout nozzle shall be Jay R. Smith – 1770, Zurn – Z199, or equal.

2.06 WATERPROOFING

- A. A sleeve flashing device shall be provided at points where pipes pass through membrane waterproofed floors or walls. The sleeve flashing device shall be manufactured, cast iron fitting with clamping device that forms a sleeve for the pipe floor penetration of the floor membrane. A galvanized steel pipe extension shall be included in the top of the fitting that will extend 2 inches above finished floor and galvanized steel pipe extension in the bottom of the fitting that will extend through the floor slab. A waterproofed caulked joint shall be provided at the top hub.

PART 3 – EXECUTION

3.01 PIPE INSTALLATION

- A. The pipe installation shall comply with the requirements of the IPC and these specifications.
- B. Branch piping shall be installed from the piping system and connect to all drains and outlets.
- C. Pipe shall be round and straight. Cutting shall be done with proper tools. Pipe, except for glass, shall be reamed to remove burrs and a clean smooth finish restored to full pipe inside diameter.
- D. All pipe runs shall be laid out to avoid interference with other work/trades.
- E. The piping shall be installed above accessible ceilings to allow for ceiling panel removal.
- F. Unless otherwise stated on the documents, minimum horizontal slope shall be one inch for every 8 feet (1 percent slope) of pipe length.
- G. The piping shall be installed free of sags and bends.
- H. Seismic restraint shall be installed where required by code.
- I. Changes in direction for storm drainage piping shall be made using appropriate branches, bends and long sweep bends. Sanitary tees and short sweep $\frac{1}{4}$ bends may be used on vertical stacks if change in direction of flow is from horizontal to vertical.

Long turn double wye branch and 1/8 bend fittings shall be used if two drains are installed back to back or side by side with common drain pipe. Do not change direction of flow more than 90 degrees. Proper size of standard increaser and reducers shall be used if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.

- J. Buried storm drainage piping shall be laid beginning at the low point of each system. Piping shall be installed true to grades and alignment indicated with unbroken continuity of invert. Hub ends shall be placed upstream. Required gaskets shall be installed according to manufacturer's written instruction for use of lubricants, cements, and other installation requirements. Bio-based materials shall be utilized when possible.
- K. Cast iron piping shall be installed according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings"
- L. Aboveground copper tubing shall be installed according to CDA A4015.
- M. Aboveground PVC piping shall be installed according to ASTM D2665. Underground PVC piping shall be installed according to ASTM D2321.

3.02 JOINT CONSTRUCTION

- A. Hub and spigot, cast iron piping with gasket joints shall be joined in accordance with CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for compression joints.
- B. Hub and spigot, cast iron piping with calked joints shall be joined in accordance with CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for lead and oakum calked joints.
- C. Hubless, cast iron piping shall be joined in accordance with CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless piping coupling joints.
- D. For threaded joints, thread pipe with tapered pipe threads according to ASME B1.20.1. The threads shall be cut full and clean using sharp disc cutters. Threaded pipe ends shall be reamed to remove burrs and restored to full pipe inside diameter. Pipe fittings and valves shall be joined as follows:
 - 1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is required by the pipe service
 - 2. Pipe sections with damaged threads shall be replaced with new undamaged sections of pipe at no additional time or cost to the Owner.
- E. Copper tube and fittings with soldered joints shall be joined according to ASTM B828. A water flushable, lead free flux conforming to ASTM B813 and a lead free alloy solder conforming to ASTM B32 shall be used.

- F. For PVC piping, solvent cement joints shall be used for joints. All surfaces shall be cleaned and dry prior to applying the primer and solvent cement. Installation practices shall comply with ASTM F402. The joint shall conform to ASTM D2855 and ASTM D2665 appendices.

3.03 SPECIALTY PIPE FITTINGS

- A. Transition coupling shall be installed at pipe joints with small differences in pipe outside diameters.
- B. Dielectric fittings shall be installed at connections of dissimilar metal piping and tubing.

3.04 PIPE HANGERS, SUPPORTS AND ACCESSORIES

- A. All piping shall be supported according to the IPC, Section 22 05 00 – Common Results for Plumbing, and these Specifications.
- B. Hangers, supports, rods, inserts and accessories used for Pipe supports shall be shop coated with zinc Chromate primer paint. Electroplated copper hanger rods, hangers and accessories may be used with copper tubing.
- C. Horizontal piping and tubing shall be supported within 12 inches of each fitting or coupling.
- D. Horizontal cast iron piping shall be supported with the following maximum horizontal spacing and minimum hanger rod diameters:
 - 1. NPS 1-1/2 to NPS 2: 60 inches with 3/8 inch rod.
 - 2. NPS 3: 60 inches with 1/2 inch rod.
 - 3. NPS 4 to NPS 5: 60 inches) with 5/8 inch rod.
 - 4. NPS 6 to NPS 8: 60 inches with 3/4 inch rod.
 - 5. NPS 10 to NPS 12: 60 inches with 7/8 inch rod.
- E. The maximum support spacing for horizontal plastic shall be 4 feet.
- F. Vertical piping and tubing shall be supported at the base, at each floor, and at intervals no greater than 15 feet.
- G. In addition to the requirements in Section 22 05 00 – Common Results for Plumbing, floor, wall and ceiling plates shall have the following characteristics:
 - 1. Solid or split unplated cast iron.

2. All plates shall be provided with set screws.
 3. Height adjustable clevis type pipe hangers.
 4. Adjustable Floor Rests and Base Flanges shall be steel.
 5. Hanger Rods shall be low carbon steel, fully threaded or threaded at each end with two removable nuts at each end for positioning rod and hanger and locking each in place.
 6. Riser Clamps shall be malleable iron or steel.
 7. Roller shall be cast iron.
 8. Hangers and supports utilized with insulated pipe and tubing shall have 180-degree (minimum) metal protection shield centered on and welded to the hanger and support. The shield shall be 4 inches in length and be 16-gauge steel. The shield shall be sized for the insulation.
- H. Miscellaneous materials shall be provided as specified, required, directed or as noted on the drawings for proper installation of hangers, supports and accessories. If the vertical distance exceeds 20 feet for cast iron pipe additional support shall be provided in the center of that span. All necessary auxiliary steel shall be provided to provide that support.
- I. Cast escutcheon with set screw shall be installed at each wall, floor and ceiling penetration in exposed finished locations and within cabinets and millwork.
- J. Penetrations:
1. Fire Stopping: Where pipes pass through fire partitions, fire walls, smoke partitions, or floors, a fire stop shall be installed that provides an effective barrier against the spread of fire, smoke and gases as specified in Section 07 84 00 – Firestopping. Clearances between raceways and openings shall be completely filled and sealed with the fire stopping materials.
 2. Water proofing: At floor penetrations, Clearances around the pipe shall be completely sealed and made watertight with sealant as specified in Section 07 90 00 – Joint Fillers, Sealants and Caulking. Bio-based materials shall be utilized when possible.

3.05 INSULATION

- A. Insulate horizontal sections and 600 mm (2 feet) past changes of direction to vertical sections for interior section of roof drains. Install insulation in accordance with the requirements of Section 22 07 19 – Plumbing Piping Insulation.

3.06 TESTS

- A. Storm sewer system shall be tested either in its entirety or in sections.
- B. Storm Water Drain tests shall be conducted before trenches are backfilled or fixtures are connected. A water test or air test shall be conducted, as directed.
 - 1. If entire system is tested with water, tightly close all openings in pipes except the highest opening, and fill system with water to point of overflow. If system is tested in sections, tightly plug each opening except highest opening of section under test, fill each section with water and test with at least a 10 foot head of water. In testing successive sections, test at least upper 10 feet of next preceding section so that each joint or pipe except upper most 10 feet of system has been submitted to a test of at least a 10 foot head of water. Water shall be kept in the system, or in portion under test, for at least 15 minutes before inspection starts. System shall then be tight at all joints.
 - 2. For an air test, an air pressure of 34 kPa (5 psig) gauge shall be maintained for at least 15 minutes without leakage. A force pump and mercury column gauge shall be used for the test.
 - 3. Final Tests: While either one of the following tests may be used, Contractor shall check with Owner's Representative as to which test will be performed.
 - a. Smoke Test: After fixtures are permanently connected and traps are filled with water, fill entire drainage and vent systems with smoke under pressure of 0.25 kPa (1 inch of water) with a smoke machine. Chemical smoke is prohibited.
 - b. Peppermint Test: Introduce .06 liters (2 ounces) of peppermint into each line or stack.
- C. Owner's Representative shall witness all tests. Contractor shall coordinate schedules with the Owner's Representative and CxA. Contractor shall provide a minimum of 10 working days prior to flushing, disinfection/sterilization, startup, and testing.

3.07 DEMONSTRATION AND TRAINING

- A. Provide services of manufacturer's technical representative for 2 hours to instruct Owner's Personnel in operation and maintenance of the system.

END OF SECTION

SECTION 22 33 00
ELECTRIC DOMESTIC WATER HEATERS

PART 1 – GENERAL

1.01 DESCRIPTION

- A. This Section describes the requirements for installing a complete electric domestic water heater system ready for operation including the water heaters, thermometers, and all necessary accessories, connections, and equipment.
- B. A complete listing of all acronyms and abbreviations are included in Section 22 05 00 – Common Results for Plumbing.

1.02 RELATED WORK

- A. Division 01 – General Conditions
- B. Section 01 33 00 – Submittal Procedures
- C. Section 01 73 23 – Anchorage and Bracing of Non-Structural Components
- D. Section 01 75 00 – Checkout and Startup Procedures
- E. Section 03 30 00 – Cast-In-Place Concrete: Concrete and Grout
- F. Section 09 90 00 – Painting: Preparation and finish painting.
- G. Section 22 05 00 – Common Results for Plumbing
- H. Section 22 11 13 – Facility Water Distribution Piping: Piping, Fittings, Valves and Gauges.
- I. Section 22 07 19 – Plumbing Piping Insulation
- J. Section 22 11 23 – Domestic Water Pumps

1.03 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. American National Standard Institute (ANSI):
 - 1. Z21.22B-2001 (R2008) – Relief Valves for Hot Water Supply Systems

03/29/22

C. American Society for Heating, Refrigerating and Air Conditioning Engineers (ASHRAE):

1. 90.1 (2013) – Energy Standard for Buildings Except Low-Rise Residential Buildings

D. American Society of Mechanical Engineers (ASME):

1. ASME Boiler and Pressure Vessel Code
2. BPVC Section IV-2013 – Rules for Construction of Heating Boilers
3. BPVC Section VIII-1-2013 – Rules for Construction of Pressure Vessels, Division 1
4. Form U-1 – Manufacturer’s Data Report for Pressure Vessels
5. B1.20.1-2013 – Pipe Threads, General Purpose (Inch)
6. B16.5-2013 – Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24 Metric/Inch Standard
7. B16.24-2011 – Cast Copper Alloy Pipe Flanges and Flanged Fittings: Classes 150, 300, 600, 900, 1500, and 2500
8. CSD-1-2012 – Controls and Safety Devices for Automatically Fired Boilers

E. American Society of Sanitary Engineering (ASSE):

1. 1005-1999 – Performance Requirements for Water Heater Drain Valves, 3/4 Inch Size

F. National Fire Protection Association (NFPA)

1. 70-2011 – National Electrical Code (NEC)

G. NSF International (NSF):

1. 5-2012 – Water Heaters, Hot Water Supply Boilers, and Heat Recovery Equipment
2. 61-2012 – Drinking Water System Components – Health Effects
3. 372-2011 – Drinking Water System Components – Lead Content

H. Underwriters Laboratories, Inc. (UL):

1. 174-04 (R2012) – Standard for Household Electric Storage Tank Water Heaters
2. 499-05 (R2013) – Standard for Electric Heating Appliances

3. 1453-04 (R2011) – Standard for Electric Booster and Commercial Storage Tank Water Heaters

1.04 SUBMITTALS

- A. Submittals, including number of required copies, shall be submitted in accordance with Section 01 33 00 – Submittal Procedures.
- B. Information and material submitted under this Section shall be marked “SUBMITTED UNDER SECTION 22 33 00 – ELECTRIC DOMESTIC WATER HEATERS”, with applicable paragraph identification.
- C. Manufacturer's Literature and Data including: Full item description and optional features and accessories. Include dimensions, weights, materials, applications, standard compliance, model numbers, size, and capacity.
 1. Water Heaters.
 2. Pressure and Temperature Relief Valves.
 3. Thermometers.
 4. Pressure Gauges.
 5. Vacuum Breakers.
 6. Expansion Tanks.
- D. For each electric domestic hot water heater type and size, the following characteristics shall be submitted:
 1. Rated Capacities.
 2. Operating characteristics.
 3. Electrical characteristics.
 4. Furnished specialties and accessories.
 5. A form U-1 or other documentation stating compliance with the ASME Boiler and Pressure Vessel code.
- E. Shop drawings shall include wiring diagrams for power, signal and control functions.
- F. Complete operating and maintenance manuals including wiring diagrams, technical data sheets and information for ordering replaceable parts:
 1. Include complete list indicating all components of the systems.

2. Include complete diagrams of the internal wiring for each item of equipment.
3. Diagrams shall have their terminals identified to facilitate installation, operation and maintenance.

1.05 QUALITY ASSURANCE

- A. For commercial applications, comply with American Society of Heating, Refrigerating and Air - Conditioning Engineers (ASHRAE) for efficiency performance. ASHRAE 90.1, "Energy Efficient Design of New Buildings Except Low-Rise Residential Buildings, for commercial water heaters." For residential applications, comply with FEMP required minimum efficiencies.
- B. Electrical components, devices and accessories shall be listed and labeled as defined in NFPA 70 by a qualified testing agency and marked for intended location and application.
- C. ASME code construction shall be a vessel fabricated in compliance with the ASME BPVC Section VIII-1. Fabricate and label equipment components that will be in contact with potable water to comply with NSF 61 and NSF 372.
- D. The domestic water heater shall be certified and labeled by an independent testing agency.
- E. Bio-Based Materials: For products designated by the USDA's Bio-Preferred Program, provide products that meet or exceed USDA recommendations for bio-based content, so long as products meet all performance requirements in this Specifications Section. For more information regarding the product categories covered by the Bio-Preferred Program, visit <http://www.biopreferred.gov>.

1.06 AS-BUILT DOCUMENTATIONDOCUMENTATION

- A. Submit operation and maintenance data updated to include submittal review comments, substitutions and construction revisions shall be inserted into a three ring binder. All aspects of system operation and maintenance procedures, including piping isometrics, wiring diagrams of all circuits, a written description of system design, control logic, and sequence of operation shall be included in the operation and maintenance manual. The operations and maintenance manual shall include troubleshooting techniques and procedures for emergency situations. Notes on all special systems or devices such as damper and door closure interlocks shall be included. A List of recommended spare parts (manufacturer, model number, and quantity) shall be furnished. Information explaining any special knowledge or tools the owner will be required to employ shall be inserted into the As-Built documentation.
- B. The installing contractor shall maintain as-built drawings of each completed phase for verification; and, shall provide the complete set at the time of final systems certification

testing. As-built drawings are to be provided, and a copy of them on Auto-Cad version 2022 provided on compact disk or DVD. Should the installing contractor engage the testing company to provide as-built or any portion thereof, it shall not be deemed a conflict of interest or breach of the 'third party testing company' requirement.

PART 2 – PRODUCTS

2.01 ELECTRIC DOMESTIC WATER HEATERS

- A. The tank construction shall be steel shell, with an inner tank liner complying with NSF 61 and NSF 372 for barrier materials for potable water. The inner liner shall be extended into the openings. The vessel shall be ASME BPVC Section VIII-1, fabricated with a pressure rating of 150 psig. Provide with access for cleaning and disinfection.
- B. Tapping (openings) shall be Factory fabricated of materials compatible with the tank and in accordance with appropriate ASME standards B1.20.1 for piping connections, pressure and temperature relief valve, pressure gauge, thermometer, drain valve, anode rods and controls as required. Tappings shall comply with the following ASME standards listed below:
 - 1. 2 inch and smaller: Threaded ends according to ASME B1.20.1.
 - 2. 2 1/2-inch and Larger: Flanged ends according to ASME B16.5 for steel and stainless steel flanges, and according to ASME B16.24.
- C. Tank insulation shall comply with ASHRAE 90.1 and ENERGY STAR requirements.
- D. For domestic water heater sizes greater than 9 KW, the heating element shall be arranged in multiples of three elements. For heaters less than 9 KW, the heater elements shall be arranged in double elements. Heater capacities are scheduled on the drawings.
- E. The domestic water heaters shall have screw in or bolt on immersion type, thermostatically adjustable elements. Set thermostat for minimum water storage temperature of 140 degrees F. The electrical characteristics are scheduled on the drawings. Heaters shall be capable of raising the discharge temperature to 170 degrees F for thermal eradication.
- F. The Combination Pressure and Temperature relief Valve shall be ANSI Z21.22 and ASME rated.
- G. The anode rod shall be replaceable magnesium.
- H. The drain valve shall be corrosion resistant metal complying with ASSE 1005.
- I. Comply with NSF 5 for water heaters.

2.02 DOMESTIC HOT WATER EXPANSION TANKS

- A. A steel pressure rated tank constructed with welded joints and factory installed butyl rubber diaphragm shall be installed as scheduled. The air precharge shall be set to minimum system operating pressure at tank.
- B. The tappings shall be factory fabricated steel, welded to the tank and include ASME B1.20.1 pipe thread.
- C. The interior finish shall comply with NSF 61 and NSF 372 for barrier materials for potable water tank linings and the liner shall extend into and through the tank fittings and outlets.
- D. The air charging valve shall be factory installed.

2.03 ELECTRIC WATER HEATER DRAIN PAN

- A. A stainless steel drain pan shall be provided that is large enough to contain the volume of the heater. The drain pan shall include a drain outlet not less than NPS 3/4 inch with ASME B1.20.7 garden hose threads.

2.04 HEAT TRAPS

- A. Heat traps shall be installed in accordance with ASHRAE 90.1 unless provided integrally with the heater.

2.05 COMBINATION TEMPERATURE AND PRESSURE RELIEF VALVES

- A. The combination pressure and temperature relief valve shall be ANSI Z21.22 and ASME rated and constructed of all brass or bronze with a self-closing reseating valve. The relief valves shall include a relieving capacity greater than the heat input and include a pressure setting less than the water heater's working pressure rating. Sensing element shall extend into storage tank.

2.06 PRESSURE GAGES FOR WATER

- A. ASME B40.100 all metal case 115 mm (4-1/2 inches) diameter, bottom connected throughout, graduated as required for service, and identity labeled. Range shall be 0 to 1380 kPa (0 to 200 psig) gauge.
- B. The pressure element assembly shall be bourdon tube. The mechanical movement shall be lined to pressure element and connected to pointer
- C. The dial shall be non-reflective aluminum with permanently etched scale markings graduated in kPa and psig.

- D. The pointer shall be dark colored metal. The window shall be glass. The ring shall be brass or stainless steel. The accuracy shall be grade A, plus or minus 1 percent of middle half of scale range.
- E. The pressure gage for water domestic use shall conform to NSF 61 and NSF 372

2.07 THERMOMETERS

- A. Thermometers shall be rigid stem or remote sensing, scale or dial type with an aluminum, black metal, stainless steel, or chromium plated brass case. The thermometer shall be back connected, red liquid (alcohol or organic-based) fill, vapor, bi-metal or gas actuated, with 9 inches high scale dial or circular dial 2 to 5 inches in diameter graduated from 40 to 212 degrees F, with two-degree graduations guaranteed accurate within one scale division. The socket shall be separable, double-seat, micrometer-fittings, with extension neck not less than 2-1/2 inches to clear tank or pipe covering. The thermometer shall be suitable for 3/4 inch pipe threads. Thermometers may be console-mounted with sensor installed in separate thermometer well.

2.08 SUPPORTS

- A. Water heater stands shall be factory-fabricated steel for floor mounting capable of supporting water heater and water a minimum of 18 inches above the floor.
- B. Wall brackets for wall mounted heaters shall be factory-fabricated steel capable of supporting water heater and water.

2.09 MANIFOLD KITS

- A. For multiple water heater installation, provide factory-fabricated copper manifold kits to include ball-type shutoff valves to isolate each water heater and balancing valves to provide balanced flow through each water heater.

PART 3 – EXECUTION

3.01 INSTALLATION

- A. Water heaters shall be installed on concrete bases unless elevated above the floor. Refer to Specification Section 03 30 00 – Cast-In-Place Concrete and Section 22 05 00 – Common Results for Plumbing.
- B. The water heaters shall be installed level and plumb and securely anchored.
- C. The water heaters shall be installed and connected in accordance with manufacturer's written instructions with manufacturer's recommended clearances.

- D. All pressure and temperature relief valves discharge shall be piped to nearby floor drains with air gap or break.
- E. Thermometers shall be installed on the water heater inlet and outlet piping and shall be positioned such that they can be read by an operator or staff standing on floor or walkway.
- F. The thermostatic control shall be set for a minimum setting of 140 degrees F for storage heaters and regulated to a maximum discharge temperature of 85 degrees F for distribution to emergency equipment
- G. Dielectric unions shall be provided if there are dissimilar metals between the water heater connections and the attached piping.
- H. Provide vacuum breakers per ANSI Z21.22 on the inlet pipe if the water heater is bottom fed. Refer to Section 22 11 13 – Facility Water Distribution Piping.
- I. Shutoff valves shall be installed on the domestic water supply piping to the water heater and on the domestic hot water outlet piping.
- J. All manufacturer's required clearances shall be maintained.
- K. A combination temperature and pressure relief valve shall be installed at the top portion of the storage tank in accordance with manufacturer's recommendations. The sensing element shall extend into the tank. The relief valve outlet drain piping shall discharge by positive air gap into a floor drain.
- L. Piping type heat traps shall be installed on the inlet and outlet piping of the electric domestic water heater storage tanks if not provided integrally with the tanks.
- M. Water heater drain piping shall be installed as indirect waste to spill by positive air gap into open drains or over floor drains. Hose end drain valves shall be installed at low points in water piping for electric domestic water heaters without integral drains.
- N. If an installation is unsatisfactory to the Owner's Representative, the Contractor shall correct the installation at no cost to the Owner.

3.02 LEAKAGE TEST

- A. Before piping connections are made, water heaters shall be tested with hydrostatic pressure of 200 psig and 240 psig for a unit with a MAWP of 160 psig. Any domestic water heater leaking water shall be replaced with a new unit at no additional cost to the Owner.

3.03 PERFORMANCE TEST

- A. All of the remote water outlets shall have a minimum of 110 degrees F and a maximum of 120 degrees F water flow at all times for domestic water and 75-85 F for emergency shower tepid water.

3.04 STARTUP AND TESTING

- A. As recommended by product manufacturer and listed standards and under actual or simulated operating conditions, tests shall be conducted to prove full compliance with design and specified requirements. Tests of the various items of equipment shall be performed simultaneously with each integrated system.
- B. The tests shall include system capacity, control function, and alarm functions.
- C. When any defects are detected, correct defects and repeat test at no additional costs to the Owner.

3.05 DEMONSTRATION AND TRAINING

- A. Provide services of manufacturer's technical representative for four (4) hours to instruct Owner's Personnel in operation and maintenance of the system.

END OF SECTION

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SECTION 22 45 00
EMERGENCY SHOWER/EYEWASH STATIONS

PART 1 – GENERAL

1.1 THE REQUIREMENT

- A. Furnish and install emergency shower/eyewash stations as shown on the Drawings and as specified herein. Coordinate work in this Section with painting and marking as specified in Section 09 90 00 – Painting. Certain equipment items will be field located by Owner, if not otherwise shown on the Drawings.

1.2 SUBMITTALS

- A. Submit Shop Drawings, Operation and Maintenance Instructions, and other information as specified for all items of equipment in this Section in accordance with Section 46 00 00 – Equipment General Provisions and Section 01 33 00 – Submittal Procedures. Shop Drawings shall also include complete erection, installation, and adjustment instructions and recommendations.

1.3 MANUFACTURERS

- A. The materials covered by these Specifications are intended to be standard equipment of proven reliability and as manufactured by reputable manufacturers having experience in the production of such equipment. The equipment furnished shall be designed, constructed, and installed in accordance with the best practices and methods and shall operate satisfactorily when installed as shown on the Drawings and operated per manufacturers' recommendations.

PART 2 – PRODUCTS

2.1 EMERGENCY SHOWER/EYEWASH STATIONS

- A. Combination shower and eyewash stations shall be installed where shown on the Contract Drawings.
- B. For exterior shower/eyewash units, the drench shower and the eyewash shall be operated independently by hand actuated flag type handles or push down plates that remain open until manually closed. All exterior shower/eyewash stations shall be insulated, freeze proof, heat traced with 5 ft of extra cabling, and shall be Model S19-310NN as manufactured by Bradley, Model 8300FP as manufactured by Haws, or equal. Dual automatic pressure compensation devices shall provide steady water flow under pressures varying from 30 to 75 psi.

- C. For interior combination shower/eyewash units, the drench shower shall be operated by pull rod with triangular handle that remains open until manually closed, and the eyewash shall be operated by hand actuated flag type handle or foot treadle that remains open until manually closed. All interior combination shower/eyewash stations shall be Model S19-310UU as manufactured by Bradley, Model 8300 as manufactured by Haws, or equal. Dual automatic pressure compensation devices shall provide steady water flow under pressures varying from 30 to 75 psi.

PART 3 – EXECUTION

3.1 INSTALLATION

- A. Emergency shower/eyewash stations shall be installed where shown on the Drawings or as directed by the Engineer. Where required by OSHA regulations, the background of the mounting location shall be painted the appropriate color.

END OF SECTION

SECTION 23 00 00
BASIC HVAC REQUIREMENTS

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. The Contractor shall furnish all labor, equipment and material for the complete installation of the heating, ventilation, air conditioning, piping, etc. as indicated on the drawings and specified herein.
- B. Air conditioning systems shall be furnished and installed to operate as a system. The Contractor shall coordinate all requirements between manufacturers to insure unit responsibility and compatibility of the systems.

1.02 SUBMITTALS

- A. The Contractor shall submit shop drawings on all equipment, accessories and appurtenances and all fabrication work or other mechanical and air conditioning work required, all in accordance with the requirements of Section 01 33 00 – Submittal Procedures.
- B. Data to be submitted shall include but not be limited to:
 - 1. Catalog data consisting of specifications, illustrations and a parts schedule that identifies the materials to be used for the various parts and accessories. The illustrations shall be in sufficient detail to serve as a guide for assembly and disassembly.
 - 2. Complete assembly, and installation drawings with clearly marked dimensions. This information shall be in sufficient detail to serve as a guide for assembly and disassembly and for ordering parts.
 - 3. Weight of all component parts and assembled weight.
 - 4. Electrical characteristics, wiring, diagrams, etc.
 - 5. Sample data sheet of equipment nameplate(s) including information contained thereon.
 - 6. Insulation materials, coating, jackets, detail density, thermal conductivity and thickness of all insulation materials to be furnished.
 - 7. Details of special fasteners and accessories.
 - 8. Type of adhesives, binders, joint cement, mastics.

9. Proposed insulation procedures and installation methods.
 10. Spare parts list
 11. Special tools list
- C. The Contractor shall obtain from the manufacturer and submit to the Engineer copies of the results of all certified shop tests.
 - D. The Contractor shall obtain from the manufacturer and submit to the Engineer copies of certified letters of compliance in accordance with the Specifications.

1.03 RELATED WORK

- A. Division 01 – General Requirements
- B. Section 01 33 00 – Submittal Procedures
- C. Section 03 30 00 – Cast-In-Place Concrete
- D. Section 07 84 00 – Firestopping
- E. Section 07 90 00 – Joint Fillers, Sealants, and Caulking
- F. Section 09 90 00 – Painting
- G. Section 26 05 00 – Basic Electrical Requirements
- H. Section 26 05 19 – Low-Voltage Conductors and Cables

1.04 OPERATION AND MAINTENANCE MANUALS

- A. The Contractor shall submit operation and maintenance manual in accordance with the procedures and requirements set forth in the General Conditions and Division 01.
- B. Operation and Maintenance Manuals shall be submitted for all equipment.

1.05 MANUFACTURER'S INSTRUCTIONS

- A. Installation of all equipment shall be in accordance with manufacturer's data.
- B. All changes from the installation procedures in manufacturers' data shall be submitted for approval in accordance with the requirements for shop drawings.
- C. Keep all manufacturers' data provided in a secure manner at the job site at all times. Catalog and index this data for convenient reference.
- D. Manufacturers' data shall be available for the information of the Owner, Engineer, and the use of other trades.

- E. Turn over all data to the Owner through the Owner's representative at completion of the Work and final testing.
- F. Furnish Owner, indexed and bound in loose leaf binders, three (3) complete sets of Operating and Maintenance Instructions and pertinent manufacturers' literature and information on all of the apparatus and equipment under this Division of the Specifications.
- G. Submit all instruction books and manuals in accordance with Division 01.

1.06 CODES, PERMITS AND STANDARDS

- A. The Contractor shall obtain and pay for all permits and shall comply with all laws and codes that apply to the Work.
- B. The Contractor shall be responsible for all added expense due to their choice of equipment, materials or construction methods.
- C. All work and materials shall be in full accordance with the latest State rules and regulations or publications including those of the State Fire Marshall, the Uniform Plumbing Code, and all local codes. Nothing in the Plans and/or Specifications shall be construed to permit work not conforming to the above codes, rules and regulations.
- D. All equipment, materials and installations shall conform to the requirements of the most recent edition with latest revisions, supplements and amendments of the following, as applicable:
 - 1. Air Conditioning and Refrigeration Institute (ARI)
 - 2. Air Diffusion Council (ADC)
 - 3. Air Moving and Conditioning Association (AMCA)
 - 4. American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc. (ASHRAE)
 - 5. American National Standards Institute (ANSI)
 - 6. American Society for Testing and Materials (ASTM)
 - 7. American Society of Mechanical Engineers (ASME)
 - 8. Factory Mutual (FM)
 - 9. National Electric Code (NEC)
 - 10. NFPA 90A - Air Conditioning and Ventilation Systems
 - 11. Occupational Safety and Health Standards (OSHA)

12. Sheet Metal & Air Conditioning Contractors National Association (SMACNA)
13. State and local codes, ordinances and statutes
14. Underwriters Laboratories (UL)
15. Others as designated in the specifications.

1.07 QUALITY ASSURANCE

- A. All material and equipment shall be the latest design, new, undeteriorated, and the first quality standard product of manufacturers regularly engaged in the production of such material and equipment.
- B. When two or more units of the same class of material or equipment are required, they shall be products of a single manufacturer.
- C. All work shall be performed in a neat and workmanlike manner by workers skilled in their respective trades, and all materials and equipment shall be installed as recommended by the manufacturers and in accordance with specified codes and standards.
- D. Touch up and/or repaint to match original finishes all factory finished or painted equipment and materials which are scratched or marred during shipment or installation.
- E. Products Criteria:
 1. Standard Products: Material and equipment shall be the standard products of a manufacturer regularly engaged in the manufacture of the products for at least 3 years (or longer as specified elsewhere). The design, model and size of each item shall have been in satisfactory and efficient operation on at least three installations for approximately three years. However, digital electronics devices, software and systems such as controls, instruments, computer work station, shall be the current generation of technology and basic design that has a proven satisfactory service record of at least three years. See other Specification Sections for any exceptions and/or additional requirements.
 2. Refer to all other Sections for quality assurance requirements for systems and equipment specified therein.
 3. All items furnished shall be free from defects that would adversely affect the performance, maintainability and appearance of individual components and overall assembly.
 4. The products and execution of work specified in Division 23 shall conform to the referenced codes and standards as required by the specifications. Local codes and amendments shall be enforced, along with requirements

of local utility companies. The most stringent requirements of these specifications, local codes, or utility company requirements shall always apply. Any conflicts shall be brought to the attention of the Owner's representative.

5. Multiple Units: When two or more units of materials or equipment of the same type or class are required, these units shall be of the same manufacturer and model number, or if different models are required they shall be of the same manufacturer and identical to the greatest extent possible (i.e., same model series).
6. Assembled Units: Performance and warranty of all components that make up an assembled unit shall be the responsibility of the manufacturer of the completed assembly.
7. Nameplates: Nameplate bearing manufacturer's name or identifiable trademark shall be securely affixed in a conspicuous place on equipment, or name or trademark cast integrally with equipment, stamped or otherwise permanently marked on each item of equipment.
8. Use of asbestos products or equipment or materials containing asbestos is prohibited.

F. HVAC Mechanical Systems Welding: Before any welding is performed, Contractor shall submit a certificate certifying that welders comply with the following requirements:

1. Qualify welding processes and operators for piping according to ASME BPVC Section IX. Provide proof of current certification.
2. Comply with provisions of ASME B31 series "Code for Pressure Piping".
3. Certify that each welder and welding operator has passed American Welding Society (AWS) qualification tests for the welding processes involved, and that certification is current.
4. All welds shall be stamped according to the provisions of the AWS or ASME as required herein and by the associated code.

G. Manufacturer's Recommendations: Where installation procedures or any part thereof are required to be in accordance with the recommendations of the manufacturer of the material being installed, printed copies of these recommendations shall be furnished to the Owner's representative with submittals. Installation of the item will not be allowed to proceed until the recommendations are received. Failure to furnish these recommendations can be cause for rejection of the material and removal by the Contractor and no additional cost or time to the Owner.

H. Execution (Installation, Construction) Quality:

1. Apply and install all items in accordance with manufacturer's written instructions. Refer conflicts between the manufacturer's instructions and the contract documents to the Owner's representative for resolution. Provide written hard copies and computer files on CD or DVD of manufacturer's installation instructions to the Owner's representative with submittals prior to commencing installation of any item. Installation of the item will not be allowed to proceed until the recommendations are received and approved by the Owner's representative. Failure to furnish these recommendations is a cause for rejection of the material.
 2. All items that require access, such as for operating, cleaning, servicing, maintenance, and calibration, shall be easily and safely accessible by persons standing at floor level, or standing on permanent platforms, without the use of portable ladders. Examples of these items include, but are not limited to, all types of valves, filters and strainers, transmitters, control devices. Prior to commencing installation work, refer conflicts between this requirement and contract documents to the Owner's representative for resolution. Failure of the Contractor to resolve, or point out any issues will result in the Contractor correcting at no additional cost or time to the Owner.
 3. Complete coordination/shop drawings shall be required in accordance with Paragraph, SUBMITTALS. Construction work shall not start on any system until the coordination/shop drawings have been approved by the Owner's representative.
 4. Workmanship/craftsmanship will be of the highest quality and standards. The Owner reserves the right to reject any work based on poor quality of workmanship this work shall be removed and done again at no additional cost or time to the Owner.
- I. Upon request by the Owner's representative, provide lists of previous installations for selected items of equipment. Include contact persons who will serve as references, with current telephone numbers and e-mail addresses.

1.08 DELIVERY, STORAGE AND HANDLING

A. Protection of Equipment:

1. Equipment and material placed on the job site shall remain in the custody of the Contractor until phased acceptance, whether or not the Owner has reimbursed the Contractor for the equipment and material. The Contractor is solely responsible for the protection of such equipment and material against any damage or theft.
2. Large equipment such as boilers, chillers, cooling towers, fans, and air handling units if shipped on open trailer trucks shall be covered with shrink on plastics or water proof tarpaulins that provide protection from

exposure to rain, road salts and other transit hazards. Protection shall be kept in place until equipment is moved into a building or installed as designed.

3. Repair damaged equipment in first class, new operating condition and appearance; or, replace same as determined and directed by the Owner's representative. Such repair or replacement shall be at no additional cost or time to the Owner.
4. Protect interiors of new equipment and piping systems against entry of foreign matter. Clean both inside and outside before painting or placing equipment in operation.
5. Existing equipment and piping being worked on by the Contractor shall be under the custody and responsibility of the Contractor and shall be protected as required for new work.
6. Protect plastic piping and tanks from ultraviolet light (sunlight).

B. Cleanliness of Piping and Equipment Systems:

1. Exercise care in storage and handling of equipment and piping material to be incorporated in the work. Remove debris arising from cutting, threading and welding of piping.
2. Piping systems shall be flushed, blown or pigged as necessary to deliver clean systems.
3. Clean interior of all tanks prior to delivery for beneficial use by the Owner.
4. Boilers shall be left clean following final internal inspection by Owner's insurance representative or inspector.
5. Contractor shall be fully responsible for all costs, damage, and delay arising from failure to provide clean systems.

1.09 EQUIPMENT AND MATERIALS IDENTIFICATION

- A. Use symbols, nomenclature and equipment numbers specified, shown on the contract documents and shown in the maintenance manuals. Identification for piping is specified in Section 09 90 00 – Painting.
- B. Interior (Indoor) Equipment: Engraved nameplates, with letters not less than 5 mm (3/16 inch) high of brass with black-filled letters, or rigid black plastic with white letters specified in Section 09 90 00 – Painting permanently fastened to the equipment. Identify unit components such as coils, filters, fans, etc.

- C. Exterior (Outdoor) Equipment: Brass nameplates, with engraved black filled letters, not less than 5 mm (3/16 inch) high riveted or bolted to the equipment.
- D. Control Items: Label all instrumentation, temperature and humidity sensors, controllers and control dampers. Identify and label each item as they appear on the control diagrams.
- E. Valve Tags and Lists:
1. HVAC and Mechanical Rooms: Provide for all valves.
 2. Valve tags: Engraved black filled numbers and letters not less than 15 mm (1/2 inch) high for number designation, and not less than 6 mm (1/4 inch) for service designation on 19-gauge 40 mm (1-1/2 inches) round brass disc, attached with brass "S" hook or brass chain.
 3. Valve lists: Typed or printed plastic coated card(s), sized 215 mm (8-1/2 inches) by 275 mm (11 inches) showing tag number, valve function and area of control, for each service or system. Punch sheets for a 3-ring notebook.
 4. Provide detailed plan for each floor of the building indicating the location and valve number for each valve. Identify location of each valve with a color-coded thumb tack in ceiling.
- F. Ceiling Grid Labels:
1. 50 mm (2 inch) long by 15 mm (1/2 inch) wide by 0.025 mm (1 mil) thick UV resistant metalized polyester label with red border color and black custom lettering on white background interior. Peel and stick adhesive backing. Label and adhesive manufactured specifically for use in equipment inventory tagging.
 2. Custom print labels with above ceiling HVAC equipment numbers.
- G. Provide manufacturer's standard laminated plastic, color coded duct markers. Conform to the following color codes:

Yellow / Green	Supply air
Blue	Exhaust, outside, return and mixed air
Nomenclature	Include the following: Direction of air flow. Duct service (supply, return, exhaust, etc.)

1.10 GASKETS AND CONNECTORS

- A. Provide new gaskets wherever gasketed mating equipment items or pipe connections have been dismantled. Gaskets shall be in accordance with manufacturer's recommendations.
- B. Replace all assembly bolts, studs, nuts and fasteners of any kind which are bent, flattened, corroded or have their threads, heads or slots damaged.
- C. Furnish all bolts, studs, nuts and fasteners for make-up of all connections to equipment and replace any of these items damaged in storage, shipment or moving.

1.11 FIRESTOPPING

- A. Section 07 84 00 – Firestopping specifies an effective barrier against the spread of fire, smoke and gases where penetrations occur for piping and ductwork. Refer to Section 23 13 13 – Metal Ducts and Duct Accessories, for firestop pipe and duct insulation.

PART 2 – PRODUCTS

2.01 GENERAL

- A. Each item of equipment shall be furnished and installed complete with all supports, mounting frames, duct work, piping, louvers, panels, grilles, electric drive units and controls, mechanical equipment, electrical work, insulation and appurtenances ready for operation.
- B. All equipment and appurtenances shall be anchored or connected to supporting members as specified or as indicated on the Plans.
- C. All mechanisms or parts shall be amply proportioned for the stresses which may occur during operation or for any other stresses which may occur during fabrication and erection. Individual parts furnished which are alike in all units shall be alike in workmanship, design, and materials and shall be interchangeable. All equipment shall be of the manufacturer's top line, industrial commercial grade.
- D. The Contractor shall ascertain that all chassis, shafts, and openings are correctly located, otherwise they shall cut all new openings required at the Contractor's expense. Cutting of new openings shall be coordinated with other trades. Proposed new cutting shall be submitted to the Engineer for review and acceptance prior to cutting.
- E. The Plans shall be taken as diagrammatic. The Contractor shall check the Structural Plans and sections for detail dimensions and clearances. Sizes of ducts and their locations are indicated, but not every offset, fitting, or structural obstruction is shown.

- F. Alignment of ducts may be varied where necessary to account for slight architectural changes or to avoid conflict with the Work of other trades without additional expense to the Owner.
- G. All supports required for the proper installation of the equipment, but not forming an integral part of the building structure, shall be provided, unless specifically noted otherwise. Equipment shall be supported on spring-type vibration isolators.

2.02 PIPE PENETRATIONS

- A. Install sleeves during construction for other than blocked out floor openings for risers in mechanical bays.
- B. To prevent accidental liquid spills from passing to a lower level, provide the following:
 - 1. For sleeves: Extend sleeve 25 mm (1 inch) above finished floor and provide sealant for watertight joint.
 - 2. For blocked out floor openings: Provide 40 mm (1-1/2 inch) angle set in silicone adhesive around opening.
 - 3. For drilled penetrations: Provide 40 mm (1-1/2 inch) angle ring or square set in silicone adhesive around penetration.
- C. Penetrations through beams or ribs are prohibited but may be installed in concrete beam flanges. Any deviation from these requirements must receive prior approval of Owner's representative.
- D. Sheet Metal, Plastic, or Moisture-resistant Fiber Sleeves: Provide for pipe passing through floors, interior walls, and partitions, unless brass or steel pipe sleeves are specifically called for below.
- E. Cast Iron or Zinc Coated Pipe Sleeves: Provide for pipe passing through exterior walls below grade. Make space between sleeve and pipe watertight with a modular or link rubber seal. Seal shall be applied at both ends of sleeve.
- F. Galvanized Steel or an alternate Black Iron Pipe with asphalt coating Sleeves: Provide for pipe passing through concrete beam flanges, except where brass pipe sleeves are called for. Provide sleeve for pipe passing through floor of mechanical rooms, laundry work rooms, and animal rooms above basement. Except in mechanical rooms, connect sleeve with floor plate.
- G. Brass Pipe Sleeves: Provide for pipe passing through quarry tile, terrazzo or ceramic tile floors. Connect sleeve with floor plate.
- H. Sleeves are not required for wall hydrants for fire department connections or in drywall construction.

- I. Sleeve Clearance: Sleeve through floors, walls, partitions, and beam flanges shall be one inch greater in diameter than external diameter of pipe. Sleeve for pipe with insulation shall be large enough to accommodate the insulation. Interior openings shall be caulked tight with fire stopping material and sealant to prevent the spread of fire, smoke, and gases.
- J. Sealant and Adhesives: Shall be as specified in Section 07 90 00 – Joint Fillers, Sealants, and Caulking.

2.03 DUCT PENETRATIONS

- A. Provide curbs for roof mounted piping, ductwork and equipment. Curbs shall be 450 mm (18 inches) high with continuously welded seams, built-in cant strip, interior baffle with acoustic insulation, curb bottom, hinged curb adapter.
- B. Provide firestopping for openings through fire and smoke barriers, maintaining minimum required rating of floor, ceiling or wall assembly. See Section 07 84 00 – Firestopping.

2.04 SPECIAL TOOLS AND LUBRICANTS

- A. Furnish, and turn over to the Owner's representative, tools not readily available commercially, that are required for disassembly or adjustment of equipment and machinery furnished.
- B. Grease Guns with Attachments for Applicable Fittings: One for each type of grease required for each motor or other equipment.
- C. Refrigerant Tools: Provide system charging/Evacuation equipment, gauges, fittings, and tools required for maintenance of furnished equipment.
- D. Tool Containers: Hardwood or metal, permanently identified for intended service and mounted, or located, where directed by the Owner's representative.
- E. Lubricants: A minimum of 0.95 L (1 quart) of oil, and 0.45 kg (1 pound) of grease, of equipment manufacturer's recommended grade and type, in unopened containers and properly identified as to use for each different application.

2.05 WALL, FLOOR AND CEILING PLATES

- A. Material and Type: Chrome plated brass or chrome plated steel, one piece or split type with concealed hinge, with set screw for fastening to pipe, or sleeve. Use plates that fit tight around pipes, cover openings around pipes and cover the entire pipe sleeve projection.
- B. Thickness: Not less than 2.4 mm (3/32 inch) for floor plates. For wall and ceiling plates, not less than 0.64 mm (0.025 inch) for up to 80 mm (3-inch pipe), 0.89 mm (0.035 inch) for larger pipe.

- C. Locations: Use where pipe penetrates floors, walls and ceilings in exposed locations, in finished areas only. Provide a watertight joint in spaces where brass or steel pipe sleeves are specified.

2.06 ASBESTOS

- A. Materials containing asbestos are prohibited.

PART 3 – EXECUTION

3.01 GENERAL

- A. If an installation is unsatisfactory to the Owner's representative, the Contractor shall correct the installation at no additional cost or time to the Owner.

3.02 ARRANGEMENT AND INSTALLATION OF EQUIPMENT AND PIPING

- A. Location of piping, sleeves, inserts, hangers, and equipment, access provisions shall be coordinated with the work of all trades. The coordination/shop drawings shall be submitted for review. Locate piping, sleeves, inserts, hangers, ductwork and equipment clear of windows, doors, openings, light outlets, and other services and utilities. Equipment coordination/shop drawings shall be prepared to coordinate proper location and personnel access of all facilities. The drawings shall be submitted for review. Follow manufacturer's published recommendations for installation methods not otherwise specified.
- B. Operating Personnel Access and Observation Provisions: Select and arrange all equipment and systems to provide clear view and easy access, without use of portable ladders, for maintenance and operation of all devices including, but not limited to: all equipment items, valves, filters, strainers, transmitters, sensors, control devices. All gauges and indicators shall be clearly visible by personnel standing on the floor or on permanent platforms. Do not reduce or change maintenance and operating space and access provisions that are shown on the contract documents.
- C. Equipment and Piping Support: Coordinate structural systems necessary for pipe and equipment support with pipe and equipment locations to permit proper installation.
- D. Location of pipe sleeves, trenches and chases shall be accurately coordinated with equipment and piping locations.
- E. Cutting Holes:
 - 1. Cut holes through concrete and masonry by rotary core drill. Pneumatic hammer, impact electric, and hand or manual hammer type drill is prohibited, except as permitted by Owner's representative where working area space is limited.

2. Locate holes to avoid interference with structural members such as slabs, columns, ribs, beams or reinforcing. Holes shall be laid out in advance and drilling done only after approval by Owner's representative. If the Contractor considers it necessary to drill through structural members, this matter shall be referred to Owner's representative for approval.
 3. Do not penetrate membrane waterproofing.
- F. Minor Piping: Generally, small diameter pipe runs from drips and drains, water cooling, and other service are not shown but must be provided.
- G. Electrical Interconnection of Instrumentation or Controls: This generally not shown but must be provided. This includes interconnections of sensors, transmitters, transducers, control devices, control and instrumentation panels, instruments and computer workstations. Devices shall be located so they are easily accessible for testing, maintenance, calibration, etc. The Owner's representative has the final determination on what is accessible and what is not. Comply with NFPA 70.
- H. Protection and Cleaning:
1. Equipment and materials shall be carefully handled, properly stored, and adequately protected to prevent damage before and during installation, in accordance with the manufacturer's recommendations and as approved by the Owner's representative. Damaged or defective items in the opinion of the Owner's representative, shall be replaced.
 2. Protect all finished parts of equipment, such as shafts and bearings where accessible, from rust prior to operation by means of protective grease coating and wrapping. Close pipe openings with caps or plugs during installation. Tightly cover and protect fixtures and equipment against dirt, water chemical, or mechanical injury. At completion of all work thoroughly clean fixtures, exposed materials and equipment.
- I. Concrete and Grout: Use concrete and non-shrink grout 20 MPa (3000 psig) minimum, specified in Section 03 30 00 – Cast-In-Place Concrete.
- J. Install gauges, thermometers, valves and other devices with due regard for ease in reading or operating and maintaining said devices. Locate and position thermometers and gauges to be easily read by operator or staff standing on floor or walkway provided. Servicing shall not require dismantling adjacent equipment or pipe work.
- K. Install steam piping expansion joints as per manufacturer's recommendations.
- L. Switchgear/Electrical Equipment Drip Protection: Every effort shall be made to eliminate the installation of pipe above electrical and data/telephone switchgear. If this is not possible, encase pipe in a second pipe with a minimum of joints. Installation of piping, ductwork, leak protection apparatus or other installations foreign to the electrical installation shall not be located in the space equal to the width and depth of the

equipment and extending from to a height of 1.8 m (6 feet) above the equipment or to ceiling structure, whichever is lower (NFPA 70).

M. Inaccessible Equipment:

1. Where the Owner determines that the Contractor has installed equipment not conveniently accessible for operation and maintenance or inspections, equipment shall be removed and reinstalled or remedial action performed as directed at no additional cost or time to the Owner.
2. The term "conveniently accessible" is defined as capable of being reached without the use of ladders, or without climbing or crawling under or over obstacles such as, but not limited to motors, fans, pumps, belt guards, transformers, high voltage lines, conduit and raceways, piping, hot surfaces, and ductwork. The Owner's representative has final determination on whether an installation meets this requirement or not.

3.03 TEMPORARY PIPING AND EQUIPMENT

- A. Continuity of operation of existing facilities will generally require temporary installation or relocation of equipment and piping.
- B. The Contractor shall provide all required facilities in accordance with the requirements of phased construction and maintenance of service. All piping and equipment shall be properly supported, sloped to drain, operate without excessive stress, and shall be insulated where injury can occur to personnel by contact with operating facilities. The requirements of Paragraph, Arrangement and Installation of Equipment and Piping apply.
- C. Temporary facilities and piping shall be completely removed and any openings in structures sealed. Provide necessary blind flanges and caps to seal open piping remaining in service.

3.04 RIGGING

- A. Design is based on application of available equipment. Openings in building structures are planned to accommodate design scheme.
- B. Alternative methods of equipment delivery may be offered by Contractor and will be considered by Owner under specified restrictions of phasing and maintenance of service requirements as well as structural integrity of the building.
- C. Close all openings in the building when not required for rigging operations to maintain proper environment in the facility for Owner's operation and maintenance of service.
- D. Contractor shall provide all facilities required to deliver specified equipment and place on foundations. Attachments to structures for rigging purposes and support of equipment on structures shall be Contractor's full responsibility. Upon request, the Owner's

representative will check structure adequacy and advise Contractor of recommended restrictions.

- E. Contractor shall check all clearances, weight limitations and shall offer a rigging plan designed by a Professional Engineer registered in the State or Commonwealth in which the project is located.
- F. All modifications to structures, including reinforcement thereof, shall be at Contractor's cost, time and responsibility.
- G. Follow approved rigging plan.
- H. Restore building to original condition upon completing of rigging work.

3.05 PIPE AND EQUIPMENT SUPPORTS

- A. Where hanger spacing does not correspond with joist or rib spacing, use structural steel channels designed by a structural engineer, secured directly to joist and rib structure that will correspond to the required hanger spacing, and then suspend the equipment and piping from the channels. Drill or burn holes in structural steel only with the prior approval of the Owner's representative.
- B. Use of chain pipe supports; wire or strap hangers; wood for blocking, stays and bracing; or, hangers suspended from piping above are prohibited. Replace or thoroughly clean rusty products and paint with zinc primer.
- C. Hanger rods shall be used that are straight and vertical. Turnbuckles for vertical adjustments may be omitted where limited space prevents use. Provide a minimum of 15 mm (1/2 inch) clearance between pipe or piping covering and adjacent work.
- D. HVAC Horizontal Pipe Support Spacing: Refer to MSS SP-58. Provide additional supports at valves, strainers, in-line pumps and other heavy components. Provide a support within one foot of each elbow.
- E. HVAC Vertical Pipe Supports:
 - 1. Up to 6-inch pipe, 30 feet long, bolt riser clamps to the pipe below couplings, or welded to the pipe and rests supports securely on the building structure.
 - 2. Vertical pipe larger than the foregoing, support on base elbows or tees, or substantial pipe legs extending to the building structure.
- F. Overhead Supports:

1. The basic structural system of the building is designed to sustain the loads imposed by equipment and piping to be supported overhead.
2. Provide steel structural members, in addition to those shown, of adequate capability to support the imposed loads, located in accordance with the final approved layout of equipment and piping.
3. Tubing and capillary systems shall be supported in channel troughs.

G. Floor Supports:

1. Provide concrete bases, concrete anchor blocks and pedestals, and structural steel systems for support of equipment and piping. Concrete bases and structural systems shall be anchored and doweled to resist forces under operating and seismic conditions (if applicable) without excessive displacement or structural failure.
2. Bases and supports shall not be located and installed until equipment mounted thereon has been approved. Bases shall be sized to match equipment mounted thereon plus 50 mm (2 inch) excess on all edges. Chiller foundations shall have horizontal dimensions that exceed chiller base frame dimensions by at least 150 mm (6 inches) on all sides. Structural contract documents shall be reviewed for additional requirements. Bases shall be neatly finished and smoothed, shall have chamfered edges at the top, and shall be suitable for painting.
3. All equipment shall be shimmed, leveled, firmly anchored, and grouted with epoxy grout. Anchor bolts shall be placed in sleeves, anchored to the bases. Fill the annular space between sleeves and bolts with a granular material to permit alignment and realignment.

3.06 MECHANICAL DEMOLITION

- A. Rigging access, other than indicated on the contract documents, shall be provided by the Contractor after approval for structural integrity by the Owner's representative. Such access shall be provided without additional cost or time to the Owner. Where work is in an operating plant, provide approved protection from dust and debris at all times for the safety of plant personnel and maintenance of plant operation and environment of the plant.
- B. In an operating facility, maintain the operation, cleanliness and safety. Owner's personnel will be carrying on their normal duties of operating, cleaning and maintaining equipment and plant operation. Confine the work to the immediate area concerned; maintain cleanliness and wet down demolished materials to eliminate dust. Debris accumulated in the area to the detriment of plant operation is prohibited. Perform all flame cutting to maintain the fire safety integrity of this plant. Adequate fire extinguishing facilities shall be available at all times. Perform all work in accordance with recognized fire protection standards. Inspection will be made by personnel of the Owner, and

Contractor shall follow all directives of the Owner's representative with regard to rigging, safety, fire safety, and maintenance of operations. Unless specified otherwise, all piping, wiring, conduit, and other devices associated with the equipment not re-used in the new work shall be completely removed from property per Section 01 74 00 – Cleaning and Waste Management. This includes all concrete pads, pipe, valves, fittings, insulation, and all hangers including the top connection and any fastenings to building structural systems. All openings shall be sealed after removal of equipment, pipes, ducts, and other penetrations in roof, walls, floors, in an approved manner and in accordance with contract documents where specifically covered. Structural integrity of the building system shall be maintained. Reference shall also be made to the contract documents of the other disciplines in the project for additional facilities to be demolished or handled.

C.

All indicated valves including gate, globe, ball, butterfly and check, all pressure gauges and thermometers with wells shall remain Owner's property and shall be removed and delivered to Owner's representative and stored as directed. The Contractor shall remove all other material and equipment, devices and demolition debris under these contract documents. Such material shall be removed from the property expeditiously and shall not be allowed to accumulate.

3.07 CLEANING AND PAINTING

- A. Prior to final inspection and acceptance of the plant and facilities for beneficial use by the Owner, the plant facilities, equipment and systems shall be thoroughly cleaned and painted. Refer to Section 09 90 00 – Painting.
- B. In addition, the following special conditions apply:
1. Cleaning shall be thorough. Solvents, cleaning materials and methods recommended by the manufacturers shall be used for the specific tasks. All rust shall be removed prior to painting and from surfaces to remain unpainted. Repair scratches, scuffs, and abrasions prior to applying prime and finish coats.
 2. The following material and equipment shall not be painted:
 - a. Motors, controllers, control switches, and safety switches.
 - b. Control and interlock devices.
 - c. Regulators
 - d. Pressure reducing valves.
 - e. Control valves and thermostatic elements.
 - f. Lubrication devices and grease fittings.

- g. Copper, brass, aluminum, stainless steel and bronze surfaces.
 - h. Valve stems and rotating shafts.
 - i. Pressure gauges and thermometers.
 - j. Glass.
 - k. Nameplates.
- 3. Control and instrument panels shall be cleaned, damaged surfaces repaired, and shall be touched-up with matching paint obtained from panel manufacturer.
 - 4. Pumps, motors, steel and cast-iron bases, and coupling guards shall be cleaned, and shall be touched-up with the same paint type and color as utilized by the pump manufacturer.
 - 5. Temporary Facilities: Apply paint to surfaces that do not have existing finish coats. This may include painting exposed metals where hangers were removed or where equipment was moved or removed.
 - 6. Final result shall be smooth, even-colored, even-textured factory finish on all items. Completely repaint the entire piece of equipment if necessary to achieve this.
 - 7. Lead based paints are prohibited.

3.08 IDENTIFICATION SIGNS

- A. Provide laminated plastic signs, with engraved lettering not less than 5 mm (3/16 inch) high, designating functions, for all equipment, switches, motor controllers, relays, meters, control devices, including automatic control valves. Nomenclature and identification symbols shall correspond to that used in maintenance manual, and in diagrams specified elsewhere. Attach by chain, adhesive, or screws.
- B. Factory Built Equipment: Metal plate, securely attached, with name and address of manufacturer, serial number, model number, size, performance.
- C. Pipe Identification: Refer to Section 09 90 00 – Painting.
- D. Attach ceiling grid label on ceiling grid location directly underneath above-ceiling air terminal, control system component, valve, filter unit, fan etc.

3.09 MOTOR AND DRIVES

- A. Use synchronous belt drives only on equipment controlled by soft starters or variable frequency drive motor controllers without a bypass contactor. Use V-belt drives on all other applications.

- B. Alignment of V-Belt Drives: Set driving and driven shafts parallel and align so that the corresponding grooves are in the same plane.
- C. Alignment of Synchronous Belt Drives: Set driving and driven shafts parallel and align so that the corresponding pulley flanges are in the same plane.
- D. Alignment of Direct-Connect Drives: Securely mount motor in accurate alignment so that shafts are per coupling manufacturer's tolerances when both motor and driven machine are operating at normal temperatures.

3.10 LUBRICATION

- A. All equipment and devices requiring lubrication shall be lubricated prior to initial operation. Field-check all devices for proper lubrication.
- B. All devices and equipment shall be equipped with required lubrication fittings or devices. A minimum of 1 quart of oil and 1 pound of grease of manufacturer's recommended grade and type for each different application shall be provided; also provide 12 grease sticks for lubricated plug valves. Deliver all materials to Owner's representative in unopened containers that are properly identified as to application.
- C. All lubrication points shall be accessible without disassembling equipment, except to remove access plates.
- D. All lubrication points shall be extended to one side of the equipment.

3.11 STARTUP, TEMPORARY OPERATION AND TESTING

- A. Perform tests as recommended by product manufacturer and listed standards and under actual or simulated operating conditions and prove full compliance with design and specified requirements. Tests of the various items of equipment shall be performed simultaneously with the system of which each item is an integral part.
- B. When any defects are detected, correct defects and repeat test at no additional cost or time to the Owner.
- C. Startup of equipment shall be performed as described in equipment specifications. Vibration within specified tolerance shall be verified prior to extended operation. Temporary use of equipment is specified in Division 01 – General Requirements, Article, Temporary Use of Mechanical and Electrical Equipment.

3.12 OPERATING AND PERFORMANCE TESTS

- A. Prior to the final inspection, perform required tests as specified in Division 01 – General Requirements, Article, Tests, and in individual Division 23 Specification Sections and submit the test reports and records to the Owner's representative.

- B. Should evidence of malfunction in any tested system, or piece of equipment or component part thereof, occur during or as a result of tests, make proper corrections, repairs or replacements, and repeat tests at no additional cost or time to the Owner.
- C. When completion of certain work or system occurs at a time when final control settings and adjustments cannot be properly made to make performance tests, then conduct such performance tests and finalize control settings for heating systems and for cooling systems respectively during first actual seasonal use of respective systems following completion of work. Rescheduling of these tests shall be requested in writing to Owner's representative for approval.
- D. No adjustments may be made during the acceptance inspection. All adjustments shall have been made by this point.

3.13 DEMONSTRATION AND TRAINING

- A. Provide services of manufacturer's technical representative for 4 hours to instruct the personnel responsible in operation and maintenance of the system.

END OF SECTION

SECTION 23 05 93
HVAC BALANCING

PART 1 – GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

- A. Section Includes:
 - 1. Balancing Air Systems:
 - a. Constant-volume air systems.

1.03 DEFINITIONS

- A. AABC – Associated Air Balance Council.
- B. Adjust – To regulate fluid flow rates and air patterns at the system or terminal level. At the system level an example would be reducing fan speed; at the terminal level an example would be changing a damper position.
- C. Balance – To proportion air or water flows within the distribution system, including submains, branches and terminals with respect to design quantities.
- D. Draft – A current of air, when referring to localized effect caused by one or more factors of high air velocity, low ambient temperature, or direction of airflow, whereby more heat is withdrawn from a person's skin than is normally dissipated.
- E. Independent – Not affiliated with or in employment of any Contractor.
- F. NEBB – National Environmental Balancing Bureau.
- G. Procedure – An approach to and execution of a sequence of work operations to yield repeatable results.
- H. Report Forms – Data sheets for recording data in logical order.
- I. Static Head – The pressure due to the weight of the fluid above the point of measurement. In a closed system, static head is equal on both sides of the pump.
- J. Suction Head – The height of fluid surface above the centerline of the pump on the suction side.

- K. System Effect – A phenomenon that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.
- L. System Effect Factors – Allowances used to calculate a reduction of the performance ratings of a fan when installed under conditions different from those presented when the fan was performance tested.
- M. TABB – Testing, Adjusting, and Balancing Bureau
- N. Balancing Specialist – An entity engaged to perform balancing work.
- O. Balancing Agent –The entity responsible for performing and reporting the balancing procedures.
- P. Terminal – A point where the controlled medium (fluid or energy) enters or leaves the distribution system.

1.04 RELATED SECTIONS

- A. Section 01 33 00 – Submittal Procedures
- B. Section 23 00 00 – Basic HVAC Requirements
- C. Section 23 05 95 – HVAC Field Testing
- D. Section 23 07 00 – HVAC Insulation
- E. Section 23 31 13 – Metal Ducts and Duct Accessories
- F. Section 23 34 00 – HVAC Fans
- G. Section 23 81 24 – Packaged Air Conditioners
- H. Section 23 82 16.14 - Electric Resistance Coils

1.05 PROCEDURES

- A. Testing and balancing of the equipment and systems of the facility shall be performed in the following order:
 - 1. Equipment Checkout (See Specification 23 05 95 – HVAC Field Testing for testing requirements)
 - 2. Equipment Testing (See Specification 23 05 95 – HVAC Field Testing for testing requirements)
 - 3. Balancing

- 4. System Testing (See Specification 23 05 95 – HVAC Field Testing for testing requirements)
- B. Balancing shall not be started until the Contractor has submitted and received approval on the Equipment Checkout and Equipment Testing of the respective equipment for the system being balanced.
- C. Certified Data. The Contractor shall provide the Agency with the certified data on pumps, chillers and other equipment required for proper balancing of the system.
- D. Adjustment. The Agency shall supervise or perform necessary adjustments to valves, pumps and other controls as required to properly balance the system.
- E. Balancing. The Agency shall follow balancing procedures published by the AABC, or NEBB.
- F. Reports: Compile the data on report forms as listed in the AABC "National Standards for Total System Balance".

1.06 SUBMITTALS

- A. Qualification Data: Within 60 days of Contractor's Notice to Proceed, submit documentation that the Balancing specialist and this Project's Balancing team members meet the qualifications specified in "Quality Assurance" Article.
- B. Contract Documents Examination Report: Within 60 days of Contractor's Notice to Proceed, submit the Contract Documents review report as specified in Part 3.0.
- C. Strategies and Procedures Plan: Within 60 days of Contractor's Notice to Proceed, submit Balancing strategies and step-by-step procedures as specified in "Preparation" Article.
- D. System Readiness Checklists: Within 60 days of Contractor's Notice to Proceed, submit system readiness checklists as specified in "Preparation" Article.
- E. Examination Report: Submit a summary report of the examination review required in "Examination" Article.
- F. Certified Balancing reports: Within 30 days of completion of balancing work, submit AABC-certified Balancing report.
- G. Submit one copy of the final Balancing Report directly to the design professional of record. Provide five additional copies to the contractor
- H. Sample report forms.
- I. Instrument calibration reports, to include the following:

1. Instrument type and make.
2. Serial number.
3. Application.
4. Dates of use.
5. Dates of calibration.

1.07 QUALITY ASSURANCE

- A. Refer to Articles, Quality Assurance and Submittals in Section 23 00 00 – Basic HVAC Requirements.
- B. Qualifications:
 1. Balancing Agency: The Balancing agency shall be a subcontractor of the General Contractor and shall report to and be paid by the General Contractor.
 2. The Balancing agency shall be either a certified member of AABC, TABB, or NEBB to perform Balancing services for HVAC, water balancing and vibrations and sound testing of equipment. The certification shall be maintained for the entire duration of duties specified herein. If, for any reason, the agency loses subject certification during this period, the General Contractor shall immediately notify the Resident Engineer and submit another Balancing firm for approval. Any agency that has been the subject of disciplinary action by either the AABC or the NEBB within the five years preceding Contract Award shall not be eligible to perform any work related to the Balancing. All work performed in this Section and in other related Sections by the Balancing agency shall be considered invalid if the Balancing agency loses its certification prior to Contract completion, and the successor agency's review shows unsatisfactory work performed by the predecessor agency.
 3. Balancing Specialist: The Balancing specialist shall be either a member and certified member of AABC, TABB, or NEBB. The certification shall be maintained for the entire duration of duties specified herein. If, for any reason, the Specialist loses subject certification during this period, the General Contractor shall immediately notify the Resident Engineer and submit another Balancing Specialist for approval. Any individual that has been the subject of disciplinary action by either the AABC, TABB, or the NEBB within the five years preceding Contract Award shall not be eligible to perform any duties related to the HVAC systems, including Balancing. All work specified in this Section and in other related Sections performed by the Balancing specialist shall be considered invalid if the Balancing Specialist loses its certification prior to Contract completion and must be performed by an approved successor.

4. Balancing Specialist shall be identified by the General Contractor within 60 days after the notice to proceed. The Balancing specialist will be coordinating, scheduling and reporting all Balancing work and related activities and will provide necessary information as required by the Resident Engineer. The responsibilities would specifically include:
 - a. Shall directly supervise all Balancing work.
 - b. Shall sign the Balancing reports that bear the seal of the Balancing standard. The reports shall be accompanied by report forms and schematic drawings required by the Balancing standard, AABC, TABB, or NEBB.
 - c. Would follow all Balancing work through its satisfactory completion.
 - d. Shall provide final permanent markings of settings of all HVAC adjustment devices.
 - e. Permanently mark location of duct test ports.
 5. All Balancing technicians performing actual Balancing work shall be experienced and must have done satisfactory work on a minimum of 3 projects comparable in size and complexity to this project. Qualifications must be certified by the Balancing agency in writing. The lead technician shall be certified by AABC, TABB, or NEBB
- C. Balancing Equipment Criteria: The instrumentation shall meet the accuracy/calibration requirements established by AABC National Standards or by NEBB Procedural Standards for Testing, Adjusting and Balancing of Environmental Systems and instrument manufacturer. Provide calibration history of the instruments to be used for balancing purpose.
- D. Balancing Criteria:
1. One or more of the applicable AABC, NEBB or SMACNA publications, supplemented by ASHRAE Handbook "HVAC Applications" Chapter 38, and requirements stated herein shall be the basis for planning, procedures, and reports.
 2. Flow rate tolerance: The following tolerances are allowed. All tolerances are based on the design flowrates listed in the contract documents. For tolerances not mentioned herein follow 2011 ASHRAE Handbook "HVAC Applications", Chapter 38, as a guideline. Air Filter resistance during balancing, artificially imposed if necessary, shall be at least 100 percent of manufacturer recommended change over pressure drop values for pre-filters and after-filters.
 - a. Air handling unit and all other fans, cubic meters/min (cubic feet per minute): Minus 0 percent to plus 10 percent.

- b. Exhaust hoods/cabinets: 0 percent to plus 10 percent.
 - c. Minimum outside air: 0 percent to plus 10 percent.
 - d. Individual room air outlets and inlets, and air flow rates not mentioned above: Minus 5 percent to plus 10 percent except if the air to a space is 100 CFM or less the tolerance would be minus 5 to plus 5 percent.
- 3. Systems shall be adjusted for energy efficient operation as described in PART 3.
- 4. Typical Balancing procedures and results shall be demonstrated to the Resident Engineer for one air distribution system (including all fans, three terminal units, three rooms randomly selected by the Resident Engineer) and one hydronic system (pumps and three coils) as follows:
 - a. When field Balancing work begins.
 - b. During each partial final inspection and the final inspection for the project if requested by Owner's Representative.
- E. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 7.2.2 – Air Balancing."
- F. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6.7.2.3 – System Balancing.

1.08 FIELD CONDITIONS

- A. Full Owner Occupancy: Owner will occupy the site and existing building during entire Balancing period. Cooperate with Owner during Balancing operations to minimize conflicts with Owner's operations.
- B. Partial Owner Occupancy: Owner may occupy completed areas of building before Substantial Completion. Cooperate with Owner during Balancing operations to minimize conflicts with Owner's operations.

1.09 WARRANTY

- A. Provide one of the following performance guarantees:
 - 1. AABC National Project Performance Guarantee
 - 2. NEBB Certificate of Conformance Certification
 - 3. Balancing Quality Assurance Program Guarantee
 - 4. TABB Project Performance Guarantee

- B. Guarantee shall include provisions that the certified Balancing firm has balanced systems according to the Contract Document and that the systems are balanced to optimum performance capabilities within design and installation limits.

PART 2 – PRODUCTS

2.01 INSTRUMENT TEST HOLES

- A. Permanent Test holes covers to be Ventlock #699.
- B. Provide plastic plugs to seal holes drilled in ductwork for test purposes.

2.02 INSULATION REPAIR MATERIAL

- A. See Section 23 07 00 – HVAC Insulation. Provide for repair of insulation removed or damaged for Balancing work.

PART 3 – EXECUTION

3.01 EXAMINATION

- A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems' designs that may preclude proper balancing of systems and equipment.
- B. Examine systems for installed balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Note the locations of devices that are not accessible for balancing.
- C. Examine the approved submittals for HVAC systems and equipment.
- D. Examine ceiling plenums and underfloor air plenums used for supply, return, or relief air to verify that are properly separated from adjacent areas. Verify that penetrations in plenum walls are sealed and fire-stopped if required.
- E. Examine equipment performance data including fan and pump curves.
- F. Examine HVAC equipment and verify that bearings are greased, belts are aligned and tight, clean permanent filters are installed, and equipment with functioning controls is ready for operation.
- G. Examine heat-transfer coils for correct piping connections and for clean and straight fins.

3.02 PREPARATION

- A. Prepare a Balancing plan that includes the following:
 - 1. Equipment and systems to be balanced.
 - 2. Strategies and step-by-step procedures for balancing the systems.
 - 3. Instrumentation to be used.
 - 4. Sample forms with specific identification for all equipment.
- B. Prepare system-readiness checklists, as described in the "AABC National Standards for Total System Balance," for use by systems installers in verifying system readiness for Balancing. These shall include, at a minimum, the following:
 - 1. Airside:
 - a. Ductwork is complete with terminals installed.
 - b. Volume, smoke and fire dampers are open and functional.
 - c. Clean filters are installed.
 - d. Fans are operating, free of vibration, and rotating in correct direction.
 - e. Variable-frequency controllers' start-up is complete and safeties are verified.
 - f. Automatic temperature-control systems are operational.
 - g. Ceilings are installed.
 - h. Windows and doors are installed.
 - i. Suitable access to balancing devices and equipment is provided.

3.03 GENERAL PROCEDURES FOR BALANCING

- A. Perform balancing procedures on each system according to the procedures contained in AABC's "National Standards for Total System Balance" and in this Section.
 - 1. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary for balancing procedures.
 - 2. Mark equipment and balancing devices, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, with paint or other suitable, permanent identification material to show final settings.
 - 3. Adjust fan speeds by maximizing adjustable sheaves and pump impeller speeds if required to obtain air and water flow rates specified or indicated. If, with these

adjustments and equipment changes, the specified or indicated design flow rates cannot be attained, notify the Resident Engineer.

4. Take report balancing measurements in inch-pound (IP) units.

3.04 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

- A. Prepare balancing reports for both fans and outlets. Obtain approved submittals and recommended balancing procedures. Crosscheck the summation of required outlet volumes with required fan volumes.
- B. Prepare single-line schematic diagram of systems for the purpose of identifying HVAC components.
- C. For variable-air-volume systems, develop a plan to simulate diversity.
- D. Determine the best locations in main and branch ducts for accurate duct-airflow measurements.
- E. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.
- F. Verify that motor starters are equipped with properly sized thermal protection.
- G. Check condensate drains for proper connections and functioning.
- H. Check for proper sealing of air-handling-unit components.

3.06 PROCEDURES FOR CONSTANT-VOLUME AIR SYSTEMS

- A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.
 1. Measure total airflow.
 - a. Set outside air, return air and relief air dampers for proper position that simulates minimum outdoor air conditions.
 - b. Where duct conditions allow, measure airflow by Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses to obtain total airflow.
 - c. Where duct conditions are not suitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.
 - d. If a reliable Pitot-tube traverse or coil traverse is not possible, measure airflow at terminals and calculate the total airflow.
 2. Measure fan static pressures as follows:

- a. Measure static pressure directly at the fan outlet or through the flexible connection.
 - b. Measure static pressure directly at the fan inlet or through the flexible connection.
 - c. Measure static pressure across each component that makes up the air-handling system.
 - d. Report any artificial loading of filters at the time static pressures are measured.
 3. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload will occur. Measure amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required brake horsepower.
- B. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows.
1. Measure airflow of submain and branch ducts.
 2. Adjust sub-main and branch duct volume dampers for specified airflow. Re-measure each sub-main and branch duct after all have been adjusted.
- C. Adjust air inlets and outlets for each space to indicated airflows.
1. Set airflow patterns of adjustable outlets for proper distribution without drafts.
 2. Measure airflow at all inlets and outlets.
 3. Adjust each inlet and outlet for specified airflow.
 4. Re-measure each inlet and outlet after all have been adjusted.
- D. Verify final system conditions.
1. Re-measure and confirm minimum outdoor air, return and relief airflows are within design. Readjust to design if necessary.
 2. Re-measure and confirm total airflow is within design.
 3. Re-measure all final fan operating data, rpms, volts, amps, static profile.
 4. Mark all final settings.
 5. Run system in economizer mode. Verify proper operation and adjust, if necessary.

6. Measure and record all operating data.
7. Record final fan-performance data.

3.07 PROCEDURES FOR MOTORS

- A. Motors, 1/2 HP and Larger: Test at final balanced conditions and record the following data:
 1. Manufacturer's name, model number, and serial number.
 2. Motor horsepower rating.
 3. Motor rpm.
 4. Phase/Hertz (Hz)
 5. Nameplate and measured voltage, each phase.
 6. Nameplate and measured amperage, each phase.
 7. Starter size and thermal-protection-element rating.
 8. Service factor and frame size.
- B. Motors Driven by Variable-Frequency Controllers: Test the manual bypass of the controller to prove proper operation.

3.08 PROCEDURES FOR CONDENSING UNITS

- A. Verify proper rotation of fans.
- B. Measure entering- and leaving-air temperatures.
- C. Record fan and motor operating data.

3.09 TOLERANCES

- A. Set HVAC system's air flow rates and water flow rates within the following tolerances:
 1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus or minus 10 percent.
 2. Air Outlets and Inlets: Plus or minus 10 percent.
 3. Heating-Water Flow Rate: Plus or minus 10 percent.

4. Cooling-Water Flow Rate: Plus or minus 10 percent.
- B. Maintaining pressure relationships as designed shall have priority over the tolerances specified above.

3.10 FINAL BALANCE REPORT

- A. The report shall be a complete record of the HVAC system performance, including conditions of operation, items outstanding, and any deviations found during the balancing process. The final report also provides a reference of actual operating conditions for the owner and/or operations personnel. All measurements and results that appear in the reports must be made on site and dated by the AABC technicians or balancing engineers.
- B. The report must be organized by systems and shall include the following information as a minimum:
 1. Title Page:
 - a. AABC, TABB, or NEBB certified company name
 - b. Company address
 - c. Company telephone number
 - d. Project identification number
 - e. Location
 - f. Project Architect
 - g. Project Engineer
 - h. Project Contractor
 - i. Project number
 - j. Date of report
 - k. AABC or NEBB Certification Statement
 - l. Name, signature, and certification number of AABC, TABB, or NEBB
 2. Table of Contents.
 3. AABC National Performance Guaranty.
 4. Report Summary:

- a. The summary shall include a list of items that do not meet design tolerances, with information that may be considered in resolving deficiencies.
- 5. Instrument List:
 - a. Type.
 - b. Manufacturer.
 - c. Model.
 - d. Serial Number.
 - e. Calibration Date.
- 6. Balancing Data:
 - a. Provide data for specific systems and equipment as required by the most recent edition of the "AABC National Standards."
- C. One copy of the final balancing report shall be sent directly to the design professional of record. Provide five additional copies to the contractor.

3.11 VERIFICATION OF BALANCING REPORT

- A. Final Verification:
 - 1. After balancing is complete and accurately documented in the final report, request that a final verification be made by design professional.
 - 2. The Balancing Agency shall conduct the verification in the presence of design professional.
 - 3. Design Professional shall randomly select measurements, documented in the final report, to be rechecked. Rechecking shall be limited to either 10 percent of the total measurements recorded or the extent of measurements that can be accomplished in a normal 8-hour business day.
 - 4. If rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements shall be noted as "FAILED."
 - 5. If the number of "FAILED" measurements is greater than 10 percent of the total measurements checked during the final verification, the balancing shall be considered incomplete.

3.12 REVERIFICATION

- A. If the balancing work is considered incomplete, proceed as follows:
1. Balancing Agency shall recheck all measurements and make adjustments as required to complete the balancing. Revise the final report and balancing device settings to include all changes; resubmit the final report and request a second verification.
 2. If the second verification also fails, Engineer may contact the applicable certification bureau.

END OF SECTION

SECTION 23 05 95
HVAC FIELD TESTING

PART 1 – GENERAL

1.01 REQUIREMENTS

- A. The requirements of this Section apply to all sections of Division 23.
- B. This Section specifies the requirements and procedures for field testing the HVAC systems. Requirements include developing a detailed testing plan and executing the testing plan to meet design requirements as indicated in this specification. Actions include but are not limited to measurement of the fluid quantities of the HVAC systems, operating HVAC equipment, proving control strategy requirements, and adjustments to meet control strategy requirements.
- C. The testing and balancing of the equipment and systems of the facility shall be performed in the following order:
 - 1. Equipment Checkout – Physical Checkout
 - 2. Equipment Testing – Short Run Test
 - 3. Balancing (See Section 23 05 93 – HVAC Balancing for balancing requirements)
 - 4. System Testing – Full Controls Test and Control Strategy Proving
- D. The Contractor shall submit and obtain approval for the Equipment Checkout and Equipment Testing prior to beginning balancing.
- E. The Contractor shall submit and obtain approval for the HVAC System Balancing prior to beginning the System Test.
- F. Where a system consists of multiple pieces of equipment (i.e., air handler and exhaust fans, etc.), all parts of the system shall have their Equipment Checkout and Equipment Testing submitted and approved before Balancing begins. Similarly, Balancing shall be completed, submitted, and approved for all system components before System Testing can begin.
 - 1. Where this action would be deleterious or prohibitive to the system or component parts, the Contractor shall specifically include the reason in the Testing Procedure submittal and receive approval.
- G. The following HVAC systems shall be field tested:

1. Air Handling Equipment including integral and external fans
 2. Air Cooling Systems
 3. Air Heating Systems
 4. Air Conveying Systems
 5. HVAC Automatic Temperature Controls(ATC) Systems
- H. This Section does not include specifications for materials for patching HVAC systems, or specifications for materials and installation of temporary devices. If devices must be added to achieve proper system testing or to execute the system control strategy, they shall be provided.
- I. The respective equipment manufacturer's representative shall be present for Equipment Checkout and Equipment Testing activities. The representative shall sign all testing reports related to these portions of the testing report.

1.02 DEFINITIONS

- A. Systems testing is the process of checking and adjusting all the building environmental systems to produce the design objectives. It includes the balance of air distribution, water distribution, the adjustment of total system to provide design quantities, the electrical measurement, and the verification of performance of all equipment and automatic controls.
1. Test: To determine quantitative performance of equipment.
 2. Adjust: To regulate the specified fluid flow rate and air patterns at the terminal equipment (e.g., reduce fan speed, throttling).
 3. Balance: To proportion flows within the distribution system (submains, branches, and terminals) according to specified design quantities.
 4. Procedure: Standardized approach and execution of sequence of work operations to yield reproducible results.
 5. Report Forms: Test data sheets arranged for collecting test data in logical order for submission and review. These data should also form the permanent record to be used as the basis for required future testing, adjusting, and balancing.
 6. Terminal: The point where the controlled fluid enters or leaves the distribution system. These are supply inlets or supply outlets on air terminals and exhaust or return inlets on air terminals such as registers, grilles, diffusers, louvers, and hoods.

7. Main: Duct containing the system's major or entire fluid flow.
8. Submain: Duct containing part of the systems' capacity and serving two or more branch mains.
9. Branch Main: Duct serving two or more terminals.
10. Branch: Duct serving a single terminal.

1.03 SUBMITTALS

- A. Submit the following in accordance with Division 01 requirements.
- B. All testing shall be witnessed by the Owner, Owner's representative, or the Resident Engineer.
- C. The Contractor shall submit a detailed testing procedure for approval. The Contractor shall have the testing procedure approved 30 days before testing is scheduled to begin. The detailed testing procedure shall include forms, procedures and diagrams for the Equipment Checkout, Equipment Test, and System Test procedures described in Part 3 of this specification. The testing procedure shall include:
 1. Detailed step by step instructions as to how the equipment tests will be performed including but not limited to temporary layout modifications, any special procedures for testing equipment functionality, and how system actions will be activated.
 2. All testing for systems that require seasonal outside air conditions shall be conducted when outside air conditions are suitable for such testing. When approved by the Engineer, the Contractor may conduct seasonal testing of the system during off-seasonal conditions. When this condition is approved, the report shall indicate how the test will accommodate testing of seasonal systems when seasonal conditions are not present.
 3. A list of any additional or temporary equipment necessary to perform the tests such as pumps, heat exchangers, heating or cooling equipment.
 4. A list of any instruments necessary to verify instrument signals in the HVAC system. The list shall include current calibration information. All instruments shall be within their calibration expiration at the date the testing is performed.
 5. Provide tables for recording all required readings, action results, and comments.
 6. Provide a checklist of items that will be checked during the test as listed in relative sections of Part 3 of this specification. Each action or step shall have a separate row. Each action or step shall be initialed by the Contractor's Testing Technician

conducting the test. All tests shall be signed and dated by the Contractor, the Testing Technician, and the Owner, Owner's Representative, or Resident Engineer. The Equipment Checkout and Equipment Test shall also be signed by the respective equipment manufacturer's representative.

- D. As each section of the Testing Procedure is completed, the Contractor shall compile and submit all signed results to the Owner for acceptance.
- E. The equipment manufacturer's representative shall be present for all testing. The Equipment Checkout and Equipment Testing results shall include a letter from the Manufacturer's representative stating that the equipment has been installed per the Manufacturer's installation requirements and is in satisfactory working order.
- F. Submit proof that the Testing Technician assigned to supervise the procedures, and the individual technicians proposed to perform the procedures meet the qualifications specified below.
- G. The Contractor shall submit the signed results of the testing to the Owner for acceptance. The equipment manufacturer's representative shall be present for all testing. The results shall include a letter from the Manufacturer's representative stating that the equipment has been installed per the Manufacturer's installation requirements and is in satisfactory working order. Any deficiencies noted by the Manufacturer's representative shall be corrected and testing repeated.
 - 1. The calibration data for all instruments used to verify HVAC system instrument readings shall be refreshed. All instruments shall be within their calibration expiration at the date the testing was performed.

1.04 QUALITY ASSURANCE

- A. Testing Personnel Qualifications: The personnel responsible for testing the specified systems shall have at least three years of experience in testing systems similar to this project and shall be an employee of the installer or an independent testing agency.
- B. Codes and Standards:
 - 1. NEBB, "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems."
 - 2. ASHRAE Handbook, 1984 Systems Volume, Chapter 37, Testing, Adjusting, and Balancing.
- C. The Contractor shall provide all necessary instrumentation, tools, ladders, and labor etc. to complete all testing activities.

- D. Instrumentation shall be in accordance with NEBB, AABC, or SMACNA requirements and shall be calibrated to the accuracy standards demanded by these organizations.
- E. The Contractor shall keep dust, dirt, and debris to an absolute minimum and reinstall all removed ceiling components to their original positions at the end of each day.
- F. The Contractor shall be fully responsible for removal and reinstallation of ceiling system and replacement of any component damaged.

1.05 SEQUENCING AND SCHEDULING

- A. Systems shall be fully operational prior to beginning procedures.

1.06 RELATED SECTIONS

- A. Section 23 00 00 - Basic HVAC Requirements
- B. Section 23 34 00 – HVAC Fans
- C. Section 23 31 13 – Metal Ducts and Duct Accessories
- D. Section 23 81 24 – Packaged Air Conditioners
- E. Section 23 82 16.14 - Electric Resistance Coils

PART 2 – PRODUCTS

PART 3 – EXECUTION

3.01 HVAC TESTING SEQUENCING

- A. The HVAC testing shall be performed in the following sequence.
 - 1. Pre-Start-up Inspection
 - 2. Equipment Test
 - 3. Balancing (See Section 23 05 93 – HVAC Balancing for balancing requirements)
 - 4. Individual System Test
 - 5. Whole HVAC System Run Test

B. HVAC PRE-START-UP INSPECTION AND EQUIPMENT TESTING

1. All HVAC equipment shall have a Pre-Start-up Inspection and Equipment test performed. The specific requirements for equipment indicated below shall be performed in addition to any requirements of the Manufacturer for startup and initial operation. All other equipment shall be inspected per the Manufacturer's requirements and run for 1 hour trouble free.
2. The equipment manufacturer's representative shall be present for all testing.
3. Fans:
 - a. Pre Startup Inspection:
 - 1) Verify proper equipment mounting and setting
 - 2) Verify that control, interlock and power wiring is complete
 - 3) Verify alignment of motors and drives
 - 4) Verify proper belt tension
 - 5) Verify proper duct connections and accessories
 - 6) Verify that lubrication is completed
 - 7) Verify that equipment is in good condition and free from damage
 - 8) Verify that all packing materials, temporary stops, and temporary supports used during shipping have been removed
 - 9) Verify that equipment and associated ducts are free from debris
 - 10) Verify that equipment is installed per the Manufacturer's requirements
 - b. Equipment Test:
 - 1) Prior to energizing motor, verify and record voltage of power supply
 - 2) Bump motor to verify direction of rotation
 - 3) Run the fan for 1 hour of continuous trouble free operation. Any issues or stops required for tuning or repairs shall cause the test to be restarted from the beginning of this procedure.
 - 4) Monitor heat build-up in bearings. Bearing temperature shall not exceed the manufacturer's recommendations.

- 5) Monitor for any abnormal noises or vibration. Abnormal noises and vibration shall be assessed and determined by the equipment manufacturer's representative.
- 6) Check motor loads against nameplate data
- 7) Record fan sound levels ten (10) feet from the surface of the fan in five (5) minute intervals during 1 hour run period. Sound levels shall be below 90 dB at all times.

C. Cooling Equipment (Refrigerant based)

1. Pre Startup Inspection:

- a. Verify proper equipment mounting and setting
- b. Verify that control, interlock and power wiring is complete
- c. Verify proper duct connections and accessories
- d. Verify that lubrication is completed
- e. Verify that equipment is in good condition and free from damage
- f. Verify that all packing materials, temporary stops, and temporary supports used during shipping have been removed
- g. Verify that equipment and associated ducts are free from debris
- h. Verify that the refrigeration system has been evacuated and charged per the Manufacturer's requirements
- i. Verify that equipment is installed per the Manufacturer's requirements

2. Equipment Test:

- a. Prior to energizing unit, verify and record voltage of power supply
- b. Run the unit for 1 hour of continuous trouble free operation, with no unexpected shutdowns, alarms or operational issues. Any issues or stops required for tuning or repairs shall cause the test to be restarted from the beginning of this procedure. If the ambient air temperature is too low to have the refrigeration system running constantly for 1 hour, the Contractor shall take into account any additional measures required to accomplish the testing based on the ambient air temperature. The Contractor shall provide any temporary heating equipment required to run this test including but not limited to temporary fans, ductwork, heaters, generators, heat exchangers,

combustion equipment, and fuel storage and pumping at no cost to the project. Use of any heating equipment that was installed as part of this work shall not be permitted to be used as a heat source.

- c. Monitor discharge and return air temperatures and compare to the manufacturer's submitted values.
- d. Monitor for any abnormal noises or vibration. Abnormal noises and vibration shall be assessed and determined by the equipment manufacturer's representative.
- e. Record fan sound levels ten (10) feet from the surface of the equipment in five (5) minute intervals during 1 hour run period. The sound levels shall not exceed 90 dB.

3. Air Handling Units

- a. Pre Startup Inspection:
 - 1) Verify proper equipment mounting and setting
 - 2) Verify that control, interlock and power wiring is complete
 - 3) Verify alignment of motors and drives
 - 4) Verify proper belt tension
 - 5) Verify proper duct connections and accessories
 - 6) Verify that lubrication is completed
 - 7) Verify that equipment is in good condition and free from damage
 - 8) Verify that all packing materials, temporary stops, and temporary supports used during shipping have been removed
 - 9) Verify that equipment and associated ducts are free from debris
 - 10) Verify that equipment is installed per the Manufacturer's requirements

4. Equipment Test:

- a. Prior to energizing unit, verify and record voltage of power supply
- b. Run the unit for 1 hour of continuous trouble free operation with no unexpected shutdowns, alarms or operational issues in heating mode and for 1 hour of continuous trouble free operation in ventilating mode. Any

issues or stops required for tuning or repairs shall cause the test to be restarted from the beginning of the respective 1 hour test. Any safety trips will cause this testing to be restarted from the beginning of this procedure. If the ambient air temperature is too high to have the unit heating constantly for 1 hour, the Contractor shall adjust the setpoint temperature of the unit. The Contractor shall coordinate this testing with all other trades. The Contractor is responsible for scheduling this testing and shall take into account any additional measures required to accomplish the testing based on the ambient air temperature. The Contractor shall not raise the temperature in the space to a point where it will cause damage to any equipment in the space or create unsafe or uncomfortable working conditions for the workers as determined by the Owner. If the Owner determines that the ambient conditions will not allow the testing of this equipment because the Contractor has scheduled the testing for a point in the season known to be warm, the Contractor shall provide any temporary cooling required to run this test including but not limited to temporary fans, ductwork, chillers, generators, cooling towers, make-up water supplies, heat exchangers, or air conditioners at no additional cost to the project.

- c. Monitor heat build-up in bearings. Temperature shall not exceed the manufacturer's recommendations.
- d. Monitor for any abnormal noises or vibration. Abnormal noises and vibration shall be assessed and determined by the equipment manufacturer's representative.
- e. Check unit loads against nameplate data
- f. Record fan sound levels ten (10) feet from the surface of the fan in five (5) minute intervals during both 1 hour continuous operating periods.

D. Drip Pans

- 1. Drip pans and drains shall be hydrostatically tested under gravity of a filled drip pan and drain line for a minimum of 30 minutes. Any leaks shall be corrected, and the drip pan/drains retested until a watertight drip pan drainage system is confirmed.

E. Ductwork

- 1. All openings in the ductwork shall be temporarily sealed and the ductwork shall be pressurized and leak tested to demonstrate that the installation meets the specified SMACNA leakage class requirements. The Contractor shall follow SMACNA procedures for testing as outlined in SMACNA's HVAC Air Duct Leakage Test Manual.

3.02 INDIVIDUAL SYSTEM TESTING

- A. The Contractor shall assist the ATC contractor with individual system testing by operating the HVAC equipment. The Contractor shall coordinate with other trades as required to complete the testing activities with minimal disruption to the owner's staff and operation of the facility.
- B. All systems shall be tested to verify the system operates per the respective equipment specifications and Control Strategies. The testing shall systematically test all control functions including but not limited to all logic sequences, modes of operation, interlocks, alarms, safeties, adjustable setpoints, and instrument readings at all control panels.

3.03 REPAIR FOLLOWING TESTING PROCEDURES

- A. All repair work shall be completed at no additional cost to the Owner.
- B. Cut insulation and ductwork for installation of test probes to the minimum extent necessary to allow adequate performance of procedures.
- C. Patch insulation, ductwork, and housings using materials identical to those removed.
- D. Seal ducts, test, and repair leaks created during the testing procedures on the hydronic and air systems.
- E. Seal insulation to re-establish integrity of the vapor barrier at all locations where the vapor barrier was disturbed during the testing procedures.
- F. Mark equipment settings, including damper control positions, valve indicators, fan speed control levers, and similar controls and devices, to show final settings. Mark with suitable permanent means of identification.

END OF SECTION

SECTION 23 07 00
HVAC INSULATION

PART 1 – GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.
- C. Division 07 Section “Firestopping”.
- D. Division 23 Section “Metal Ductwork” for duct liners.

1.02 SUMMARY

- A. Work Included:
 - 1. Flexible Glass Wool Blanket
 - 2. Flexible Elastomeric Duct Insulation
 - 3. Jacketing
 - 4. Accessories
 - 5. Duct Insulation Accessories
 - 6. Duct Insulation Compounds
 - 7. Outdoor Ducting Cover

1.03 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

- A. Without limiting the generality of other requirements of the specifications, all work herein shall conform to the applicable requirements of the following documents. All referenced specifications, codes, and standards refer to the most current issue available at the time of Bid.
 - 1. ASTM E84 “Standard Test Method for Surface Burning Characteristics of Building Materials”.

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2. ASTM C533 "Standard Specification for Calcium Silicate Block and Pipe Thermal Insulation".
3. NFPA 255 "Standard Method of Test of Surface Burning Characteristics of Building Materials".
4. ASTM C921 "Standard Practice for Determining the Properties of Jacketing Materials for Thermal Insulation".
5. ASTM C1071A "Standard Specification for Fibrous Glass Duct Lining Insulation".
6. ASTM C1136 "Standard Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation".

1.04 SUBMITTALS

- A. Shop Drawings: Submit for approval Shop Drawings showing the following:
 1. Manufacturers' catalog literature, specifications, and illustrations with the following information:
 - a. Thermal properties.
 - b. Physical properties (thickness, density etc).
 - c. Fire hazard ratings.
 - d. Facing information.
 - e. Installation instructions.
 - f. Jointing recommendations for butt joints and longitudinal seam.
 - g. Fabrication instructions for duct fittings and valve insulation and coatings.
 2. Schedule of Project Specific Product Data: Identify thermal conductivity, thickness, and jackets (both factory and field applied, if any), for each type of product indicated and for which type of duct or piping system it is associated with. Submit a tabular schedule for the entire project.
 3. Samples: For each type of insulation and field-applied jacket. Identify each Sample, describing product and intended use. Submit 8-inch square sections of each sample material.
 4. Installer Certificates: Signed by the Contractor certifying that installers comply with requirements.

1.05 QUALITY ASSURANCE

- A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the U.S. Department of Labor, Bureau of Apprenticeship and Training. Company or firm that employs the insulation installers shall have a minimum of 5 years of experience in the business of installing HVAC related duct and piping insulation systems.
- B. Fire-Test-Response Characteristics: As determined by testing materials identical to those specified in this Section according to ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and sealer and cement material containers with appropriate markings of applicable testing and inspecting agency.
- C. Products shall not contain asbestos, lead, mercury, or mercury compounds.
- D. Supply insulation products that assure excellent IAQ (Indoor Air Quality) performance through Greenguard Certification whenever possible.
- E. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.
- F. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.
- G. Design Criteria: Insulation systems including covering, mastics, adhesives, sealers and facings shall have the following fire hazard classifications:
 - 1. Flame spread, 25 maximum.
 - 2. Fuel contributed, 50 maximum.
 - 3. Smoke developed, 50 maximum.
- H. Source Quality Control: Perform the following tests and inspections at the factory:
 - 1. Flame spread.
 - 2. Smoke developed.
 - 3. Fuel contributed.
- I. Requirements of Regulatory Agencies:
 - 1. Permits: Contractor shall obtain and pay for all required fees, inspections and approvals by authorities having jurisdiction.

2. Building Codes: Comply with applicable requirements of all State and local building codes.
 3. Underwriters' Laboratories, Incorporated.
 4. National Fire Protection Association.
- J. Reference Standards: Comply with applicable provisions and recommendations of the following except as otherwise shown or specified:
1. Federal Specification HH 1 558B, Insulation Blocks, Boards, Blankets, Felts, Sleeves, Duct Fitting Covering.
 2. ASTM C 547, Mineral Fiber Preformed Duct Insulation.
 3. ASTM E 84, Surface Burning Characteristics of Building Materials.
- K. Field Measurements: Take field measurements where required prior to installation to ensure proper fitting of Work.

1.06 PRODUCT DELIVERY, STORAGE AND HANDLING

- A. Delivery of Material: Material shall be delivered to the job site in corrugated cartons.
- B. Packaging: Ship insulation materials in containers marked by manufacturer with appropriate ASTM specification designation, type and grade, and maximum use temperature.
- C. Storage of Material:
1. Store material in clean, dry area, out of the weather.
 2. Material shall be tightly covered to protect against dirt, water, mechanical injury or chemical damage.
 3. Material shall remain in original cartons until time of installation.
 4. Insulation and Mold: Store all cartons of insulation elevated off the floor on pallets or wood blocking away from dust, dirt and debris. Store in a clean, dry, well-ventilated area. Carefully inspect any insulation that has been exposed to water. If insulation shows any sign of mold growth it must be discarded. If the material is wet but shows no sign of mold, it should be dried rapidly and thoroughly. If it shows signs of facing degradation from wetting, it should be replaced. Mineral fiber based air handling insulation used in the air stream must be discarded if exposed to water regardless of signs of mold.

1.07 JOB CONDITIONS

A. Protection:

1. All material applied in one day shall have the vapor barrier applied the same day and any exposed ends shall be temporarily protected with a moisture barrier and sealed to the duct.
2. Insulating materials shall, at all times, be protected from moisture.
3. Material shall be warehoused on or near the job site and drawn from this protected area as used.

1.08 DEFINITIONS

- A. Greenguard: Greenguard Environmental Institute, independent testing of products for emissions of respirable particles and Volatile Organic Compounds (VOCs), including formaldehyde and other specific product-related pollutants. Provides independent, third-party certification of IAQ performance. Certification is based upon criteria used by EPA, OSHA and WHO.
- B. IAQ: Indoor Air Quality
- C. EPA: Environmental Protection Agency
- D. WHO: World Health Organization
- E. ASJ: All Service Jacket
- F. SSL: Self-Sealing Lap
- G. FSK: Foil-Scrim-Kraft; jacketing
- H. PSK: Poly-Scrim-Kraft; jacketing
- I. PVC: Polyvinyl Chloride
- J. FRP: Fiberglass Reinforced Plastic

1.09 COORDINATION

- A. Schedule insulation application after testing duct and piping systems. Insulation application may begin on segments of duct or piping that has satisfactory test results. Do not install insulation prior to building interior being fully enclosed and weather tight.
- B. Coordinate clearance requirements with duct and piping installers for insulation application.

- C. Coordinate size and location of supports, hangers, and insulation shields specified in Division 15 Section "Pipe Supports."
- D. Coordinate clearance requirements with piping Installer for piping insulation application duct Installer for duct insulation application, and equipment Installer for equipment insulation application.

DESIGNER SHALL SELECT APPROPRIATE INSULATION MATERIAL FOR APPLICATION. REMOVE ALL UNUSED TYPES.

PART 2 – PRODUCTS

2.01 MANUFACTURERS

- A. Flexible Glass Wool Blanket:
 - 1. Certainteed
 - 2. Johns Manville
 - 3. Knauf
 - 4. Owens-Corning
 - 5. Or approved equivalent.
- B. Flexible Elastomeric Duct Insulation:
 - 1. Armacell LLC Armaflex
 - 2. K-Flex USA
 - 3. Aeroflex USA
 - 4. Or approved equivalent.
- C. Jacketing:
 - 1. ITW Insulation Systems
 - 2. Johns Manville
 - 3. GLT Products
 - 4. Or approved equivalent.
- D. Accessories:

1. ITW Insulation Systems
2. Johns Manville
3. GLT Products
4. Or approved equivalent.

E. Duct Insulation Accessories:

1. Certainteed
2. Johns Manville
3. Owens-Corning
4. Or approved equivalent.

F. Duct Insulation Compounds:

1. Certainteed
2. Johns Manville
3. Owens-Corning
4. Or approved equivalent.

2.02 FLEXIBLE GLASS WOOL BLANKET

A. ASTM C553, Type 1, Class B-2; flexible blanket.

1. 'K' Value: $0.27 \text{ BTU} \cdot \text{in} / (\text{hr} \cdot \text{sf} \cdot \text{F})$ at 75 degrees F installed, maximum service temperature: 250 degrees F.
2. Density: 0.75 pounds per cubic foot.
3. DBDE-free. UL/E validated to be formaldehyde-free.
4. Vapor Barrier Jacket: FSK aluminum foil reinforced with glass wool yarn and laminated to fire resistant Kraft, secured with UL listed pressure sensitive tape or outward clinched expanded staples and vapor barrier mastic as needed.

2.03 FLEXIBLE ELASTOMERIC DUCT INSULATION

A. Elastomeric Foam: ASTM C534; flexible, cellular elastomeric, molded or sheet.

1. Thermal Conductivity Value: 0.28 BTU*in/(hr*sf°F) at 75 degrees F.
 2. Maximum Service Temperature of 220 degrees F.
 3. Maximum Flame Spread: 25.
 4. Maximum Smoke Developed: 50 (1-inch thick and below).
 5. Connection: Waterproof vapor retarder adhesive as needed.
 6. UV Protection: UV outdoor protective coating as needed per manufacturer's requirements.
- B. Glue: Contact adhesive specifically manufactured for cementing flexible elastomeric foam.
- C. Paint: Nonhardening high elasticity type, manufactured as protective covering of flexible elastomeric foam insulation for prevention of degradation due to exposure to sunlight and weather.

2.04 JACKETING

- A. Canvas Jacket: UL listed fabric, 6 ounce/sq.yd., plain weave cotton treated with dilute fire retardant lagging adhesive.
- B. PVC preformed molded insulation covers. Zeston or approved equivalent.
- C. Aluminum Jacket: 0.016-inch-thick sheet, (smooth/embossed) finish, with longitudinal slip joints and 2-inch laps, die-shaped fitting covers with factory attached protective liner.
- D. Stainless Steel Jacket: Type 304 stainless steel, 0.010-inch, smooth finish.

2.05 ACCESSORIES

- A. Equipment Insulation Jacketing: Presized glass cloth, not less than 7.8 ounces/sq.yd., except as otherwise indicated. Coat with gypsum based cement.
- B. Equipment Insulation Compounds: Provide adhesives, cement, sealers, mastics and protective finishes as recommended by insulation manufacturer for applications indicated.
- C. General: Provide staples, bands, wire, wire netting, tape corner angles, anchors, stud pins and metal covers as recommended by insulation manufacturer for applications indicated. Accessories, i.e., adhesives, mastics, cements and tape to have the same flame and smoke component ratings as the insulation materials with which they are used. Shipping cartons to bear a label indicating that flame and smoke ratings do not exceed those listed above. Provide permanent treatment of jackets or facings to impart

flame and smoke safety. Provide non-water soluble treatments. Provide UV protection recommended by manufacturer for outdoor installation.

2.06 DUCT INSULATION ACCESSORIES

- A. Staples, bands, wires, tape, anchors, corner angles and similar accessories as recommended by insulation manufacturer for applications indicated.

2.07 DUCT INSULATION COMPOUNDS

- A. Cements, adhesives, coatings, sealers, protective finishes and similar accessories as recommended by insulation manufacturer for applications indicated.

PART 3 – EXECUTION

3.01 GENERAL INSTALLATION REQUIREMENTS

- A. Verification of Conditions:
 - 1. Do not apply insulation until pressure testing and inspection of ducts and piping has been completed.
 - 2. Examine areas and conditions under which duct and pipe insulation will be installed. Do not proceed with work until unsatisfactory conditions have been corrected.
- B. Preparation: Clean and dry surfaces to be insulated.
- C. Installation:
 - 1. Insulation: Continuous through walls, floors and partitions except where noted otherwise.
 - 2. Piping and Equipment:
 - a. Install insulation over clean, dry surfaces with adjoining sections firmly butted together and covering surfaces. Fill voids and holes. Seal raw edges. Install insulation in a manner such that insulation may be split, removed, and reinstalled with vapor barrier tape on strainer caps and unions. Do not install insulation until piping has been leak tested and has passed such tests. Do not insulate manholes, equipment manufacturer's nameplates, handholes, and ASME stamps. Provide beveled edge at such insulation interruptions. Repair voids or tears.
 - b. Cover insulation on pipes above ground, outside of building, with aluminum jacketing. Position seam on bottom of pipe.

- D. Provide accessories as required. See Part 2 Article "Accessories" above.
- E. Protection and Replacement: Installed insulation during construction. Replace damaged insulation which cannot be repaired satisfactorily, including units with vapor barrier damage and moisture saturated units.
- F. Labeling and Marking: Provide labels, arrows and color on piping and ductwork. Attach labels and flow direction arrows to the jacketing.
- G. Ductwork:
 - 1. Install insulation in conformance with manufacturer's recommendations to completely cover duct.
 - 2. Butt insulation joints firmly together and install jackets and tapes smoothly and securely.
 - 3. Apply duct insulation continuously through sleeves and prepared openings, except as otherwise specified. Apply vapor barrier materials to form complete unbroken vapor seal over insulation.
 - 4. Coat staples and seals with vapor barrier coating.
 - 5. Cover breaks in jacket materials with patches of same material as vapor barrier. Extend patches not less than 2-inches beyond break or penetration on all directions and secure with adhesive and staples. Seal staples and joints with vapor barrier coating.
 - 6. Fill jacket penetrations. i.e., hangers, thermometers and damper operating rods, and other voids in insulation with vapor barrier coating. Seal penetration with vapor barrier coating. Insulate hangers and supports for cold duct in un-conditioned spaces to extent to prevent condensation on surfaces.
 - 7. Seal and flash insulation terminations and pin punctures with reinforced vapor barrier coating.
 - 8. Continue insulation at fire dampers and fire/smoke dampers up to and including those portions of damper frame visible at outside of the rated fire barrier. Insulating terminations at fire dampers in accordance with this Section.
 - 9. Do not conceal duct access doors with insulation. Install insulation terminations at access door in accordance with this Section.
- H. Insulated Pipe Exposed to Weather: Where piping is exposed to weather, cover insulation with aluminum jacket. Seal watertight jacket per manufacturer's recommendations. Install metal jacket with 2-inch overlap at longitudinal and butt joints

with exposed lap pointing down. Secure jacket with stainless-steel draw bands 12-inches on center and at butt joints.

- I. Insulation Shields: Provide hangers and shields (18 gauge minimum) outside of insulation for cold piping (<60 degrees F). Hot water piping hangers may penetrate insulation to contact pipe directly. Provide 18-inch long, non-compressible insulation section at insulation shields for lines 2-inches and larger (hot and cold) piping.
- J. Condensate piping shall be insulated in 1-inch of elastomeric foam insulation. Provide aluminum or stainless steel jacketing cover for the insulation.
- K. Ductwork Surfaces to be Insulated:

Item to be Insulated	System Insulation Type	Duct Size	Insulation Thickness
Supply ductwork where duct is not specified to be lined.	Flexible Glass Blanket / Flexible Elastomeric; Aluminum or SST jacket	All	1.5-inch
Return ductwork where duct is not specified to be lined.	Flexible Glass Blanket / Flexible Elastomeric; Aluminum or SST jacket	All	None

Note: Insulation thickness shown is a minimum. If state codes require additional thickness, then provide insulation thickness per code requirements.

3.02 FLEXIBLE GLASS WOOL BLANKET

- A. Install insulation in conformance with manufacturer's recommendations and requirements.
- B. Duct Wrap: Cover air ducts per insulation table except ducts internally lined where internal duct lining is adequate to achieve adequate insulating values to meet local Energy Codes (indicate on shop drawings, locations where duct wrap is planned to be omitted and indicate internal duct lining insulating values to confirm they will meet the Energy Code.) Wrap tightly with circumferential joints butted and longitudinal joints overlapped minimum of 2-inches. On ducts over 24-inches wide, additionally secure insulation with suitable mechanical fasteners at 18- inches on center. Circumferential and longitudinal joints stapled with flare staples 6-inches on center and covered with 3-inch wide, foil reinforced tape.

3.03 FLEXIBLE ELASTOMERIC DUCT INSULATION

- A. Install insulation in conformance with manufacturer's recommendations and requirements.

3.04 JACKETING

- A. See General Installation Requirements above.
- B. Install in accordance with manufacturer's instructions.

3.05 ACCESSORIES

- A. Install insulation in conformance with manufacturer's instructions, recommendations and requirements.
- B. See General Installation Requirements above.
- C. Provide and install accessories for all insulation types listed in this Section.

3.06 DUCT INSULATION ACCESSORIES

- A. Install insulation in conformance with manufacturer's recommendations and requirements.

3.07 DUCT INSULATION COMPOUNDS

- A. Install insulation in conformance with manufacturer's recommendations and requirements.

END OF SECTION

SECTION 23 31 13
METAL DUCTS AND DUCT ACCESSORIES

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. The Contractor shall furnish and install all ductwork, fittings, and accessories as shown on the Drawings and in accordance with the Specifications.
- B. The equipment shall be furnished complete with all accessories, special tools, base attachments, mountings, anchor bolts and other appurtenances as specified or as may be required for a complete installation.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 23 00 00 – Basic HVAC Requirements
- B. Section 23 05 93 – HVAC Balancing
- C. Section 23 05 95 – HVAC Field Testing

1.03 SUBMITTALS

- A. The Contractor shall submit shop drawings on all new and modified ductwork, accessories and appurtenances and all fabrication work required for all equipment specified in this Section in accordance with Section 01 33 00 – Submittal Procedures.
- B. The Contractor shall submit shop drawings for supports for new and modified ductwork. The shop drawings shall locate and identify each support, brace, hanger, guide, component and anchor. Ductwork support systems shall be designed and Shop Drawings prepared and sealed by a Registered Professional Engineer in the State or Commonwealth in which the project is located. Include sealed calculations used to support the final support design.
- C. The Contractor shall submit shop drawings for support of multi-section dampers and louvers. The shop drawings shall identify all supports and reinforcement required to allow the multi-section dampers and louvers to be rated for the maximum pressure of the individual damper and louver sections. The support system shall be designed and calculations prepared and sealed by a Registered Professional Engineer in the State or Commonwealth in which the project is located.

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1.04 WARRANTY AND GUARANTEE

Warranty and Guarantee shall be as specified in Section 46 00 0 – Equipment General Provisions with the exception that the warranty period shall be for two (2) years.

PART 2 – PRODUCTS

2.01 GENERAL REQUIREMENTS

- A. All work shall be constructed and installed in a first-class workmanlike manner in accordance with the recommendations given in the latest edition of the Sheet Metal & Air Conditioning Contractors National Association (SMACNA) HVAC Duct Construction Standards and Round Industrial Duct Construction Standards, unless otherwise specified.
- B. All ductwork shall be constructed in accordance with the Schedule of Duct Construction Standards listed on the last page of this Section. Transverse duct connections shall be bolted, gasketed connections.
- C. All ducts shall conform accurately to the dimensions indicated on the Drawings, shall be straight and smooth on the inside with neatly finished joints, and shall not be decreased at any point to avoid obstructions. No piping, conduit or structural work shall be installed in or through any ductwork. All ductwork shall be run as close as possible to structural members, walls and ceilings. Duct work shall be as shown on the drawings, subject to such modifications as may be necessary to suit field conditions.
- D. Where existing walls, floors or roofs must be penetrated, the Contractor shall neatly cut the required openings and patch the existing work to provide a neat and finished appearance.
- E. All ducts shall be made reasonably tight throughout and shall have no openings other than those required for the proper operation and maintenance of the systems.
- F. Minimum thickness for metal ducts shall be per SMACNA guidelines, but in no instance shall be less than 20 gauge for steel ducts and 14 gauge for aluminum ducts.
- G. Supports for ducts shall be provided and securely fastened in place at every change in direction and as required to prevent deflection.
- H. Changes in size of ducts shall be by means of a taper transformation piece, the included angle of the taper being not more than 20 degrees.
- I. All duct work joints shall be sealed to achieve a SMACNA Seal Classification Rating as indicated in the ductwork schedule of this specification.

- J. The weight of material used for ducts and stiffeners, the fabrication methods, cross breaking or beading of flat duct surfaces, and assembling of the ductwork shall conform to the Duct Manual and Sheet Metal Construction for Ventilating and Air Conditioning Systems published by the Sheet Metal and Air Conditioning Contractors National Association, Inc.
- K. All duct panels shall be braced or reinforced as necessary, in addition to the minimum requirements in the ASHRAE Guide, to eliminate vibration and noise and to prevent deflection from the indicted shapes and dimensions.

2.02 GALVANIZED STEEL AND ALUMINUM DUCT

- A. Ductwork material shall be as indicated in the duct schedule in Part 3 of this specification.
- B. Galvanized Steel: ASTM A653/A653M, G90 galvanizing for all applicable ducts and of adequate strength and rigidity to meet the conditions of the service and installation requirements and shall be properly protected where subject to mechanical injury.
- C. Aluminum: ASTM B209, alloy 1100, 3003, or 5052 for all applicable ducts and of adequate strength and rigidity to meet the conditions of the service and installation requirements and shall be properly protected where subject to mechanical injury.
- D. Transverse duct connections for round ducts shall be bolted, gasketed connections in accordance with chapter 12 of SMACNA Round Industrial Duct Construction Standards. Duct connections shall be the same material as the duct. Utilize longitudinal seam ductwork. Gaskets shall be suitable for exposure to hydrogen sulfide 2 ppm and outdoor use.
- E. All ductwork shall be shop fabricated in sections with flanged ends. The Ductmate 35 flange system shall be factory spot welded to the ductwork. No field welding of ductwork shall be permitted. Welding equipment and electrodes shall be of a type specifically suited for welding light gauge galvanized steel to provide consistently good quality welds.
- F. All duct sections shall be constructed and installed without forming dips and traps.
- G. All ducts shall have a minimum clearance of three (3) inches from all combustible material.

2.03 HANGERS AND SUPPORTS

- A. All ductwork shall be securely hung and anchored to the building structure. Unless otherwise shown or specified, hangers and stiffeners for ducts shall conform with the recommendations given in the SMACNA HVAC Duct Construction standards and

SMACNA seismic restraint manual. Ducts shall be supported on trapeze hangers consisting of angles and rods. Use of strap hangers and straps is prohibited.

- B. All hangers, rods, supports, bolts, nuts, washers, inserts, and appurtenances shall be constructed of the same material as the ductwork that it supports.
- C. All ductwork shall be supported from trapeze type hangers. Stainless steel hanger rods shall be minimum 3/8 inch for all ducts with half perimeter up to 72 inches, and 1/2 inch diameter for all ducts with half perimeter larger than 72 inches. Aluminum hanger rods shall be of sufficient diameter to achieve the equivalent strength of the stainless steel hanger rods for the sizes indicated. A pair of rods shall be provided at each duct support point. Maximum hanger spacing shall be 8 feet for ducts with half perimeter up to 72 inches and 6 feet for ducts with half perimeter larger than 72 inches.
- D. Hanger Construction and installation shall conform to SMACNA Standards, except as specified. No sheet metal duct hangers or straps will be allowed.
- E. Support shall be furnished at each fitting. Material of supports shall match duct material.
- F. Seismic & Wind Requirements: All ductwork shall be provided with seismic and wind restraints in accordance with the Seismic Restraint Manual, Guidelines for Mechanical Systems, as published by SMACNA, in accordance with the State approved Building Code, the indicated design wind speed, and ASCE-7 to the extent that the most stringent provisions are utilized. Material of seismic and wind restraints shall be as specified herein. A calculation signed and sealed by a Registered Professional Engineer in the State or Commonwealth in which the project is located shall be provided verifying that the installed supports meet the seismic and wind requirements. See Structural Design Drawings for additional details and requirements.

2.04 ACCESSORIES

- A. Manual Volume & Backdraft Dampers in Rectangular Stainless Steel or Aluminum Duct:
 - 1. Manufacturer: Provide products of one of the following:
 - a. Greenheck
 - b. Ruskin
 - c. Nailor
 - d. or equal
 - 2. Frame, blade, axle, bearings, jamb seal, and linkage materials: Match ductwork.
 - 3. Blades:

- a. Opposed blades for volume dampers and parallel blades for backdraft dampers;
 - b. Vinyl edge seals, thermoplastic elastomer seals for corrosive/chemical services.
4. Damper shafts shall be solid hexagonal or square shape.
5. Linkage shall be concealed in damper frame.
6. Provide outside handle, quadrant and approved position indicator and locking device on volume dampers.
7. Reference: SMACNA Standards.

B. Backdraft Dampers in Round Stainless Steel or Aluminum Duct:

1. Manufacturer: Provide products of one of the following:
 - a. Ruskin
 - b. Greenheck
 - c. Nailor
 - d. Or equal
2. Frame, blade, axle, bearings: Match ductwork
3. Damper shall be of the two blade design mounted on separate axles and shall be suitable for horizontal or vertical installations
4. Blades shall be retained in the closed position by a tensioned spring. The spring shall be field adjustable
5. Seal shall be a vinyl foam

C. Steel Motorized Dampers:

1. Manufacturer: Provide products of one of the following:
 - a. Ruskin
 - b. Greenheck
 - c. or equal

2. Frame, blade, axle, bearings, jamb seal, and linkage materials: Galvanized steel
3. Blades:
 - a. Opposed blades (control) and Parallel blades (shut-off)
 - b. Vinyl edge seals, thermoplastic elastomer seals for corrosive/chemical services.
4. Damper shafts shall be solid hexagonal or square shape.
5. Actuators shall be externally mounted to the damper and shall be a minimum of NEMA 2. All actuators shall be enclosed in a NEMA 4X case unless otherwise specified. Actuators located in classified spaces shall be enclosed in a NEMA 7 case unless otherwise specified.
 - a. For actuator requirements, see the following:
 - 1) Section 23 09 00 – HVAC Automatic Temperature Controls (BMS Logic).
6. Damper leakage rate shall not exceed 3 cfm/sq. ft. at 1" w.g.
7. Reference: SMACNA Standards.

D. Aluminum Motorized Dampers:

1. Manufacturer: Provide products of one of the following:
 - a. Ruskin
 - b. Greenheck
 - c. Or equal
2. Frame, blade, axle, bearings, jamb seal, and linkage materials: 6063T5 Aluminum
3. Blades:
 - a. Opposed blades (modulating control) and Parallel blades (2 position shut-off)
 - b. Neoprene blade edge seals and flexible metal compressible jamb seals.
4. Damper shafts shall be solid hexagonal or square shape.
5. Actuators shall be externally mounted to the damper and shall be a minimum of NEMA 2. All actuators shall be enclosed in a NEMA 4X case unless otherwise

specified. Actuators located in classified spaces shall be enclosed in a NEMA 7 case unless otherwise specified.

6. Reference: SMACNA Standards.

E. Stationary Louvers:

1. Manufacturer: Provide products of one of the following:
 - a. Ruskin
 - b. Greenheck
 - c. Or equal
2. Frame, blade, and jamb seal materials: 6063T5 Aluminum or 316 Stainless Steel
3. Inside and outside of all aluminum parts shall be coated with a corrosion resistant coating. The coating shall be Kynar 500 or approved equal. Final color selection shall be provided by the Owner. The Contractor shall submit a full color chart for selection and approval.
4. Frame shall be a minimum 0.125 inches thick for aluminum and 18 gauge for stainless steel
5. Blades:
 - a. Drainable with minimum wall thickness of 0.081 inch for aluminum and 18 gauge for stainless steel
 - b. Blades shall be angled at 37 degrees
6. Drain gutters shall be in head frame and each blade
7. Downspouts in jambs shall drain water from louver
8. Provide bird screens in identical material to match louver. Screens shall be expanded and flattened type.

F. Filter Bank:

1. Manufacturer: Provide products of one of the following:
 - a. Flanders
 - b. or equal

2. Housing and internal rack materials shall match the associated ductwork material.
 3. Filter box shall have flanged duct connections.
 4. Filters bank shall be V-type arrangement with a minimum of two (2) 2" MERV 8 pleated filters.
 5. Filter bank shall have a differential pressure switch set to indicate when the filters are dirty. The contacts shall be located in a NEMA 12 rated enclosure in spaces that have unclassified area classifications. In areas that have area classifications, the contacts shall be in a NEMA 7 rated enclosure or the device shall be rated for installation in spaces that are classified as Class I, Div I or Div II.
- G. Sheet Metal Saffing: Provide sheet metal saffing of the same material as the duct, to close off and seal airtight all unused areas behind louvers.
- H. Screens: ½-inch (13 mm) mesh, with screen material matched duct material, framed with bolt holes unless indicated otherwise.
- I. Registers and Grilles:
1. Manufacturer: Provide product(s) of one of the following:
 - a. Titus (Basis of Design, model numbers scheduled on drawings)
 - b. Anemostat
 - c. Price Industries
 - d. Nailer Industries, Inc.
 - e. Hart and Cooley.
 2. Units shall be factory-fabricated of Type 316 stainless steel construction for stainless steel and FRP ductwork and aluminum for aluminum ductwork. They shall distribute the specified air volume (cubic feet per minute).
 3. Outlets for diffusion, spread, throw, and noise level shall be as required for specified performance.
 4. Diffusers and registers shall be provided with volume damper with accessible operator, unless otherwise indicated; or if standard with the manufacturer, an automatically controlled device will be acceptable. Volume dampers shall be opposed blade type for all diffusers and registers.
 5. Registers shall be provided with sponge-rubber gasket between flanges and wall or ceiling.

6. An additional volume damper shall be installed in duct stub to each air outlet for balancing of air volume.
7. Supply Registers:
 - a. Supply registers shall be double deflection type, complete with adjustable vertical face bars and a key operated opposed blade damper.
8. Exhaust and Return Registers and Grilles:
 - a. Exhaust and return registers shall be furnished with fixed vertical face bars, set straight, and a key operated opposed blade damper.
- J. Duct-Mounted Access Doors and Panels:
 1. Provide access doors at all duct connections dampers for access and maintenance of damper motor actuators and linkages.
 2. Fabricate doors and panels airtight and suitable for duct pressure class.
 3. Seal around frame attachment to duct and door to frame with neoprene.
 4. Door and frame to be of same material as duct.
- K. Flexible Connectors unless indicated otherwise shall meet the following requirements:
 1. Self-extinguishing material shall meet NFPA 90A, NFPA 701 and UL-214 Standards.
 2. Material:
 - a. Commercial grade neoprene coated woven fiberglass, Proflex by DUCTMATE, or approved equal.
 - b. Corrosion/chemical resistant applications shall be of Teflon coated woven fiberglass fabric. Minimum density 18 oz./sq. yd. and rated to 500 F.
 3. Extra wide edge connectors factory fabricated with a strip of fabric. Material of connectors shall match duct material.
- L. Instrument Test Holes: Material to suit duct material, including screw. Size holes to allow insertion of pitot and other testing instruments, and length to suit duct insulation thickness.
- M. Turning Vanes:

1. Turning vanes shall be double wall turning vanes fabricated from the same material as the duct. Mounting rails shall have friction insert tabs that align the vanes automatically.
2. Tab spacing shall be as specified in Figure 2-3 of the 1995 SMACNA Manual, "HVAC Duct Construction Standards, Metal & Flexible" Second Edition standard. Rail systems with non-standard tab spacing shall not be accepted.
3. Due to tensile loading, vanes shall be capable of supporting 250 pounds when secured according to the manufacturer's instructions.

N. Drip Pans

1. Drip pans shall be welded 16 gauge, type 316 Stainless Steel.
2. Drip pans shall extend 2" beyond the dimensions of the equipment of ductwork above on all sides.
3. Drip pan shall have a minimum 1" lip.
4. Drip pan shall be sloped to a ¾" copper type L drain line such that pooling or standing water is prevented. The drain shall be continuously sloped a minimum of 1/8" per foot. The drain shall terminate 6" above the sink or nearest floor drain.
5. Provide a dielectric coupling between the stainless steel drip pan and copper drain line to prevent contact between dissimilar metals.
6. Contractor shall coordinate drip pan supports with the existing structural construction above. The Contractor shall provide all supplemental beams and channels needed. The support system shall be capable of supporting the weight of a full drip pan plus an additional 300 lb. load.
7. See Section 23 05 93 – Testing, Adjusting, and Balancing for HVAC for drip pan testing procedures.

2.05 DUCT INSULATION

1. See specification 23 07 00 – HVAC Insulation.

PART 3 – EXECUTION

3.01 DELIVERY, STORAGE, AND HANDLING

- A. Protect shop-fabricated and factory-fabricated ductwork, accessories and purchased products from damage during shipping, storage and handling.

- B. Prevent end damage and prevent dirt and moisture from entering ducts and fittings. Where possible, store ductwork inside and protect from weather. If necessary to store outside, store above grade and enclose with waterproof wrapping.

3.02 INSTALLATION OF DUCTWORK

- A. Examine areas and conditions under which ductwork is to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in a manner acceptable to Installer.
- B. Assemble and install ductwork in accordance with recognized industry practices, Manufacturer's installation instructions, and SMACNA standards to achieve the seal and leakage classes indicated in the Duct Construction Table at the end of this specification.
- C. Install each run with minimum number of joints. Align ductwork accurately at connections, within 1/8" misalignment tolerance and with internal surfaces smooth.
- D. Support ducts rigidly with suitable ties, braces, hangers and anchors of type which will hold ducts true-to-shape and to prevent buckling. Support vertical ducts at every floor.
- E. Field Fabrication: Complete fabrication of work at project as necessary to match shop-fabricated work and accommodate installation requirements.
- F. Locate ductwork runs, except as otherwise indicated, vertically and horizontally and avoid diagonal runs wherever possible. Locate runs as indicated by diagrams, details and notations or, if not otherwise indicated, run ductwork in shortest route which does not obstruct useable space or block access for servicing building and its equipment.
- G. Hold ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building. Limit clearance to 3" where furring is shown for enclosure or concealment of ducts, but allow for insulation thickness, if any. Where possible, locate insulated ductwork for 1" clearance outside of insulation. Wherever possible in finished and occupied spaces, conceal ductwork from view, by locating in mechanical shafts, hollow wall construction or above suspended ceilings.
- H. Do not encase horizontal runs in solid partitions, except as specifically shown. Coordinate layout with suspended ceiling and lighting layouts and similar finished work.
- I. Turning vanes shall be installed in all miter elbows to permit air to make the abrupt turns with a minimum of turbulence. The turning vanes shall be quiet and free from vibration when the system is in operation. Vanes shall be installed in all short radius elbows in accordance with SMACNA Duct Construction standards.
- J. The dial regulators for manual volume dampers shall be marked so that the "open" and "shut" positions are clearly identified. The dial regulators on insulated ductwork shall be mounted on an elevated platform which will finish flush with the surface of the insulation.

Manual volume dampers shall be located at accessible points and wherever possible some distance from a duct transition or fitting. Care shall be taken during installation to make certain that sheet metal fasteners do not protrude into the duct and interfere with damper operation. Volume dampers shall be provided in each branch duct take off and in both ducts downstream of each trunk duct split.

- K. Duct access doors shall be provided before and after duct mounted coils, within working distance of, and on the fusible link side of all fire dampers, adjacent to volume dampers, on the linkage side of automatic dampers, duct mounted sensors, and at all other apparatus requiring service or inspection in the duct system. Access doors shall be a minimum of 15 x 18 inches; where the size of the duct will not accommodate this size the doors shall be made as large as practical. The doors shall be rigid and airtight, and provided with neoprene gaskets, hinges and sash locks. Whenever space requirements are such that a hinged access door is impractical, a screw fastened lift-out door shall be provided instead.
- L. Test openings shall be installed in the ductwork at the points listed below. The test openings shall be a minimum of 3/8" and shall be sealed by a screw cap and gasket, and shall be installed so that the insulation is not disturbed when the cap is removed. The test openings shall be located as follows in all heating, ventilating, air conditioning, and dehumidification systems:
 - 1. Upstream and downstream of each coil, duct heater, filter bank, or other inline equipment that heats, cools, humidifies, dehumidifies, or filters air.
 - 2. In the outside air, supply, and return ducts adjacent to the respective connections on all AHUs, HVs, DHUs, etc.
 - 3. In the main supply duct on single zone units and in each zone supply duct on multizone units
 - 4. As indicated on the Contract Drawings
- M. Air filter gauges for measuring the differential pressure through all filter banks shall be supplied and installed; one gauge shall be installed for each bank. The gauge shall be of the inclined tube differential type complete with 1" thick acrylic plastic body, mirror-polished scale, built-in level vial, over pressure safety traps, signal flags, 2 vent valves for zeroing gauge, 2 static pressure tips, two 5-foot lengths of 1/4" stainless steel tubing, 2 compression fittings, mounting hardware, a bottle of red gauge oil and instructions. The gauges shall have a range of 0-1.0 inch water column with minor divisions of .02 inch water column.
- N. The Contractor shall install prefabricated roof curbs before the installation of roofing.
- O. All air outlets shall be with rigid connection to the ductwork.

- P. After the installation is completed, the Contractor shall seal all joints air tight. Sealants and tape shall have a flame spread not greater than 25 and a smoke developed rating of not over 50 per ASTM E-84.

3.03 DUCT LEAKAGE TESTS

- A. Where indicated to be required, all openings in the ductwork shall be temporarily sealed and the ductwork shall be pressurized and leak tested to demonstrate that the installation meets the specified SMACNA leakage class requirements. The Contractor shall follow SMACNA procedures for testing as outlined in SMACNA's HVAC Air Duct Leakage Test Manual.

3.04 INSULATION INSTALLATION

- A. Insulation shall be installed on all outdoor ductwork carrying conditioned air, all ductwork carrying conditioned air through unconditioned spaces, and all ductwork carrying unconditioned air through conditioned spaces. Conditioned air is any air that has received any heating, cooling, or dehumidification from HVAC equipment. Conditioned spaces are any spaces that receive conditioned air. Return and exhaust ductwork serving a conditioned space is considered conditioned air.
- B. Ductwork carrying cooled conditioned air passing through spaces that only receive heated conditioned air shall be insulated. Ductwork carrying cooled air for spaces that require year-round cooling such as electrical rooms, shall be insulated when passing through spaces that are provided heated conditioned air during the heating season.
- C. Follow manufacturer's installation instructions and recommended adhesives. The installation method shall provide a continuous vapor barrier.
- D. The insulation vapor barrier shall be maintained through all supports, flanges, reinforcement, and penetrations. Where the duct weight would deform the insulation material at supports, the Contractor shall use fiberglass insulation blocks. The blocks shall be the same thickness as the insulation. The vapor barrier shall be maintained using a system approved by the insulation manufacturer for spanning the insulation block.

3.05 DAMPER AND LOUVER INSTALLATION

- A. The Contractor shall install dampers and louvers per the manufacturer's installation instructions.
- B. The Contractor shall install all reinforcement required for multi-section dampers and louvers to all the assembly to withstand the rated velocity and pressure of the individual damper and louver sections.

3.06 EQUIPMENT CONNECTIONS

- A. Connect metal ductwork to equipment as indicated, provide flexible connection for each ductwork connection to equipment mounted on vibration isolators, and/or equipment containing rotating machinery. Provide access doors as indicated in the Contract Drawings and Specifications.

3.07 ADJUSTING AND CLEANING

- A. Clean ductwork internally, unit by unit as it is installed, of dust and debris. Clean external surfaces of foreign substances which might cause corrosive deterioration of metal or, where ductwork is to be painted, might interfere with painting or cause paint deterioration.
- B. At ends of ducts which are not connected to equipment or air distribution devices at time of ductwork installation, provide temporary closure of polyethylene film or other covering which will prevent entrance of dust and debris until time connections are to be completed.

3.08 MANUFACTURER'S FIELD SERVICES

- A. The services of a qualified manufacturer's Technical Representative shall be provided. The manufacturer Technical Representative's services shall include the following site visits:

Duct Construction Schedule

Service	Pressure Class	Duct Material	Seal Class	Leakage Class	Construction Standards
Electrical Rooms	+/- 2 inwg.	G90 Galvanized Steel	A	6	SMACNA HVAC Duct Construction Standards
Process Areas	+/- 2 inwg.	Aluminum	A	6	SMACNA HVAC Duct Construction Standards

END OF SECTION

SECTION 23 34 00

HVAC FANS

PART 1 – GENERAL

1.01 GENERAL REQUIREMENTS

- A. All parts of the equipment furnished shall be amply designed and constructed for the maximum stresses occurring during fabrication, erection and continuous operation. All materials shall be new and both workmanship and materials shall be of the very best quality, entirely suitable for the service to which the unit is to be subjected and shall conform to all applicable sections of these specifications. All parts of duplicate equipment shall be interchangeable without modification. Manufacturer's design shall accommodate all the requirements of these specifications.
- B. All anchor bolts, washers, clips, clamps and fasteners of any type shall be constructed of 316 stainless steel.
- C. All fan motors shall be provided with high premium energy efficient totally enclosed fan cooled type, unless otherwise noted.
- D. Provide exhaust fans which have been tested and rated in accordance with AMCA standard, and bear AMCA Certified Ratings Seal.
- E. Provide motors and electrical accessories complying with NEMA standards.
- F. Fans shall be standard prefabricated units of the type, size and arrangement indicated on the Drawings. All fans shall be rated and constructed in accordance with the Air Moving and Conditioning Association. Special construction materials, coatings and multi-speed fan motors shall be provided as indicated on the Drawings.
- G. Impellers shall be rigidly constructed, accurately balanced dynamically and statically at the speed at which it is scheduled to operate and free from objectionable vibration or noise. Fans with corrosion resistant coatings shall be balanced after being coated.
- H. Fans shall have no overloading characteristics for the horsepower indicated. All points on the fan brake horsepower curve shall not exceed the motor horsepower rating
- I. Fan shall have a Fan Energy Index equal to or greater than 1.0 as determined by AMCA 207.
- J. V-belt drives shall be rated at least 50 percent greater than the rated motor horsepower, and shall have sheaves which can vary the fan speed by 10 percent above or below the rating point. The fan motor shall be mounted on an adjustable heavy mounting plate.

- K. The operating fan speed shall be no greater than 85% of the maximum allowable fan speed for the selected model.
- L. For belt driven fans, airflow rate shall match what is listed in the fan schedule. For direct-drive fans, airflow rate shall be within +10% of the airflow rate listed in the fan schedule.
- M. Unless otherwise noted on the Fan Schedule fans shall be manufactured to meet the balance quality and vibration limits of Fan Application Category BV-3 per AMCA Standard 204.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 23 00 00 – Basic HVAC Requirements
- B. Section 23 31 13 – Metal Ducts and Duct Accessories
- C. Section 23 05 93 – HVAC Balancing
- D. Section 23 05 95 – HVAC Field Testing

1.03 SUBMITTALS

- A. The Contractor shall submit shop drawings on all equipment, accessories and appurtenances and all fabrication work required for all equipment specified in this Section in accordance with Section 01 33 00 – Submittal Procedures.
- B. The Contractor shall submit shop drawings for fan supports, locating and identifying each support, brace, hanger, guide, component and anchor. Fan support systems shall be designed and Shop Drawings prepared and sealed by a Registered Professional Engineer of the State or Commonwealth in which the project is located.
- C. Required information shall include:
 - 1. Horsepower, voltage, and rotating speed of motors.
 - 2. Total weight of the equipment plus the approximate weight of the shipped materials.
 - 3. Complete erection, installation, and adjustment instructions and recommendations.
 - 4. Fan performance curve at the operating speed, minimum, and maximum speeds. Provide brake horsepower curve for the operating speed.
 - 5. Details of corrosion resistance coating.

6. Detailed construction information and data sheets for all accessories such as roof curbs, dampers, damper operators disconnect switches, vibration isolators etc.
 7. Example equipment nameplate data sheet.
 8. Interconnecting wiring diagrams.
 9. List of recommended lubricants.
 10. Special Tools List
 11. Reports of Certified Shop Tests
 12. AMCA Approval for Fan Ratings
 13. Sound data
 14. Manufacturer's Installation Certification
 15. Manufacturer's Field Test Results Certification
- D. The Contractor shall submit to the Owner a color chart of available colors for the corrosion coating to be applied to fans as indicated in the Contract Documents. The Owner shall select the final color choice.

1.04 OPERATION AND MAINTENANCE MANUALS

- A. The Contractor shall submit complete operation and maintenance manuals in accordance with the procedures and requirements set forth in Section 01 33 00 – Submittal Procedures.

1.05 MANUFACTURERS

- A. The materials covered by these specifications are intended to be equipment of proven reliability and as manufactured by reputable manufacturers having experience in the production of such equipment. The equipment furnished shall be designed, constructed, and installed in accordance with the best practices and methods and shall operate satisfactorily when installed as shown on the Contract Drawings and operated per manufacturer's recommendations.

1.06 CONTRACTOR'S RESPONSIBILITY AND MANUFACTURER'S FIELD SERVICES

- A. The services of a qualified manufacturer's Technical Representative shall be provided. The manufacturer Technical Representative's services shall include the following site visits:

Service	Total Days	No. of Trips	Remarks
Installation Checkout	1	1	In accordance with Section 23 34 00 – HVAC Fans
Startup and Testing	1	1	In accordance with Section 23 05 93 – Testing, Adjusting and Balancing and Section 23 08 00 – Commissioning of HVAC System
Training	1	1	In accordance with Section 07 79 00 – Instruction of Owner's Personnel

- B. A written report covering the representative's findings and installation approval shall be mailed directly to the Engineer covering all inspection and outlining in detail any deficiencies noted.
- C. The times specified are exclusive of travel time to and from the facility and shall not be construed as to relieve the manufacturer of any additional visits to provide sufficient service to place the equipment in satisfactory operation.

1.07 SPECIAL TOOLS

- A. Furnish all special tools necessary to disassemble, service, repair and adjust the equipment.

PART 2 – PRODUCT

2.01 ROOF MOUNTED UPBLAST CENTRIFUGAL EXHAUST FANS

- A. Centrifugal fans shall be backwardly inclined, non-overloading blades of aluminum construction. Wheel inlets shall overlap an aerodynamic aluminum inlet cone.
- B. Wheel shall be balanced in accordance with AMCA Standard 204-05.
- C. Provide exhaust fans which are listed by UL and have UL label affixed, and which are designed, manufactured, and tested in accordance with UL 705 "Power Ventilators".
- D. Fans shall be V-belt or direct driven as indicated on the drawings or as contained herein.
- E. The aluminum base shall have a one-piece inlet spinning and continuously welded curb cap corners.
- F. The two-piece top cap shall have stainless steel quick release latches to provide access to the motor compartment without the use of tools.
- G. Fans shall have internal terminal box mounted on the exterior for ready wiring.
- H. The motor shall be separated from the exhaust air stream.

- I. Bearings shall be heavy duty regreasable ball type in a cast iron pillow block housing selected for a minimum L50 life in excess of 200,000 hours at maximum catalogued operating speed.
- J. Belts shall be oil and heat resistant, static conducting.
- K. Drives shall be keyed and securely attached to the wheel and motor shafts.
- L. All drives shall be variable pitched type and shall be sized for 150 percent of the installed motor horsepower.
- M. Centrifugal fans shall be as manufactured by Loren Cook Co., Greenheck Fan Corp, or approved equal.
- N. See Paragraph 2.04 of this specification for additional requirements.

2.02 ROOF MOUNTED CENTRIFUGAL FANS

- A. Centrifugal fans shall be airfoil, non-overloading blades of aluminum construction continuously welded. Wheel inlets shall overlap an aerodynamic aluminum inlet cone.
- B. Wheel shall be balanced in accordance with AMCA Standard 204-05.
- C. Provide supply fans which are listed by UL and have UL label affixed, and which are designed, manufactured, and tested in accordance with UL 705 "Power Ventilators".
- D. Fans shall be V-belt or direct driven as indicated on the Contract Drawings or as contained herein.
- E. The fan shall utilize all aluminum construction.
- F. The aluminum base shall have continuously welded curb cap corners.
- G. Fans shall have adjustable motor mounting plate with threaded studs for positive belt tensioning.
- H. Fans shall have internal terminal box mounted on the exterior for ready wiring.
- I. The motor shall be separated from the exhaust air stream.
- J. Bearings shall be heavy duty regreasable ball type in a cast iron pillow block housing selected for a minimum L50 life in excess of 200,000 hours at maximum catalogued operating speed.
- K. Belts shall be oil and heat resistant, static conducting.
- L. Drives shall be keyed and securely attached to the wheel and motor shafts.

- M. All drives shall be variable pitched type and shall be sized for 150 percent of the installed motor horsepower.
- N. Centrifugal fans shall be as manufactured by Loren Cook Co., Greenheck Fan Corp, PennBarry, Hartzell, or approved equal.
- O. See Paragraph 2.04 of this specification for additional requirements.

2.03 ROOF MOUNTED AXIAL SUPPLY FANS.

- A. Propeller shall be aluminum construction with swept, steeply pitched blade design.
- B. Wheel shall be balanced in accordance with AMCA Standard 204-05.
- C. Provide fans which are listed by UL and have UL label affixed, and which are designed, manufactured, and tested in accordance with UL 705 "Power Ventilators".
- D. Fans shall be V-belt or direct driven as indicated on the drawings or as contained herein.
- E. The aluminum base shall have a one-piece inlet spinning and continuously welded curb cap corners.
- F. The two-piece top cap shall have stainless steel quick release latches to provide access to the motor compartment without the use of tools.
- G. Fans shall have internal terminal box mounted on the exterior for ready wiring.
- H. The motor shall be separated from the exhaust air stream.
- I. Bearings shall be heavy duty regreasable ball type in a cast iron pillow block housing selected for a minimum L50 life in excess of 200,000 hours at maximum catalogued operating speed.
- J. Belts shall be oil and heat resistant, static conducting.
- K. Drives shall be keyed and securely attached to the wheel and motor shafts.
- L. All drives shall be variable pitched type and shall be sized for 150 percent of the installed motor horsepower.
- M. Fans shall be as manufactured by Greenheck Fan Corp., Loren Cook Co., Twin City, or approved equal.
- N. See Paragraph 2.04 of this specification for additional requirements.

2.04 ADDITIONAL REQUIREMENTS FOR ALL FANS

- A. The following additional requirements shall apply to all fans.
1. Backdraft or motor-operated dampers shall be provided and installed in the openings as indicated on the Contract Drawings.
 2. All fans shall be provided with either integral or supplementary spring vibration or sound-absorbing mountings.
 3. Where indicated, roof mounted exhaust fans shall be mounted on a prefabricated roof curb.
 4. All motors unless indicated otherwise in this Specification or the Contract Drawings shall be TEFC. The break horsepower at any point on the fan curve for the design speed shall not exceed the motor nameplate horsepower. The break horse power shall include all applicable belt drive losses. Using the motor service factor shall be prohibited.
 5. All equipment shall be seismically secured and restrained in accordance with the Seismic Restraint Manual, Guidelines for Mechanical Systems, latest edition, as published by the Sheet Metal and Air Conditioning Contractors National Association, Inc. (SMACNA) and designed in accordance with the seismic provisions of ASCE-7 and the current Building Code of the State or Commonwealth in which the project is located to the extent that the most stringent provisions are utilized in developing the design seismic forces.
 6. All non-fiberglass fans shall receive a corrosion resistant coating. The coating shall be an epoxy coating suitable for protecting the equipment from continuous exposure to air containing hydrogen sulfide 3ppm. The fans in the Supplemental Carbon Facility shall be suitable for exposure to methanol in addition to hydrogen sulfide. The coating shall be applied to all surfaces of the fans including but not limited to fan wheels, propellers, hubs, structural components, housings (interior and exterior), inlet boxes, dampers, screens, lube lines, curb boxes, and curb box adapters. A UV resistant top coat shall be applied to all coating systems that are not rated for UV exposure. The Contractor shall submit and coordinate the available color choices to the Owner for final color selection.
 7. Where indicated in the design documents, fans shall exceed the uncertainty requirements of AMCA standard 203 and shall perform within +/- 3% of the flowrate with respect to the static pressure of the fan curve.
 8. Motors with VFDs shall not be selected to operate above the rated motor speed.

2.05 DAMPERS

- A. See the respective paragraphs in Section 23 31 13 – Metal Ducts and Duct Accessories for construction requirements.
- B. Dampers shall be coordinated to operate and interface with the fan being furnished.
- C. Dampers shall be sized to fit the specified openings.

2.06 PREFABRICATED ROOF AND WALL CURBS

- A. Prefabricated roof and wall curbs shall be installed where indicated on the Drawings or as specified herein. The curbs shall be fabricated of .064 inch sheet aluminum with all joints heliarc welded. Cants and roof flanges shall be an integral part of the curb. The inside of the curb shall be insulated with rigid glass-fiber thermal and acoustical liner of approximately 3-lb. density and 1-1/2 inch minimum thickness with a neoprene or equal coating for protection from erosion. The lining shall conform to NFPA 90A Standards with a flame spread and fuel contributed rating not exceeding 50. Pressure-treated wood nailers shall be provided at the tops of the curbs. The curbs shall be sized to suit equipment. Roof curbs shall be a nominal of 12-inches above the height of the roof unless indicated otherwise on the Contract Drawings. The roof curbs shall receive an epoxy corrosion resistant coating on the interior and exterior surfaces that is suitable for the conditions indicated in the Additional Requirements for All Fans section above.

PART 3 – EXECUTION

3.01 INSTALLATION

- A. Contractor shall install fans in accordance with manufacturer's installation instructions and recognized industry practices to ensure that ventilators serve their intended function.
- B. Contractor shall coordinate fan work with work of walls, and ceilings, as necessary for proper interfacing.
- C. Connect ducts to fans in accordance with manufacturer's installation instructions.
- D. The Contractor shall have the Manufacturer's Technical Representative provide in writing that the equipment is installed per the manufacturer's requirements and operates as required by the Contract. The Contractor shall submit the written confirmation to the Engineer for information only.

3.02 FIELD QUALITY CONTROL

- A. Testing: After installation of fans has been completed, test each fan to demonstrate proper operation of units at performance requirements as specified. When possible, field

correct malfunctioning units, then retest to demonstrate compliance. Replace units which cannot be satisfactorily corrected. See Section 23 05 93 – Testing, Adjusting and Balancing for HVAC for testing requirements.

- B. Cleaning: Clean factory-finished surfaces. Repair any marred or scratched coatings with a coating specified by the equipment manufacturer for repairs.

END OF SECTION

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SECTION 23 81 24
PACKAGED AIR CONDITIONERS

PART 1 – GENERAL

1.01 SUMMARY

- A. These specifications describe requirements for an environmental control system. The system shall be designed to maintain temperature and humidity conditions in the rooms containing electronic equipment. The manufacturer shall design and furnish all equipment to be fully compatible with heat dissipation requirements of the room.
- B. The equipment shall include the following items plus whatever concrete housekeeping pads, anchor bolts, etc. that are required to mount the indoor and outdoor units and appurtenances, as required for a complete operational system and as shown on the Contract Drawings. Contractor shall provide all concrete pads shown on the HVAC drawings, unless provided as part of the General Contractors work on multiple prime contracts.
- C. All necessary accessory equipment and appurtenances shall be provided for a complete and operating system whether or not specifically stated in the Specifications. This installation shall incorporate the highest standards for the type of service shown on the Drawings included field testing of the entire installation and instruction of the regular operating personnel in the care, operation, and maintenance of all equipment.
- D. The equipment shall be furnished complete with all accessories, special tools, spare parts, extra set of filters, and other appurtenances as specified or as may be required for a satisfactory installation.
- E. The entire packaged system of indoor unit and outdoor condenser shall be provided by one manufacturer with sole responsibility for the satisfactory manufacture, factory testing, installation supervision, and performance of the systems.
- F. The unit shall be provided with a SCOP rating per ASHRAE 127.
- G. The unit shall be UL listed and meet or exceed ASHRAE 90.1 efficiency requirements.
- H. Work Included Under Other Sections:
 - 1. 480V, 3-phase power wiring and conduit under Division 26 – Electrical.
 - 2. Motor starters under Division 26 – Electrical, unless factory mounted and wired by equipment manufacturer.

1.02 DELIVERY, STORAGE AND HANDLING

- A. Deliver, store, protect and handle products to the Project Site under the provisions of Division 01.
- B. Accept products on site in factory-fabricated protective containers, with factory-installed shipping skids and lifting lugs. Inspect for damage.
- C. Store in clean dry place and protect from weather and construction traffic. Handle carefully to avoid damage to components, enclosures and finish.
- D. Protect openings in casing and seal them with plastic wrap to keep dirt and debris. Protect coils from entry of dirt and debris with pipe caps or plugs.

1.03 SPARE PARTS

- A. Provide one additional set of specified fan belts, sheaves, thermostat, and filters for each unit, packaged for storage. Tag products to identify associated unit.

1.04 SCHEDULES ON DRAWINGS

- A. In general, all capacities of equipment and motor and starter characteristics are shown in schedules on the Drawings. Reference shall be made to the schedules for such information. The capacities shown are minimum capacities. Variations in capacities of the scheduled equipment supplied under this Contract will be permitted only with the written direction of the Engineer.
- B. Motors and wheel diameters shown on the schedules are the minimum. If a larger wheel diameter or horsepower is required, it shall be so quoted and noted.

1.05 MANUFACTURER'S INSTRUCTIONS

- A. Installation of all equipment shall be in accordance with manufacturer's data.
- B. All changes from the installation procedures in manufacturers' data shall be submitted for approval in accordance with the requirements for shop drawings.
- C. Keep all manufacturers' data provided in a secure manner at the job site at all times. Catalog and index this data for convenient reference.
- D. Manufacturers' data shall be available for the information of the Owner, Engineer, and the use of other trades.
- E. Turn over all data to the Owner through the Owner's representative at completion of the Work and final testing.
- F. Submit all instruction books and manuals in accordance with Division 01.

1.06 CODES, PERMITS AND STANDARDS

- A. The Contractor shall obtain and pay for all permits (unless specifically excluded under Division 01 requirements) and shall comply with all laws and codes that apply to the Work.
- B. The Contractor shall be responsible for all added expense due to his choice of equipment, materials or construction methods.
- C. All work and materials shall be in full accordance with the latest State/Commonwealth rules and regulations or publications including those of the State/Commonwealth Fire Marshall, the International Mechanical and Energy Codes, and all local codes. Nothing in the Plans and/or Specifications shall be construed to permit work not conforming to the above codes, rules and regulations.
- D. All equipment, materials and installations shall conform to the requirements of the most recent edition with latest revisions, supplements and amendments of the following, as applicable:
 - 1. Air Conditioning and Refrigeration Institute (ARI)
 - 2. Air Moving and Conditioning Association (AMCA)
 - 3. American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc. (ASHRAE)
 - 4. American National Standards Institute (ANSI)
 - 5. American Society for Testing and Materials (ASTM)
 - 6. National Electric Code (NEC)
 - 7. NFPA 90A - Air Conditioning and Ventilation Systems 2019 edition
 - 8. International Mechanical Code Current edition in force.
 - 9. State/Commonwealth and local codes, ordinances and statutes
 - 10. Underwriters Laboratories (UL)

1.07 SUBMITTALS

- A. The Contractor shall submit shop drawings and other information in accordance with the requirements of Section 01 33 00 – Submittal Procedures and Section 01 77 19 – Closeout Requirements.

1. Equipment specifications and data sheets identifying all materials used and methods of fabrication.
2. Rated performance and capacities of coils, fans, and motors.
3. Complete assembly, layout required clearances, installation and foundation drawings with clearly marked dimensions.
4. Include all specification technical exceptions in the submittal. The manufacturer agrees that the equipment is in compliance with Specification Sections that are not identified in the list of technical exceptions.
5. Refrigerant piping diagrams.
6. Interconnecting wiring diagram.
7. Motor nameplate data as specified in Section 26 05 60 – Low-Voltage Electric Motors.
8. Example equipment nameplate data sheet.
9. Spare parts list.
10. Reports of certified shop tests.

1.08 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this Section with minimum of five years of documented experience, who issues complete catalog data on total product.
- B. The Manufacturer of the equipment shall provide documentation supporting compliance with ISO-9000:2000 (Model for Quality Assurance in Design/Development, Production, Installation and Servicing). Product literature provided by the manufacturer shall contain the ISO-9000:2000 Certification Mark from the applicable registrar.
- C. All material and equipment shall be the latest design, new, not deteriorated, and the first quality standard product of manufacturers regularly engaged in the production of such material and equipment.
- D. When two or more units of the same class of material or equipment are required, they shall be products of a single manufacturer.
- E. All work shall be performed in a neat and workmanlike manner by workers skilled in their respective trades, and all materials and equipment shall be installed as recommended by the manufacturers and in accordance with specified codes and standards.

- F. Touch up and/or repaint to match original factory coatings/finishes for all coated, finished or painted equipment and materials which are scratched or marred during shipment or installation.
- G. Factory Authorized Start-Up Services: The Contractor shall provide the services of a qualified manufacturer's technical representative who shall adequately supervise the installation and field testing of all equipment furnished under this Contract and instruct the Contractor's personnel and the Owner's operating personnel in its maintenance and operation as outlined in Division 01.

PART 2 – PRODUCTS

2.01 PACKAGED ROOFTOP AIR CONDITIONING UNITS

- A. Subject to compliance with requirements, provide precision control air conditioning unit(s) manufactured by one of the following:
- B. Trane (Basis of Design).
- C. Carrier
- D. AAON
- E. Or approved equal
- F. Manufacturers that take any exceptions to the protective coil coating systems specified herein will not be approved for acceptance on this project.

2.02 PACKAGED UNITS

- A. The packaged cooling unit is completely self-contained. All components are enclosed in the weatherproof cabinet. The unit does not use any of the valuable floor space inside the secure space. Instead, it is mounted on the outside wall. No additional space is required outside or on a roof. The unit shall be assembled, wired, piped, charged with R-458B refrigerant and fully factory-tested as a system. The system shall have the following built-in components:
- B. Cabinet and Frame Construction: The exterior cabinet is constructed of powder coated steel panels. Internal structural parts (including base) are hot dipped galvanized steel. The evaporator compartment is insulated with 1/2-in. (13mm) thick, 2 lb. (0.9kg) density, neoprene faced, fiberglass insulation. The system shall be designed for 105 degrees F ambient. All coils shall be coated with the manufacturer's coastal protective coating.

- C. Scroll Compressor: The compressor shall be scroll-type. The compressor shall feature a suction gas cooled motor, an internal centrifugal oil pump, vibration isolating mountings and internal thermal overloads.
- D. The refrigeration circuit includes a liquid line filter drier, an externally equalized expansion valve and a high-pressure switch.
- E. The evaporator coil shall be constructed of mechanically expanded copper tubes in enhanced surface aluminum fins. A stainless steel condensate drain pan shall be provided.
- F. The air-cooled condenser coil is constructed of mechanically expanded copper tubes in enhanced surface aluminum fins. Components are rated for up to 130°F ambient. Provide Manufacturer's coastal protective coating.
- G. Evaporator air is supplied by a direct drive blower package. Fans are centrifugal, double width, double inlet.
- H. Unit shall have economizer option with enthalpy sensors to compare outdoor ambient temperature and humidity and indoor cooling setpoint. When conditions allow the unit shall modulate the economizer damper to use outside air as supply air.
- I. Unit shall have dehumidification mode to maintain space humidity. Unit shall utilize hot gas reheat, no new energy shall be used to reheat the supply air.
- J. Filter shall be 2-inch deep, pleated, with a minimum efficiency rating of MERV 8 per ASHRAE Standard 52.2 (20% efficient per ASHRAE 52.1). Located within the cabinet, the filter is serviceable from the front of the unit.
- K. Provide a Low Pressure Switch, a Low Pressure Bypass and a Fan Cycle Control.
- L. Condenser Fan Cycling Control: Consists of a reverse acting pressure switch. During low outdoor temperatures, the pressure switch cycles the condenser fan to maintain discharge pressures that will allow the system to function. Allows unit operation down to -20°F (Low ambient Operation).
- M. Provide a lockout relay for the detection of a high-pressure condition in the refrigeration circuit to prohibit operation of the compressor until the abnormal pressure conditions is acknowledged. The lockout relay is reset by cycling the unit main power or by changing the set point on the thermostat to temporarily eliminate a call for cooling.
- N. Common Alarm: A common alarm accessory shall include the necessary components to detect high pressure, low pressure, high temperature or loss of indoor air flow, to provide a customer signal via a contact closure. Dry contacts shall be provided for remote alarm/unit lockout notification.

- O. Indoor supply and return grills: The supply grill shall be aluminum louvered, double deflection type grill allowing user adjustment of direction of air distribution. The return grill is an aluminum louvered, fixed, single deflection style grill.

2.03 THERMOSTAT

- A. Provide manufacturer matching seven day programmable wall thermostat capable of controlling the cooling and heating stage(s) with automatic changeover, dehumidification, and economizer functions, as applicable.

2.04 REFRIGERANT ACCESSORIES

- A. The Contractor shall supply and install expansion valve, sight glass, shut-off valves, hot gas bypass regulator valve, solenoid valves, strainers, drier and any other refrigerant system accessories required for a complete installation.

2.05 SCHEDULE

- A. All air conditioning units shall be furnished by one manufacturer. Units shall be furnished in accordance with the schedule shown on the Drawings.

2.06 CONDENSATE DRAIN PIPE

- A. Poly (Vinyl Chloride) Pipe and Fittings:
 - 1. Pipe: Drain, waste and sanitary pipes and fittings shall be DWV Schedule 40 PVC, ASTM D2665.
 - 2. Joints: Chemical weld with manufacturers recommended solvent.

3.01 INSTALLATION

- A. Installation shall meet or exceed all applicable federal, state/commonwealth and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.
- B. All installation shall be in accordance with manufacturer's published recommendations.
- C. Install precision air-conditioning units level and plumb, maintaining manufacturer's recommended clearances.
- D. Water and Drainage Connections: Comply with applicable requirements in Division 23 piping installation sections. Provide adequate connections for condensate drain, and humidifier flushing system. Pipe condensate to nearest floor drain unless drawings indicate alternate pipe routing.

- E. Install pre-charged refrigerant line sets per factory installation guidelines and per routing shown on drawings. Install refrigerant sight glass, shut-off and service valves and accessories and test all pipe joints and connections. Repair all leaks and charge complete system with correct refrigerant to factory specifications.
- F. The air conditioning unit(s) shall be connected and placed in proper working order in accordance with the manufacturer's instructions and details. Do not operate the air conditioning unit(s) until significant completion of construction, or without explicit approval from the engineer. The Contractor shall furnish and install interconnecting wiring and conduits between all low voltage factory field mounted devices and the unit.

3.02 MANUFACTURER'S SERVICES

- A. Furnish services of qualified manufacturer's factory trained service personnel to assist in the installation of the equipment, check the installation before it is placed into operation, supervise initial operations and instruct plant operators in the care, operation and maintenance of the equipment.

3.03 CLEANING

- A. Clean dirt and marks and other debris from exterior of equipment weekly.
- B. Remove debris and waste material resulting from installation weekly.

3.04 GUARANTEE

- A. All components, parts, and assemblies shall be guaranteed against defects in materials and workmanship for a period of one (1) year. The period of such warranties shall start on the date the particular equipment is placed in use by the Owner with corresponding start-up certification provided by the manufacturer's technical representative as specified herein, provided that the equipment demonstrates satisfactory performance during the thirty day operational period after the equipment startup. If the equipment does not perform satisfactorily during the thirty day operational period, the start of the warranty period will be delayed until the equipment demonstrates proper operation. The Equipment Supplier shall repair or replace without charge to the Owner any part of equipment which is defective or showing undue wear within the guarantee period, or replace the equipment with new equipment if the mechanical performance is unsatisfactory; furnishing all parts, materials, labor, etc., necessary to return the equipment to its specified performance level.

END OF SECTION

SECTION 23 82 16.14
ELECTRIC-RESISTANCE AIR COILS

PART 1 – GENERAL

1.01 REQUIREMENT

- A. The Contractor shall furnish all labor, materials, tools and equipment necessary for furnishing, installing, connecting, testing and placing into satisfactory operation all electric space heating units as required for a complete electric installation as specified herein and indicated on the Drawings.
- B. The extent of the electric space heaters work is indicated on the Drawings and further defined by the requirements of this Section. The Contractor shall reference the Schedule included herein or indicated on the Drawings for quantities, electrical ratings, ventilation ratings, and other unit specific information.
- C. All field mounted equipment, conduit, and wiring that is required to for the heating equipment shall conform the applicable requirements of Division 26.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 23 00 00 – Basic HVAC Requirements
- B. Section 23 31 13 – Metal Ducts and Duct Accessories
- C. Section 23 05 93 – HVAC Balancing
- D. Section 23 05 95 – HVAC Field Testing
- E. Division 26 – Electrical

1.03 TESTING

- A. All tests shall be performed in accordance with the requirements of Division 01. The following tests are required:
 - 1. Certified Shop Tests. The electric space heating units shall be given routine factory tests in accordance with the requirements of the appropriate standards.
 - 2. Field Tests. Field tests shall be performed in accordance with the requirements specified in the General Conditions, Division 01, and Section 26 05 00 – Basic Electrical Requirements. The tests shall be made by the Contractor who shall also furnish the required testing equipment.

1.04 SUBMITTALS

- A. In accordance with the procedures and requirements set forth in the Section 01 33 00 – Submittal Procedures and Division 01, the Contractor shall obtain from the equipment manufacturer and submit the following:
 - 1. Shop Drawings
 - 2. Special Tools List
 - 3. Reports of Certified Shop Tests
 - 4. Operation and Maintenance Manuals
 - 5. Testing Procedure per Section 23 05 93 – Testing, Adjusting, Balancing for HVAC.
 - 6. Manufacturer's Installation Certification
 - 7. Manufacturer's Field Test Results Certification
- B. Each submittal shall be identified by the applicable Specification Section.

1.05 SHOP DRAWINGS

- A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.
- B. Partial, incomplete or illegible submittals will be returned to the Contractor without review for resubmittal.
- C. Shop drawings shall include but not be limited to:
 - 1. Equipment specifications and product data sheets identifying all materials used and methods of fabrication.
 - 2. Example equipment nameplate data sheet.
 - 3. Complete wiring diagrams showing all devices requiring electrical connection, wire numbers, terminal block numbers and other pertinent wiring information.

1.06 OPERATION AND MAINTENANCE MANUALS

- A. The Contractor shall submit operation and maintenance manuals in accordance with the procedures and requirements set forth in General Conditions and Division 01.

1.07 SPECIAL TOOLS

- A. The electric space heating units shall be furnished with all special tools necessary (one set per like piece of equipment) to disassemble, service, repair and adjust the equipment.

1.08 IDENTIFICATION

- A. Each electric space heating unit shall be identified with the identification number on the Drawings (e.g. UH-1, UH-2, etc.). A nameplate shall be securely affixed in a conspicuous place on each unit. Nameplates shall be as specified in Section 26 05 00 – Basic HVAC Requirements.

1.09 WARRANTY

- A. Manufacturer shall provide a one year comprehensive warranty.

PART 2 – PRODUCTS

2.01 MANUFACTURER

- A. The equipment covered by this Specification is intended to be standard equipment of proven performance as manufactured by reputable firms regularly engaged in the manufacturing of electric space heating units, of types and sizes required, whose products have been in satisfactory use in similar service for not less than 3 years. Equipment shall be designed, constructed and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as shown on the Drawings.

2.02 ELECTRIC UNIT HEATERS

- A. Product and Manufacturers: Provide completely factory assembled and wired units as made by one of the following:
 - 1.
 - 2. Indeeco IUH Unit Heater
 - 3. Qmark MUH Unit Heater
 - 4. Chromalox HVH Unit Heater
 - 5. Approved Equal
- B. Capacity and electrical supply characteristics shall be as shown on the Drawings.

C. Construction:

1. Unit shall be UL listed.
2. Finned tubular heating elements shall be brazed copper plated steel fins and epoxy sealed ends.
3. The motor shall be UL rated, permanently lubricated ball bearings, designed to resist moisture and corrosion.
4. Heating elements and motor shall be enclosed in a heavy gauge galvanized steel cabinet with a durable polyester powder coat finish.
5. The unit shall contain an adjustable outlet grille.
6. The unit shall be wired for single point power connection.
7. The enclosure shall house the element terminals and the following factory pre-wired controls:
 - a. Automatic reset over temperature cutout
 - b. Secondary manual reset/over temperature cutout
 - c. 24V Control transformer
 - d. Fan delay relay
 - e. Terminal blocks for field wiring
 - f. Three position selector switch (Auto, Off, Fan Only)
 - g. Internal thermostat with external adjustable knob
 - h. "Heater On" Pilot light to indicate when heating elements are energized

- D. The Contractor shall furnish universal swivel mounting brackets. The mounting bracket shall be suitable for horizontal wall mounting or vertical ceiling or suspended mounting.

2.03 WASHDOWN ELECTRIC UNIT HEATERS

- A. Product and Manufacturers: Provide completely factory assembled and wired units as made by one of the following:
1. Indeeco Triad Washdown Unit Heater
 2. Chromalox HD3D Washdown Unit Heater

3. Qmark QWD Washdown Unit Heater
 4. Approved Equal
- B. Capacity and electrical supply characteristics shall be as shown on the Drawings.
- C. Construction:
1. Unit shall be UL listed for corrosive areas and NEMA 4X hose down requirements.
 2. Finned tubular heating elements shall be type 316 stainless steel sheath with mechanically wound stainless steel fins and mounting fittings.
 3. The motor shall be UL rated, totally enclosed with permanently lubricated ball bearings, designed to resist moisture and corrosion. The motor shall be fitted with an epoxy-coated aluminum fan blade and factory wired to a NEMA 4X enclosure.
 4. Heating elements and motor shall be enclosed in a round, stainless steel shroud. The shroud shall be a minimum of 16 gauge.
 5. The shroud shall contain a stainless steel louvered outlet grille and plated rear grille.
 6. The unit shall be wired for single point power connection.
 7. The NEMA 4X enclosure shall house the element terminals and the following factory pre-wired controls:
 - a. Automatic reset over temperature cutout
 - b. Secondary manual reset/over temperature cutout
 - c. 24V Control transformer
 - d. Fan delay relay
 - e. Terminal blocks for field wiring
 - f. For unit above 12kW, a separate motor contactor shall be supplied
 - g. Three position selector switch (Auto, Off, Fan Only)
 - h. Internal thermostat with external adjustable knob
 - i. "Heater On" Pilot light to indicate when heating elements are energized

- 8. Each unit shall receive a corrosion resistant coating internally and externally including housing, fan blade, and grilles. The coating shall be Heresite or approved equal. The coating shall be rated for high temperature applications.
- D. The Contractor shall furnish universal swivel mounting brackets. The mounting brackets shall be a minimum of 16-gauge 304 stainless steel. The mounting bracket shall be suitable for horizontal wall mounting or vertical ceiling or suspended mounting.

PART 3 – EXECUTION

3.01 STORAGE AND HANDLING

- A. The Contractor shall handle the unit heaters and components carefully to prevent damage, breaking, denting, and scoring. Contractor shall not install damaged electric unit heaters or components.
- B. The Contractor shall store the unit heaters and components in a clean dry place, which will adequately protect the units from weather, dirt, fumes, water, construction debris, and physical damage.
- C. The Contractor shall comply with the manufacturer's rigging and installation instructions for unloading unit heaters and moving them to final location.

3.02 INSTALLATION

- A. The Contractor shall install unit heaters as indicated on the Contract Drawings, in accordance with the manufacturer's installation instructions, and shall verify that the manufacturer's nameplate data corresponds with the unit designation.
- B. The Contractor shall hang/support the units from substantial structural components of the building (e.g. walls, floors, columns, beams, etc.). Supports for the units and associated ductwork supports for insertion type installations shall not be hung from piping, other ductwork, or other equipment supports. After installation, the unit shall be protected with a protective cover during the balance of construction.
- C. The Contractor shall have the Manufacturer's Technical Representative provide in writing that the equipment is installed per the manufacturer's requirements and operates as required by the Contract. The Contractor shall submit the written confirmation to the Engineer for information only.

3.03 TESTING, ADJUSTING, AND CLEANING

- A. After installation is completed, the Contractor shall clean all exposed unit surfaces, vacuum the heating coils and vacuum the inside of the cabinets.

- B. See Section 23 05 93 – Testing, Adjusting, and Balancing for HVAC for testing and adjusting requirements.

3.04 MANUFACTURER’S FIELD SERVICES

- A. The services of a qualified manufacturer's Technical Representative shall be provided. The manufacturer Technical Representative's services shall include the following site visits:

Service	Total Days	No. of Trips	Remarks
Installation Checkout	1	1	In accordance with this specification
Startup and Testing	1	1	In accordance with Section 23 05 93 – HVAC Testing, Adjusting and Balancing
Training	1	1	In accordance with Section 01 79 00 – Instruction of Owner's Personnel

END OF SECTION

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SECTION 26 05 00
BASIC ELECTRICAL REQUIREMENTS

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. The Contractor shall furnish all labor, materials, tools, and equipment, and perform all work and services necessary for, or incidental to, the furnishing and installation of all electrical work as shown on the Drawings, and as specified in accordance with the provisions of the Contract Documents, and completely coordinate with the work of other trades involved in the general construction. Although such work is not specifically shown or specified, all supplementary or miscellaneous items, appurtenances, and devices incidental to or necessary for a sound, secure, and complete installation shall be furnished and installed as part of this work. The Contractor shall obtain approved Shop Drawings showing wiring diagrams, connection diagrams, roughing-in, and hook up details for all equipment and comply therewith. All electrical work shall be complete and left in operating condition in accordance with the intent of the Drawings and the Specifications for the electrical work.
- B. Reference Section 40 61 13 – Process Control System General Provisions and General Requirements in Division 01 for scope of work details as they relate to the Division 40 Instrumentation and Control System Subcontractor.
- C. The electrical scope of work for this project primarily includes, but is not limited to, the following:
 - 1. Demolition of electrical equipment and raceway systems as shown on the Drawings.
 - 2. Modifications to existing electrical equipment as shown on the Drawings and as specified herein.
 - 3. Furnish and install new low voltage power circuit breaker switchboards.
 - 4. Furnish and install new medium voltage liquid-filled, pad-mount style transformers.
 - 5. Furnish and install low voltage motor control equipment including reduced voltage motor starters and variable frequency drives.
 - 6. Furnish and install power panelboards, lighting panelboards, dry-type transformers, and other low voltage electrical power distribution equipment.
 - 7. Furnish and install all aboveground raceway systems including conduit, fittings, boxes, supports, and other pertinent components.

8. Furnish and install all underground raceway systems including conduit, fittings, manholes, handholes and other pertinent components.
 9. Furnish and install new lighting systems and wiring devices.
 10. Furnish and install facility lightning protection systems and grounding systems where specified or indicated on the Drawings.
 11. Other electrical work as specified herein and indicated on the Drawings.
- D. All material and equipment shall be the product of an established, reputable, and approved manufacturer; shall be new and of first-class construction; shall be designed and guaranteed to perform the service required; and shall bear the Label of approval of the Underwriters Laboratories, Inc., where such approval is available for the product of the listed manufacturer as approved by the Engineer.
 - E. When a specified or indicated item has been superseded or is no longer available, the manufacturer's latest equivalent type or model of material or equipment as approved by the Engineer shall be furnished and installed at no additional cost to the Owner.
 - F. Where the Contractor's selection of equipment of specified manufacturers or additionally approved manufacturers requires changes or additions to the system design, the Contractor shall be responsible in all respects for the modifications to all system designs, subject to approval of the Engineer. The Contractor's bid shall include all costs for all work of the Contract for all trades made necessary by such changes, additions or modifications or resulting from any approved substitution.
 - G. Furnish and install all stands, racks, brackets, supports, and similar equipment required to properly serve the equipment which is furnished under this Contract, or equipment otherwise specified or indicated on the Drawings.
 - H. All electrical components and systems (e.g., conduit and other raceways, freestanding equipment, etc.) and their anchorage, including electrical equipment foundations, shall be designed to resist the controlling load combination of gravity loads, operational forces, wind forces, seismic forces, thermal loads, and any other applicable forces required in accordance with the governing Building Code and Section 01 73 23 – Anchorage and Bracing of Nonstructural Components. Seismic design shall be in accordance with ASCE 7 Chapter 13 unless the nonstructural component meets the criteria to be exempt.

1.02 EQUIPMENT LOCATION

- A. The Drawings show the general location of feeders, transformers, equipment, devices, conduits, and circuit arrangements. Because of the small scale of the Drawings, it is not possible to indicate all of the details involved. The Contractor shall carefully investigate the structural and finish conditions affecting the work and shall arrange such work

accordingly. Contractor shall furnish and install such fittings, junction boxes, and accessories as may be required to meet such conditions. The Contractor shall refer to the entire Drawing set to verify openings, special surfaces, and location of other equipment, or other special equipment prior to roughing-in for panels, switches, and other outlets. The Contractor shall verify all equipment dimensions to ensure that proposed equipment will fit properly in spaces indicated.

- B. Where outlets are shown near identified equipment furnished by this or other Contractors, it is the intent of the Specifications and Drawings that the outlet be located at the equipment to be served. The Contractor shall coordinate the location of these outlets to be near the final location of the equipment served whether placed correctly or incorrectly on the Drawings.

1.03 LOCAL CONDITIONS

- A. The Contractor shall examine the site and become familiar with conditions affecting the work. The Contractor shall investigate, determine, and verify locations of any overhead or buried utilities on or near the site, and shall determine such locations in conjunction with all public and/or private utility companies and with all authorities having jurisdiction (AHJs). All costs, both temporary and permanent to connect all utilities, shall be included in the Bid. The Contractor shall be responsible for scheduling and coordinating with the local utility for temporary and permanent services.
- B. In addition, the Contractor shall relocate all duct banks, lighting fixtures, receptacles, switches, boxes, and other electrical equipment as necessary to facilitate the Work included in this project. Costs for such work shall be included in the Bid.
- C. The Contractor is responsible for coordinating all electric utility equipment installations with the serving electric utility. The Contractor shall furnish and install all electric utility equipment required by the electric utility to be installed by the Contractor whether specifically shown on the Drawings or not.
- D. The Contractor shall furnish and install the following electric utility equipment as a minimum:
 - 1. Concrete transformer/equipment pads constructed in accordance with utility requirements and/or as instructed by the electric utility.
 - 2. Primary and /or secondary conduits/ductbank and manholes.
 - 3. Metering equipment cabinets and/or bases.
 - 4. Conduit and wire required from metering cabinet to metering current transformers and potential transformers.
 - 5. Secondary conductors .

6. Secondary terminations.
- E. The electric utility will furnish and install the following equipment:
1. Primary conductors and terminations.
 2. Utility Transformer.
- F. The Contractor is responsible for ensuring all electric utility equipment and construction installed by the Contractor is furnished and installed in accordance with the electric utility's design specifications and requirements. The Contractor is fully responsible for coordinating all required work with the electric utility. Any additional required electric utility construction or equipment not specified herein or shown on the Drawings shall be supplied by the Contractor at no additional cost to the Owner.
- G. The contact person at the serving electrical utility is:
- Keith Reed
PWC Electric
keith.reid@faypwc.com

1.04 SUBMITTALS

- A. In accordance with the procedures and requirements set forth in Section 01 33 00 – Submittal Procedures and the requirements of the individual Specification Sections, the Contractor shall obtain from the equipment manufacturer and submit the following:
1. Shop Drawings
 2. Operation and Maintenance Manuals
 3. Spare Parts List
 4. Proposed Testing Methods and Reports of Certified Shop Tests
 5. Reports of Certified Field Tests
 6. Manufacturer's Representative's Certification
- B. Submittals shall be sufficiently complete in detail to enable the Engineer to determine compliance with Contract requirements.
- C. Submittals will be approved only to the extent of the information shown. Approval of an item of equipment shall not be construed to mean approval for components of that item for which the Contractor has provided no information.

- D. Some individual electrical specification sections may require a Compliance, Deviations, and Exceptions (CD&E) letter to be submitted. If the CD&E letter is required and shop drawings are submitted without the letter, the submittal will be rejected. The letter shall include all comments, deviations, and exceptions taken to the Drawings and Specifications by the Contractor AND Equipment Manufacturer/Supplier. This letter shall include a copy of the applicable specification section(s). In the left margin beside each and every paragraph/item, a letter "C", "D", or "E" shall be typed or written in. The letter "C" shall be for full compliance with the requirement. The letter "D" shall be for a deviation from the requirement. The letter "E" shall be for taking exception to a requirement. Any requirements with the letter "D" or "E" beside them shall be provided with a full typewritten explanation of the deviation/exception. Handwritten explanation of the deviations/exceptions is not acceptable. The CD&E letter shall also address deviations and exceptions taken to each Drawing related to the applicable specification section(s).
- E. Submit design for all nonstructural electrical components and systems and their anchorage in accordance with the governing Building Code and Section 01 73 23 – Anchorage and Bracing of Nonstructural Components.

1.05 APPLICABLE CODES AND REQUIREMENTS

- A. Conformance
 - 1. Unless otherwise noted, all work, equipment, and materials furnished shall conform with the latest available version of the rules, requirements, and specifications of the following:
 - a. Insurance Rating Organization having jurisdiction.
 - b. The serving electric utility company.
 - c. The currently adopted edition of the National Electrical Code (NEC).
 - d. The National Electric Manufacturers Association (NEMA).
 - e. The Institute of Electrical and Electronic Engineers (IEEE).
 - f. The Insulated Cable Engineers Association (ICEA).
 - g. The American Society of Testing Materials (ASTM).
 - h. The American National Standards Institute (ANSI).
 - i. The requirements of the Occupational Safety Hazards Act (OSHA).

- j. The National Electrical Contractors Association (NECA) Standard of Installation.
 - k. National Fire Protection Association (NFPA).
 - l. InterNational Electrical Testing Association (NETA).
 - m. All other applicable Federal, State/Commonwealth, and local laws and/or ordinances.
- 2. All equipment and materials shall be Listed by and shall bear the Label of Underwriter's Laboratories, Incorporated (UL), if the material and equipment is of the type/class inspected by said laboratories.

B. Nonconformance

- 1. Any paragraph of requirements in these Specifications or Drawings deviating from the rules, requirements, and specifications of the above organizations shall be invalid and their (the above organizations) requirements shall hold precedent thereto. The Contractor shall be held responsible for adherence to all rules, requirements, and specifications as set forth above. Any additional work or material necessary for adherence will not be allowed as an extra, but shall be included in the Bid. Ignorance of any rule, requirement, or specification shall not be allowed as an excuse for nonconformity. Acceptance by the Engineer does not relieve the Contractor from the expense involved for the correction of any errors which may exist in the drawings submitted or in the satisfactory operation of any equipment.

C. Certification

- 1. Where applicable, upon completion of the work, the Contractor shall obtain certificate(s) of inspection and approval from the inspection organization having jurisdiction and shall deliver same to the Engineer and the Owner.

1.06 PERMITS AND INSPECTIONS

- A. The Contractor shall reference the General Conditions and Section 01 11 00 – Summary of Work.

1.07 TEMPORARY LIGHTING AND POWER

- A. The Contractor shall reference the General Conditions and Section 01 51 00 – Temporary Utilities.

1.08 PHASE ROTATION

- A. The Contractor shall verify electrical phasing and phase rotation (clockwise ABC or counterclockwise CBA) of all existing loads prior to the start of demolition. The Contractor is responsible for coordinating and ensuring correct phasing of wiring such that phase rotation and color coding are consistent throughout the site. Motors (new or existing re-fed) shall be “bump tested” prior to placing in full service to ensure they are rotating in the correct direction. Refer to 26 05 60 Low-Voltage Electric Motors for additional requirements.
- B. Any “rolling of phases” shall be done at the motor, not at the disconnect switch. Refer to 26 05 19 – Low Voltage Conductors and Cable for additional requirements.
- C. Phase rotation for the site shall be consistent with the phase rotation of the upstream device when new equipment is installed or existing equipment is replaced. Phase rotation shall not be changed when existing equipment is modified to ensure existing loads are not disturbed.

1.09 TESTS

- A. Upon completion of the installation, the Contractor shall perform tests for operation, load (Phase) balance, overloads, and short circuits. Tests shall be made with and to the satisfaction of the Owner and Engineer.
- B. The Contractor shall perform all field tests and shall provide all labor, equipment, and incidentals required for testing and shall pay for electric power required for the tests. All defective material and workmanship disclosed shall be corrected by the Contractor at no cost to the Owner. The Contractor shall show by demonstration in service that all circuits and devices are in good operating condition. Test shall be such that each item of control equipment will function not less than five (5) times.
- C. Refer to each individual specification section for detailed test requirements.
- D. The Contractor shall complete the installation and field testing of the electrical installation at least two (2) weeks prior to the startup and testing of any equipment served by that electrical equipment. During the period between the completion of electrical installation and the startup and testing of all other equipment, the Contractor shall make all components of the Work available as it is completed for their use in performing Preliminary and Final Field Tests.
- E. Before each test commences, the Contractor shall submit a detailed test procedure, and also provide test engineer resume, personnel, and scheduling information for the approval by the Engineer. In addition, the Contractor shall furnish detailed test procedures for any electrical equipment required as part of the field tests of other systems.

1.10 INFRARED INSPECTION

- A. Just prior to the final acceptance of a piece of equipment, the Contractor shall perform an infrared inspection to locate and correct all heating problems associated with electrical equipment terminations. The infrared inspection shall be performed by a qualified, independent, third-party testing company, not the Electrical Contractor.
- B. Equipment located in hazardous areas shall be excluded from infrared testing requirements since the equipment in those areas is not intended to be operated while the enclosure is open. The infrared inspection shall apply to all new equipment and existing equipment in non-hazardous areas that is in any way modified under this Contract. All heating problems detected with new equipment furnished and installed under the Scope of this Contract shall be corrected by the Contractor at no additional cost to the Owner. All problems detected with portions of existing equipment modified under this Contract shall also be corrected by the Contractor at no additional cost to the Owner.
- C. Any issues detected with portions of existing equipment that were not modified under this Contract are not the responsibility of the Contractor. Despite the Contractor not being held responsible for these problems, the Contractor shall report them to the Owner and Engineer immediately for resolution.
- D. The infrared inspection report shall include both digital photos and infrared (IR) photos positioned side by side. Both the digital and IR photos shall be clear and high quality. Fuzzy, grainy, or poorly illuminated photos are not acceptable. Each IR photo shall be provided with a temperature scale beside it, and an indication of the hot spot temperature in the photo. Reports shall be furnished in a 3-ring binder, with all pages printed in full color, with equipment assemblies separated by tabs.

1.11 PROTECTIVE DEVICE SETTING AND TESTING

- A. The Contractor shall provide the services of a qualified, independent, third-party testing company using NETA certified technicians to adjust, set, calibrate, and test all protective devices in the electrical system. The company shall not be a subsidiary of the electrical equipment manufacturer. The qualifications of the testing company and resumes of the technicians as well as all data forms to be used for the field testing shall be submitted.
- B. All protective devices in the electrical equipment shall be set, adjusted, calibrated, and tested in accordance with the manufacturers' recommendations, the coordination study, and best industry practice.
- C. Proper operation of all equipment associated with the device under test and its compartment shall be verified, as well as complete resistance, continuity, and polarity tests of power, protective, and metering circuits. Any minor adjustments, repairs, and/or lubrication necessary to achieve proper operation shall be considered part of this Contract.

- D. All solid state trip devices shall be checked and tested for setting and operation using manufacturers' recommended test devices and procedures.
- E. Circuit breakers and/or contactors associated with the above devices shall be tested for trip and close functions with their protective device.
- F. When completed, the Contractor shall provide a comprehensive report for all equipment tested indicating condition, readings, faults, and/or deficiencies in same. Inoperative or defective equipment shall be brought immediately to the attention of the Engineer.
- G. Prior to placing any equipment in service, correct operation of all protective devices associated with this equipment shall be demonstrated by field testing under simulated load conditions.

1.12 POWER SYSTEM STUDIES

- A. The Engineer will provide the Power System studies to the firm providing the protective device setting and testing services. The Contractor shall submit to the Engineer a tabulated listing of all protective devices requiring setting at least three (3) weeks prior to the scheduled date for setting and testing of protective devices. This table shall include the protective device manufacturer, model number, ampere rating (if applicable), instrument transformer ratios, and all other required information.

1.13 SCHEDULES AND FACILITY OPERATIONS

- A. Since the equipment testing required herein shall require that certain pieces of equipment be taken out of service, all testing procedures and schedules shall be submitted to the Engineer for review and approval one (1) month prior to any work beginning. When testing has been scheduled, the Engineer shall be notified 48 hours prior to any work to allow time for load switching and/or alternation of equipment. In addition, all testing that requires temporary shutdown of facility equipment shall be coordinated with the Owner/Engineer so as not to affect proper facility operations.
- B. At the end of the workday, all equipment shall be back in place and ready for immediate use should a facility emergency arise. In addition, should an emergency condition occur during testing, at the request of the Owner, the equipment shall be placed back in service immediately and turned over to Owner personnel.
- C. In the event of accidental shutdown of Owner equipment, the Contractor shall notify Owner personnel immediately to allow for an orderly restart of affected equipment.
- D. Maintaining the operation of these facilities during the duration of the construction period is essential and required. The Contractor shall furnish and install temporary equipment as required to maintain facility operation. Reference Section 01 14 00 – Coordination with Owner's Operations for construction sequencing and specific operational constraint information.

1.14 EQUIPMENT, MATERIALS, AND SPARE PARTS HANDLING AND STORAGE

- A. Materials arriving on the job site shall be stored in such a manner as to keep material free of rust and dirt and to keep material properly aligned and true to shape. Rusty, dirty, or misaligned material will be rejected. Electrical conduit shall be stored to provide protection from the weather and accidental damage. Rigid non-metallic conduit shall be stored on even supports and in locations not subject to direct sun rays or excessive heat. Cables shall be sealed, stored, and handled carefully to avoid damage to the outer covering or insulation and damage from moisture and weather. Adequate protection shall be required at all times for electrical equipment and accessories until installed and accepted. Materials damaged during shipment, storage, installation, or testing shall be replaced or repaired in a manner meeting with the approval of the Engineer. If space heaters are provided in a piece of electrical equipment, they shall be temporarily connected to a power source during storage. The Contractor shall store equipment and materials in accordance with Section 01 55 00 – Contractor Access and Parking.
- B. Spare parts lists, included with the shop drawing submittal for each Section, shall indicate specific sizes, quantities, and part numbers of the items to be furnished. Terms such as "1 lot of packing material" are not acceptable.
- C. Spare parts shall be completely identified with a numerical system to facilitate parts inventory control and stocking. Each part shall be properly identified by a separate number. Those parts which are identical for more than one size, shall have the same parts number.
- D. Spare parts shall be packed in containers suitable for long term storage, bearing labels clearly designating the contents and the pieces of equipment for which they are intended.
- E. Spare parts shall be delivered at the same time as the equipment to which they pertain. The Contractor shall properly store and safeguard such spare parts until completion of the work, at which time they shall be delivered to the Owner.

1.15 WARRANTIES

- A. Unless otherwise specified in an individual specification section, all electrical equipment and electrical construction materials shall be provided with a warranty in accordance with the requirements of Section 46 00 00 – Equipment General Provisions and the General Conditions.

1.16 TRAINING

- A. Unless otherwise specified in an individual specification section, all training for electrical equipment shall be provided in accordance with the requirements of Section 46 00 00 – Equipment General Provisions.

PART 2 – PRODUCTS

2.01 PRODUCT REQUIREMENTS

- A. Unless otherwise indicated, the materials to be provided under this Specification shall be the products of manufacturers regularly engaged in the production of all such items and shall be the manufacturer's latest design. The products shall conform to the applicable standards of UL and NEMA, unless specified otherwise. International Electrotechnical Commission (IEC) standards are not recognized. Equipment designed, manufactured, and labeled in compliance with IEC standards is not acceptable.
- B. All items of the same type or ratings shall be identical. This shall be further understood to include products with the accessories indicated.
- C. All equipment and materials shall be new, unless indicated or specified otherwise.
- D. The Contractor shall submit proof if requested by the Engineer that the materials, appliances, equipment, and/or devices that are provided under this Contract meet the requirements of Underwriters Laboratories, Inc. with regard to fire and casualty hazards. Documentation indicating Listing and Labeling by Underwriters Laboratories, Inc., will be accepted as meeting this requirement.
- E. Where the above items are Labeled by (bearing the certification mark of) an OSHA Nationally Recognized Testing Laboratory (NRTL) other than UL, and the NRTL is authorized by the Occupational Safety and Health Administration (OSHA) to test and certify those items to the same standard(s), then the certification mark of that NRTL shall be considered equivalent to the 'UL' certification mark.

2.02 SUBSTITUTIONS

- A. Unless specifically noted otherwise, any reference in the Specifications or on the Drawings to any article, service, product, material, fixture, or item of equipment by name, make, or catalog number shall be interpreted as establishing the type, function, and standard of quality and shall not be construed as limiting competition. The Contractor, in such cases may use any article, device, product, material, fixture, or item of equipment which in the judgment of the Engineer, expressed in writing, is equal to that specified.

2.03 CONCRETE

- A. The Contractor shall furnish all concrete required for the installation of all electrical work. Concrete shall be Class A unless otherwise specified. Concrete and reinforcing steel shall meet the appropriate requirements of Division 03 of the Specifications.
- B. The Contractor shall provide concrete equipment pads for all free-standing electrical apparatus and equipment located on new or existing floors or slabs. The Contractor shall provide all necessary anchor bolts, channel iron sills, and other materials as required.

The exact location and dimensions shall be coordinated for each piece of equipment well in advance of the scheduled placing of these pads. Equipment pads shall be 4 inches high unless otherwise indicated on the Drawings and shall conform to the Standard Detail for equipment pads shown on the Drawings. Equipment pads shall not have more than 3 inches of excess concrete beyond the edges of the equipment.

- C. The Contractor shall provide concrete foundations for all free-standing electrical apparatus and equipment located outdoors or where floors or slabs do not exist and/or are not or provided by others under this Contract. The Contractor shall provide all necessary anchor bolts, channel iron sills, and other materials as required. The location and dimensions shall be coordinated for each piece of equipment well in advance of the scheduled placing of the foundations. Equipment foundations shall be constructed as detailed on the Drawings or if not detailed on the Drawings shall be 6 inches thick minimum reinforced with #4 bars at 12-inch centers each way placed mid-depth. Concrete shall extend 6 inches minimum beyond the extreme of the equipment base and be placed on a compacted stone bed (#57 stone or ABC) 6 inches thick minimum.

2.04 RUBBER INSULATING MATTING

- A. Rubber insulating matting shall be furnished and installed for each piece of electrical equipment that is located indoors and installed under this Contract. Rubber insulating matting shall not be installed outdoors. Matting shall be installed in the front of all equipment and in the rear of equipment that is rear accessible. The mat shall be long enough to cover the full length of the equipment. The mat shall be ¼-inch thick with beveled edges, canvas back, solid type with corrugations running the entire length of the mat. The matting shall meet OSHA requirements and the requirements of ASTM D-178 for Type 2, Class 2 insulating matting. Matting shall be 36 inches wide, minimum. However, matting width shall be no less than the NEC working clearance for the equipment with which it is associated.
- B. Matting shall be provided for the following equipment:
 - 1. PLC/RTU Enclosures
 - 2. Motor Control Centers
 - 3. Switchgear Assemblies
 - 4. Switchboard Assemblies
 - 5. Variable Frequency Drives
 - 6. Reduced Voltage Starters
 - 7. Unit Substations

8. Panelboards
9. Automatic Transfer Switches
10. Generator Output Circuit Breakers
11. Generator Control Panels
12. Fire Alarm Control Panels
13. Harmonic Correction Equipment

PART 3 – EXECUTION

3.01 CUTTING AND PATCHING

A. Coordination

1. The Work shall be coordinated between all trades to avoid delays and unnecessary cutting, channeling, and drilling. Sleeves shall be placed in concrete for passage of conduit wherever possible.

B. Damage

1. The Contractor shall perform all chasing, channeling, drilling, and patching necessary to the proper execution of this Contract. Any damage to the building, structure, or any equipment shall be repaired by qualified mechanics of the trades involved at the Contractor's expense. If, in the Engineer's judgment, the repair of damaged equipment would not be satisfactory, then the Contractor shall replace damaged equipment at the Contractor's expense.

C. Existing Equipment

1. Provide a suitable cover or plug for openings created in existing equipment as the result of work under this Contract. For example, provide round plugs in equipment enclosures where the removal of a conduit creates a hole in the enclosure. Covers and plugs shall maintain the NEMA rating of the equipment enclosure. Covers and plugs shall be watertight when installed in equipment located outdoors.

3.02 EXCAVATION AND BACKFILLING

- A. The Contractor shall perform all excavation and backfill required for the installation of all electrical work. All excavation and backfilling shall be in complete accordance with the applicable requirements of Division 31.

3.03 CORROSION PROTECTION

- A. Wherever dissimilar metals, except conduit and conduit fittings, come into contact, the Contractor shall isolate these metals as required with neoprene washers, nine (9) mil polyethylene tape, or gaskets.

END OF SECTION

SECTION 26 05 19
LOW VOLTAGE CONDUCTORS AND CABLES

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. The Contractor shall furnish, install, connect, test, and place in satisfactory operating condition all low voltage wire and cable indicated on the Drawings, as specified herein, and/or required for proper operation. The work of connecting cables to equipment and devices shall be considered a part of this Section. All appurtenances required for the installation of wire and cable systems shall be furnished and installed by the Contractor.
- B. The scope of this Section does not include internal wiring factory installed by electrical equipment manufacturers.
- C. Reference the following Specification Sections:
 - 1. Section 26 05 00 – Basic Electrical Requirements
 - 2. Section 26 05 33.16 – Boxes for Electrical Systems
 - 3. Section 26 28 16.16 – Enclosed Switches

1.02 CODES AND STANDARDS

- A. All low voltage wire, cable, and appurtenances shall be Listed by and shall bear the Label of Underwriter's Laboratories, Incorporated (UL).
- B. Low voltage wire, cable, and appurtenances shall be designed, manufactured, and/or Listed to the following standards as applicable:
 - 1. American Society for Testing and Materials (ASTM):
 - a. ASTM B3 – Standard Specification for Soft or Annealed Copper Wire.
 - b. ASTM B8 – Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.
 - c. ASTM B33 – Standard Specification for Tin-Coated Soft or Annealed Copper Wire for Electrical Purposes.
 - d. ASTM D69 – Standard Test Methods for Friction Tapes.

- e. ASTM D4388 – Standard Specification for Nonmetallic Semi-Conducting and Electrically Insulating Rubber Tapes.
- 2. Institute of Electrical and Electronic Engineers (IEEE):
 - a. IEEE 1202 – Standard for Flame Testing of Cables.
- 3. Insulated Cable Engineers Association (ICEA):
 - a. ICEA S-58-679 – Standard for Control, Instrumentation and Thermocouple Extension Conductor Identification.
 - b. ICEA T-29-520 – Conducting Vertical Cable Tray Flame Tests with Theoretical Heat Input Rate of 210,000 B.T.U./Hour.
- 4. National Fire Protection Association (NFPA):
 - a. NFPA 70 – National Electrical Code (NEC).
- 5. Underwriters Laboratories (UL):
 - a. UL 13 – Standard for Power-Limited Circuit Cables.
 - b. UL 44 – Thermoset-Insulated Wires and Cables.
 - c. UL 83 – Thermoplastic-Insulated Wires and Cables.
 - d. UL 486A-486B – Standard for Safety Wire Connectors
 - e. UL 1277 – Standard for Electrical Power and Control Tray Cables with Optional Optical-Fiber Members.
 - f. UL 1581 – Reference Standard for Electrical Wires, Cables, and Flexible Cords.
 - g. UL 1685 – Standard for Vertical-Tray Fire-Propagation and Smoke-Release Test for Electrical and Optical-Fiber Cables.
 - h. UL 2250 – Standard for Instrumentation Tray Cable.
 - i. UL 2556 – Wire and Cable Test Methods.

1.03 SUBMITTALS

- A. In accordance with the procedures and requirements set forth in the General Conditions and Section 01 33 00 – Submittal Procedures, the Contractor shall obtain from the wire and cable manufacturer and submit the following:

1. Shop Drawings
 2. Cable pulling plan (if required)
 3. Reports of Field Tests
 4. Circuit Logs
- B. Each submittal shall be identified by the applicable Specification Section.

1.04 SHOP DRAWINGS

- A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed material's compliance with the Contract Documents.
- B. Partial, incomplete, or illegible Submittals will be returned to the Contractor without review for resubmittal.
- C. Shop drawings shall include but not be limited to:
1. Product data sheets for the following:
 - a. Wire and cable
 - 1) The product data sheets for wire and cable for up to four (4) manufacturers for each type of wire/cable specified herein will be reviewed if they are submitted at the same time under the same submittal cover for simultaneous review.
 - b. Power and control wire terminations, including wire ferrules
 - c. Instrumentation cable terminations
 - d. Pulling lubricant.
 2. Wiring identification methods and materials.
- D. The shop drawing information shall be complete and organized in such a way that the Engineer can determine if the requirements of these specifications are being met. Copies of technical bulletins, technical data sheets from "soft-cover" catalogs, and similar information which is "highlighted" or somehow identifies the specific equipment items the Contractor intends to provide are acceptable and shall be submitted.

PART 2 – PRODUCTS

2.01 MANUFACTURERS

- A. The wire and cable to be furnished and installed for this project shall be the product of manufacturers who have been in the business of manufacturing wire and cable for a minimum of ten (10) years. Wire and cable shall be designed, constructed, and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as specified herein and indicated on the Drawings.

2.02 POWER AND CONTROL WIRE AND CABLE

- A. Power wire installed in ductbank or between the output terminals of a VFD and the respective motor shall consist of insulated copper conductors. Conductor insulation shall be rated for 90°C in both wet and dry locations, and 600V. Insulated conductors shall be UL 44 Listed as NEC Type XHHW-2.
- B. Power wire for all other loads and control wire shall consist of insulated copper conductors with a nylon (or equivalent) outer jacket. Conductor insulation shall be rated 90°C for dry locations, 75°C for wet locations, and 600V. Insulated conductors shall be UL 83 Listed as NEC Type THHN/THWN.
- C. Unless specified otherwise herein, conductors shall be stranded copper per ASTM B-8 and B-3, with Class B or C stranding contingent upon the size. Power conductors for lighting and receptacle branch circuits shall be solid copper per ASTM B-3.
- D. Power conductor size shall be no smaller than No. 12 AWG and Control conductor size shall be no smaller than No. 14 AWG.
- E. Multi-conductor cable assemblies shall include a grounding conductor and an overall PVC jacket. The jacket shall be PVC and resistant to abrasion, sunlight, and flame in accordance with UL 1277. Multi-conductor cable assemblies shall be UL 1277 Listed as NEC Type TC (Power and Control Tray Cable).
- F. Power wire and cable shall be as manufactured by the Okonite Company, the Southwire Company, General Cable, Encore Wire, or Engineer approved equal.

2.03 INSTRUMENTATION CABLE

- A. For single-analog signal applications, instrumentation cable shall consist of a single, twisted pair or triad of individually insulated and jacketed copper conductors with an overall cable shield and jacket. Conductor insulation shall be rated 90°C in both wet and dry locations, and 600V. The jacket shall be PVC and resistant to abrasion, sunlight, and flame in accordance with UL 1277. Cable shall be UL 1277 Listed as NEC Type TC (Power and Control Tray Cable).

- B. For multiple-analog signal applications, instrumentation cable shall consist of multiple, twisted pairs or triads (i.e., groups) of individually insulated and jacketed copper conductors with individual pair/triad shields (i.e., group shields) and an overall cable shield and jacket. Conductor insulation shall be rated 90°C in both wet and dry locations, and 600V. The jacket shall be PVC and resistant to abrasion, sunlight, and flame in accordance with UL 1277. Cable shall be UL 1277 Listed as NEC Type TC (Power and Control Tray Cable).
- C. Cable and group shields shall consist of overlapped aluminum/polyester tape/foil providing 100% coverage. Instrumentation cables shall include an overall copper shield drain wire. Cables containing multiple twisted pairs or triads shall also include group shield drain wires.
- D. Conductors, including drain wires, shall be tin or alloy coated (if available), soft, annealed copper, stranded per ASTM B-8, with Class B stranding unless otherwise specified.
- E. Instrumentation signal conductor size shall be no smaller than No. 16 AWG.
- F. Instrumentation cable shall be Okoseal-N Type P-OS (for single pair or triad applications) or Okoseal-N Type SP-OS (for multiple pair or triad applications) as manufactured by the Okonite Company, Belden equivalent, Southwire Company equivalent, or Engineer approved equal.

2.04 OTHER CABLES

- A. Category 6 UTP communication cables and fiber optic cables shall be as specified in Specification Section 40 66 00 – Network and Communication Equipment.

2.05 CONDUCTOR IDENTIFICATION

- A. Conductors shall be identified using a color-coding method. Color coding for individual power, control, lighting, and receptacle conductors shall be as follows:
 - 1. 480/277V AC Power
 - a. Phase A – BROWN
 - b. Phase B – ORANGE
 - c. Phase C – YELLOW
 - d. Neutral – GREY
 - 2. 120/208V or 120/240V AC Power
 - a. Phase A – BLACK

- b. Phase B – RED
 - c. Phase C – BLUE
 - d. Neutral – WHITE
- 3. DC Power
 - a. Positive Lead – RED
 - b. Negative Lead - BLACK
- 4. DC Control
 - a. All wiring – BLUE
- 5. 120 VAC Control
 - a. 120 VAC control wire shall be RED except for a wire entering a motor control center compartment, motor controller, or control panel which is an interlock. This interlock conductor shall be color coded YELLOW. For the purposes of this Section, an interlock is defined as any wiring that brings voltage into the above-mentioned equipment from a source outside that equipment.
- 6. 24 VAC Control
 - a. All wiring - ORANGE
- 7. Equipment Grounding Conductor
 - a. All wiring - GREEN
- B. Individual conductors No. 2 AWG and smaller shall have factory color coded insulation. It is acceptable for individual conductors larger than No.2 AWG to be provided with factory color coded insulation as well, but it is not required. Individual conductors larger than No.2 AWG that are not provided with factory color coded insulation shall be identified by the use of colored tape in accordance with the requirements listed in Part 3 herein. Insulation colors and tape colors shall be in accordance with the color-coding requirements listed above.
- C. Conductors that are part of multi-conductor cable assemblies shall have black insulation. The conductor number shall be printed on each conductor's insulation in accordance with ICEA S-58-679, Method 4. Each conductor No.2 AWG and smaller within the cable assembly shall also be identified with a heat shrink tag with color coded background. Each conductor larger than No.2 AWG within the cable assembly shall also be identified by the use of colored tape. Heat shrink tags and colored tape shall be in accordance

with the requirements listed in Part 3 herein. Tape color and heat shrink tag background color shall be in accordance with the color-coding requirements listed above.

2.06 CABLE PULLING LUBRICANTS

- A. Cable pulling lubricants shall be non-hardening, non-wax based type and approved for use on the type of cable installed. Lubricant shall be Polywater J by Polywater, Cable Gel by Greenlee, Poly-Gel by Gardner Bender, or equal.

PART 3 – EXECUTION

3.01 CABLE PULLING PLANS

- A. The Contractor shall submit cable pulling plans for Engineer approval at least 10 working days prior to making any cable pull in which all of the following are true:
 - 1. The amount of cable to be installed will be greater than 200 linear feet between pull points.
 - 2. The installation will have one or more bends.
 - 3. The wire/cable is size #1/0 AWG and larger.
- B. Each cable pulling plan shall consist of the following minimum elements:
 - 1. Site plan and/or building plan view drawings (as appropriate) explicitly annotated with the following information:
 - a. Locations of the cable reels and cable tugging device.
 - b. Locations of any pull out/pull in points along the path of the pull between the cable reels and the tugging device.
 - c. Locations of all manholes, handholes, pull boxes, vaults, and termination cabinets.
 - d. Locations of all cable splices (where splices are explicitly permitted herein).
 - e. Locations of each cable pull segment number which corresponds to the segment numbers listed in the pulling calculations.
 - f. Listing of pulling hardware (radius rollers, tripods, forklift, etc.) being used at the start and end of the pull as well as at each of the manholes, handholes, vaults, and pull boxes in between.

2. Cable pulling calculations performed by a currently registered Professional Engineer in the State or Commonwealth in which the project is located. Pulling calculations requirements are as follows:
 - a. Show pulling tension and sidewall pressure values for each cable pull segment with cable pull segment numbers corresponding to those listed in the annotated plan views. Pulling tension and sidewall pressure values shall not exceed the maximum values allowed by the cable manufacturer.
 - b. Show pull segment lengths, bend types, bend radii, and bend direction (up, down, horizontal).
 - c. Use the minimum radius allowed by the NEC for each conduit bend unless evidence (submittals, pictures, etc.) can be provided to substantiate the use of large bending radii in the calculations.

3.02 WIRE AND CABLE INSTALLATION

A. General

1. All wire and cable furnished under this Contract, including wire and cable furnished under other Divisions, shall be installed in raceways (e.g., conduit) unless specifically noted otherwise.
2. Wire and cable shall be installed as specified herein and indicated on the Drawings. Unless specifically indicated otherwise on the Drawings, wire and cable shall be installed in separate raceways according to wiring type. For example, power wiring shall not be combined with control wiring, and control wiring shall not be combined with instrumentation wiring.
3. Wire shall be furnished and installed as single conductor cables, with limited exceptions. Multi-conductor cable assemblies shall only be installed where indicated on the Drawings, required by the NEC, or after obtaining written permission from the Engineer.
4. Where instrumentation cables are installed in control panels, motor controllers, and other locations, the Contractor shall arrange wiring to provide maximum clearance between these cables and other conductors. Instrumentation cables shall not be installed in same bundle with conductors of other circuits.
5. Instrumentation cable shielding shall be continuous and shall be grounded at one point only.

B. Splices

1. Splices shall not be allowed in power wire and cable unless approved in writing by the Engineer. If unique field conditions exist or pulling calculations indicate that splices may be required, the Contractor shall submit a detailed request indicating why splices are required to the Engineer. The Engineer shall be under no obligation to grant such request.
2. Splicing materials shall be UL 486A Listed barrel type butt splice connectors and heat shrink tubing as manufactured by 3M, Ideal, or equal. The use of screw-on wire connectors (wire nuts) shall only be permitted for lighting and receptacle circuits.
3. No splicing of control or instrumentation cable is permitted.

C. Wire and Cable Sizes

1. The sizes of wire and cable shall be as indicated on the Drawings, or if not shown, as approved by the Engineer. If required due to field routing, the size of conductors and respective conduit shall be increased so that the voltage drop measured from source to load does not exceed 2-1/2%.

D. Additional Conductor Identification

1. In addition to the color-coding identification requirements specified in Part 2 herein, individual conductors shall be provided with heat shrinkable identification tags. Identification tags for individual conductors shall have a white background where the conductor insulation is colored. Identification tags for individual conductors shall have a colored background where the conductor insulation is black. Background color shall match that of the taping provided on the individual black conductors.
2. Multi-conductor cables shall be provided with heat shrinkable identification tags in accordance with Part 2 herein.
3. All wiring shall be identified at each point of termination. This includes but is not limited to identification at the source, load, and in any intermediate junction boxes where a termination is made. The Contractor shall meet with the Owner and Engineer to come to an agreement regarding a wire identification system prior to installation of any wiring. Wire numbers shall not be duplicated.
4. Wire identification shall be by means of a heat shrinkable sleeve with appropriately colored background and black text. Wire sizes #14 AWG through #10 AWG shall have a minimum text size of 7 points. Wire sizes #8 AWG and larger shall have a minimum text size of 10 points. Sleeves shall be of appropriate length to fit the required text. The use of handwritten text for wire identification shall not be permitted.

5. Sleeves shall be suitable for the size of wire on which they are installed. Sleeves shall not be heat-shrunk onto control cables. Tags shall remain loose on cable to promote easier identification. For all other applications, sleeves shall be tightly affixed to the wire and shall not move. Sleeves shall be heat shrunk onto wiring with a heat gun approved for the application. Sleeves shall not be heated by any means which employs the use of an open flame. The Contractor shall take special care to ensure that the wiring insulation is not damaged during the heating process.
6. Sleeves shall be installed prior to the completion of the wiring terminations and shall be oriented so that they can be easily read.
7. Sleeves shall be polyolefin as manufactured by Brady, Seton, Panduit, or equal.
8. Wire identification in manholes, handholes, pull boxes, and other accessible components in the raceway system where the wiring is continuous (no terminations are made) shall be accomplished by means of a tag installed around the bundled group of individual conductors or around the outer conductor jacket of a multi-conductor cable. Identification shall utilize a FROM-TO system. Each group of conductors shall consist of all the individual conductors in a single conduit or duct. The tag shall have text that identifies the bundle in accordance with the 'FROM' and 'TO' column for that specific conduit number in the conduit and wire schedule. Minimum text size shall be 10 point. The tag shall be affixed to the wire bundle using nylon wire ties and shall be made of polyethylene as manufactured by Brady, Seton, Panduit, or equal.
9. Where colored tape is used to identify cables, it shall be wrapped around the cable with a 25% overlap and shall cover at least 2 inches of the cable.

E. Wiring Supplies

1. Rubber insulating tape shall be in accordance with ASTM D4388. Friction tape shall be in accordance with ASTM D69.

F. Training of Cable in Manholes, Handholes, and Vaults

1. The Contractor shall furnish all labor and material required to train cables around cable vaults, manholes, and handholes. Sufficient length of cable shall be provided in each handhole, manhole, and vault so that the cable can be trained and racked in an approved manner. In training or racking, the radius of bend of any cable shall be not less than the manufacturer's recommendation. The training shall be done in such a manner as to minimize chaffing.
2. Instrumentation cable shall be racked and bundled separate from AC wiring to maintain the required separation as follows:

- a. 18 inches for 480/277 VAC wiring
- b. 12 inches for 208/120 VAC wiring
- c. 6 inches for 24 VAC wiring

G. Conductor Terminations

1. Where wires are terminated at equipment which requires lugs, connections shall be made by solderless mechanical lug, crimp type ferrule, or irreversible compression type lugs. Reference individual equipment Specification Sections as applicable for additional termination requirements.
2. For conductors with stranding other than Class B or C, a UL 486A Listed wire ferrule shall be installed prior to each conductor termination. Ferrules shall be suitable for the size of conductors and shall be made of a material that is compatible with the conductors. Ferrules shall be crimped on in accordance with the ferrule manufacturer's instructions.
3. Where enclosure sizes and sizes of terminals at limit switches, solenoid valves, float switches, pressure switches, temperature switches, and other devices make terminations impractical due to the size of the field wiring, the Contractor shall terminate field wiring in an adjacent junction box per the requirements of Section 26 05 33.16 – Boxes for Electrical Systems, complete with terminal strips. Contractor shall install the smaller wiring from the device to the junction box in a conduit, using the terminal strip as the means for joining the two different wire sizes. Splicing of wires in lieu of using terminal strips is not acceptable.
4. The cables shall be terminated in accordance with the cable and/or termination product manufacturer's instructions for the particular type of cable.
5. To minimize oxidation and corrosion, selected wire and cable shall be terminated using an oxide-inhibiting joint compound recommended for electrical connections. The compound shall be Penetrox E for copper-to-copper connections, and Penetrox A for all other connections, as manufactured by Burndy Electrical, or equal. The joint compound shall be used in the following installations:
 - a. Termination of aluminum conductors, where aluminum conductors are specifically allowed by the Engineer.
 - b. Terminations in all Class I and Class II, Division 1 and 2 hazardous areas.
6. All spare conductors shall be terminated on terminal blocks mounted within equipment or junction boxes. Unless otherwise noted, coiling up of spare conductors within enclosure is not acceptable.

H. Pulling Temperature

1. Cable shall not be installed when the temperature of the jacket is such that damage will occur due to low temperature embrittlement. When cable will be pulled with an ambient temperature of 40°F or less within a three (3) day period prior to pulling, the cable reels shall be stored three (3) days prior to pulling in a protected storage area with an ambient temperature of 55°F or more. Cable pulling shall be completed during the workday for which the cable is removed from the protected storage. Any cable reels with wire remaining on them shall be returned to storage at the completion of the workday.

I. Circuit Log

1. The Contractor shall maintain a written log of installed circuit lengths for all single-phase and three-phase power circuits operating at 208VAC or greater. The log shall be organized in a tabular format, recording the following items for each circuit:
 - a. Circuit ID or Conduit ID(s) as shown on the Drawings.
 - b. From (originating equipment).
 - c. To (terminating equipment).
 - d. Conductor sizes and counts.
 - e. Conductor length.

3.03 TESTING

- A. All testing shall be performed in accordance with the requirements of the General Conditions and Division 01. The following tests are required:

1. Shop Tests

- a. Wires and cables shall be tested in accordance with the applicable ICEA Standards. Wire and cable shall be physically and electrically tested in accordance with the manufacturer's standards.

2. Field Tests

- a. After installation, all wires and cables shall be tested for continuity. Testing for continuity shall be "test light" or "buzzer" style.
- b. After installation, wires and cables shall be tested for insulation resistance levels between conductors of the same circuit and between conductor and ground as follows:

- 1) For #8 AWG and larger 600V wire and cable, apply 1,000 VDC from a Megohmmeter for one (1) minute. Resistance shall be no less than 100 Megohms.
 - 2) Instrumentation signal cable shall be tested from conductor to conductor, conductor to shield, and conductor to ground using a Simpson No. 260 volt-ohmmeter or approved equal. The resistance value shall be 200 Megohms or greater.
 - 3) Insulation resistance testing is not required for power and control cables smaller than #8 AWG.
- c. Wires and cables shall be tested after required terminations are made, but before being connected to any equipment.
 - d. If tests reveal defects or deficiencies, the Contractor shall make the necessary repairs or shall replace the cable as directed by the Engineer, without additional cost to the Owner. All conductors of a multi-phase circuit shall be replaced if one conductor fails the required testing. If part of a multi-set (parallel conductors per phase) circuit fails testing, only the set containing failure shall be replaced.
 - e. All tests shall be made by and at the expense of the Contractor who shall supply all testing equipment. Test reports shall be submitted to the Engineer.

Exhibit A
Test Data – Megohms
Test No. _____

Date:			Company:				
Time:			Location:				
Circuit:	Circuit Length:	Aerial:	Duct:	Buried:	No. of Conductors	Size:	AWG MCM Shield:
Insulation Material:			Insulation Thickness:		Voltage Rating:		Age:
Type: _____ Pothead _____ Terminal					Location: Indoors _____ Outdoors _____		
Number and Type of Joints:							
Recent Operating History:							
Manufacturer:							
State if Potheads or Terminals were grounded during test:							
List associated equipment included in test:							
Miscellaneous Information:							

Exhibit A
Test Data – Megohms
Test No. _____

Part Tested:	Test Performed: _____ Hours/Days: _____ After Shutdown: _____
Grounding Time:	Dry Bulb Temperature: _____ Wet Bulb Temperature: _____
Test Voltage:	Equipment Temperature: _____ How Obtained: _____ Relative Humidity: _____ Absolute Humidity: _____ Dew Point: _____

Megohmmeter: Serial Number: _____ Range: _____
 Voltage: _____ Calibration Date: _____

Test Connections	To Line To Earth To Ground	To Line To Earth To Ground	To Line To Earth To Ground	Test Connections	To Line To Earth To Ground	To Line To Earth To Ground	To Line To Earth To Ground
1/4 Minute				5 Minutes			
1/2 Minute				6 Minutes			
3/4 Minute				7 Minutes			
1 Minute				8 Minutes			
2 Minutes				9 Minutes			
3 Minutes				10 Minutes			
4 Minutes				10/1 Minute Ratio			

Remarks:

END OF SECTION

SECTION 26 05 26
GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. The Contractor shall furnish and install grounding systems complete in accordance with the requirements established by Article 250 of the NEC. Article 250 of the NEC shall be considered a minimum requirement for compliance with this Specification.
- B. Grounding of all instrumentation and control systems shall be furnished and installed in accordance with the manufacturer/system requirements and IEEE 1100. Conflicts shall be promptly brought to the attention of the Engineer.
- C. In addition to the NEC requirements, building structural steel columns and metallic chemical storage tanks shall be permanently and effectively grounded:
- D. Reference Section 26 05 00 – Basic Electrical Requirements

1.02 CODES AND STANDARDS

- A. Equipment and materials covered under this Section shall be designed, manufactured, and/or Listed to the following standards as applicable:
 - 1. American National Standards Institute (ANSI)/Institute of Electrical and Electronic Engineers (IEEE):
 - a. IEEE 81 – Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System.
 - b. IEEE 1100 – Recommended Practice for Power and Grounding Electronic Equipment.
 - 2. National Fire Protection Association (NFPA):
 - a. NFPA 70 – National Electrical Code (NEC).
 - 3. Underwriters Laboratories (UL):
 - a. UL 467 – Grounding and Bonding Equipment.

1.03 SUBMITTALS

- A. In accordance with the procedures and requirements set forth in the General Conditions and Section 01 33 00 – Submittal Procedures, the Contractor shall obtain from the equipment manufacturer and submit the following:

1. Shop Drawings
 2. Reports of certified field tests.
- B. Each submittal shall be identified by the applicable Specification Section.

1.04 SHOP DRAWINGS

- A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.
- B. Partial, incomplete, or illegible submittals will be returned to the Contractor without review for resubmittal.
- C. Shop drawings shall include but not be limited to:
1. Product data sheets.
 2. Drawings and written description of how the Contractor intends to furnish and install the grounding system.

PART 2 – PRODUCTS

2.01 MANUFACTURERS

- A. The equipment covered by these specifications shall be standard equipment of proven performance as manufactured by reputable concerns. Equipment shall be designed, constructed, and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as shown on the Drawings.

2.02 GROUND RODS AND GRID

- A. Ground rods shall be rolled to a commercially round shape from a welded copper-clad steel manufactured by the molten-welding process or by the electro-formed process (molecularly bonded). They shall have an ultimate tensile strength of 75,000 pounds per square inch (psi) and an elastic limit of 49,000 psi. The rods shall be not less than 3/4 inch in diameter by 10 feet in length; and the proportion of copper shall be uniform throughout the length of the rod. The copper shall have a minimum wall thickness of 0.010 inch at any point on the rod. Ground rods shall be UL 467 Listed. The ground rods shall be manufactured by Erico Products, Blackburn, or Engineer approved equal.
- B. Except where specifically indicated otherwise, all exposed non –current carrying metallic parts of electrical equipment, metallic raceway systems, grounding conductors in nonmetallic raceways, and neutral conductors of wiring systems shall be grounded.
- C. The ground connection shall be made at the main service equipment and shall be extended to the ground grid surrounding the structure. The ground grid shall also be

connected to the point of entrance of the metallic water service. Connection to the water pipe shall be made by a suitable ground clamp or lug connection to a plugged tee. If flanged pipes are encountered, connection shall be made with the lug bolted to the street side of the flanged connection.

- D. Where ground fault protection is employed, care shall be taken so that the connection of the ground and neutral does not interfere with the correct operation of the ground fault protection system.

2.03 FITTINGS

- A. Grounding connections to equipment shall be bolted. Cable end connections shall be made by hydraulic crimp or exothermically welded. Split bolt type connectors are not acceptable. Fittings shall be UL 467 Listed. Underground connections shall be exothermally welded only.

2.04 EQUIPMENT GROUNDING CONDUCTORS

- A. An insulated equipment grounding conductor, which shall be separate from the electrical system grounded (neutral) conductor, shall be furnished and installed for all circuits. Insulation shall be of the same type as the ungrounded conductors in the raceway and shall be green in color. Equipment grounding conductors shall be furnished and installed in all conduits. Use of conduits as the NEC required equipment grounding conductor is not acceptable.

2.05 EQUIPMENT GROUNDS

- A. Equipment grounds shall be solid and continuous from a connection at earth to all distribution panelboards. Ground connections at panelboards, outlets, equipment, and apparatus shall be made in an approved and permanent manner.
- B. For all control panels, disconnect switches, and other electrical enclosures, equipment grounds, and bonding jumpers shall be terminated individually on a ground bar or mechanical lugs. No wire nuts will be permitted.

2.06 GROUND BARS

- A. Ground bars shall be furnished and installed where indicated on the Drawings and where required in the Specifications. Ground bars shall be tin-plated copper, 1/4-inch thick (minimum) with hole pairs spaced for NEMA 2-hole cable termination lugs. The number of hole pairs shall be as required for the number of cables terminated, plus four (4) spares (minimum). Ground bars shall be provided with insulated mounting hardware.

2.07 EXOTHERMIC WELDS

- A. All exothermic welding shall be completed per welding kit manufacturer's instructions. Exothermic welds shall be CadWeld by Erico or ThermoWeld.

PART 3 – EXECUTION

3.01 INSTALLATION

- A. Metal surfaces where grounding connections are to be made shall be clean and dry. Steel surfaces shall be ground or filed to remove all scale, rust, grease, and dirt. Copper and galvanized steel shall be cleaned with emery cloth to remove oxide before making connections.
- B. Ground Grid
 - 1. A main ground grid shall be provided for each structure and interconnecting structure grids consisting of driven ground rods as shown on the Drawings. Ground rods shall be driven straight down into the earth, or if objects are encountered, at an angle to avoid the obstruction.
 - 2. The ground rods shall be interconnected by the use of copper cable sized as shown on the Drawings. The interconnecting cables shall be connected to ground rods by hydraulic crimp or exothermic weld where buried, and removable bolted clamp where shown to be installed in test wells. The grounding cables shall be installed after the excavations for the building have been completed and prior to the pouring of concrete for the footings, mats, etc. Copper "pigtailes" shall be connected to the ground grid and shall enter the buildings and structure from the outside, and shall be connected to steel structures, equipment as described in this Section, and as required to provide a complete grounding system. The copper pigtailes shall be hydraulically crimped or exothermically welded to the ground grid and connected to building reinforcement steel by hydraulic crimp.
 - 3. Grounding conductors shall be continuous between points of connection; splices shall not be permitted.
 - 4. Where conductors are exposed and subject to damage from personnel, traffic, etc., conductors shall be installed in metal raceway. The raceway shall be bonded to the grounding system.
 - 5. Where subsurface conditions do not permit use of driven ground rods to obtain proper ground resistance, rods shall be installed in a trench or plate electrodes shall be provided, as applicable and necessary to obtain proper values of resistance.
 - 6. Buried hydraulic crimp connections, exothermic welds, and ground ring shall not be backfilled until inspected by Engineer.
- C. Raceways
 - 1. Conduit which enters equipment such as switchgear, switchboards, motor control centers, transformers, panelboards, variable frequency drives, instrument and

control panels, and similar equipment shall be bonded to the ground bus or ground lug, where provided, and as otherwise required by the NEC.

3.02 TESTING

- A. All tests shall be performed in accordance with the requirements of the General Conditions and Division 01. The following tests are required:
 - 1. Witnessed Shop Tests
 - a. None required.
 - 2. Field Tests
 - a. Field testing shall be done in accordance with the requirements specified in the General Conditions, Division 01, and NETA Acceptance Testing Specifications, latest edition.
 - b. Fall of potential tests shall be performed on the ground grid per IEEE 81 recommendations by a third party, independent testing firm. A fall of potential plot shall be submitted at the conclusion of testing for Engineer review. Documentation indicating the location of the rod and grounding system as well as the resistance and soil conditions at the time the measurements were made shall be submitted. Testing shall show that the ground grid has 5 ohms resistance or less. Due to soil conditions and/or unforeseen field conditions, ground resistances greater than 5 ohms may be acceptable if specifically approved in writing by the Engineer. Ground resistance measurements shall be made in normally dry weather not less than 48 hours after rainfall and with the ground grid under test isolated from other grounds.
 - c. Continuity tests for the grounding electrode conductor shall be performed. Test will be accepted when a resistance of less than 1 ohm is shown for this conductor.

END OF SECTION

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SECTION 26 05 29
HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. The Contractor shall furnish and install structural supports for mounting and installing all conduits, electrical equipment, lighting, alarm systems, instrumentation, and control and communications equipment furnished under this Contract.
- B. Equipment shall be installed strictly in accordance with recommendations of the manufacturer and best practices of the trade resulting in a complete, operable, and safe installation. The Contractor shall obtain written installation manuals from the equipment manufacturer prior to installation.
- C. Support design for all nonstructural electrical components (e.g., conduit and other raceways, freestanding equipment, etc.) shall be provided in accordance with the governing Building Code and Section 01 73 23 – Anchorage and Bracing of Nonstructural Components.
- D. Metal welds and fasteners shall be provided in accordance with the governing Building Code and Section 05 05 23 – Metal Fastening.
- E. Reference the following Specification Sections:
 - 1. Section 01 73 23 – Anchorage and Bracing of Nonstructural Components
 - 2. Section 05 10 00 – Metal Materials
 - 3. Section 05 05 23 – Metal Fastening
 - 4. Section 26 05 00 – Basic Electrical Requirements.

1.02 CODES AND STANDARDS

- A. Equipment and materials covered under this Section shall be designed, manufactured, and/or Listed to the following standards as applicable:
 - 1. American Society for Testing and Materials (ASTM):
 - a. ASTM A123 – Standard Specification for Zinc (Hot Dip Galvanized) Coatings on Iron and Steel Products.

- b. ASTM A153 – Standard Specification for Zinc Coating (Hot Dip) on Iron and Steel Hardware.
 - c. ASTM A240 – Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
 - d. ASTM A276 – Standard Specification for Steel Bars and Shapes.
 - e. ASTM B783 – Standard Specification for Materials for Ferrous Powder Metallurgy Structural Parts.
- 2. National Fire Protection Association (NFPA):
 - a. NFPA 70 – National Electrical Code (NEC).

1.03 SUBMITTALS

- A. In accordance with the procedures and requirements set forth in the General Conditions and Section 01 33 00 – Submittal Procedures, the Contractor shall obtain from the equipment manufacturer and submit the following:
 - 1. Shop drawings
 - 2. Structural support calculations and designs in accordance with the governing Building Code and Section 01 73 23 – Anchorage and Bracing of Nonstructural Components.
- B. Each submittal shall be identified by the applicable Specification Section.

1.04 SHOP DRAWINGS

- A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.
- B. Partial, incomplete, or illegible submittals will be returned to the Contractor without review for resubmittal.
- C. Shop drawings shall include but not be limited to:
 - 1. Product data sheets.
 - 2. Complete assembly, layout, installation, and foundation drawings with clearly marked dimensions.

PART 2 – PRODUCTS

2.01 MANUFACTURERS

- A. The equipment covered by this Specification is intended to be standard equipment of proven performance as manufactured by reputable concerns. Equipment shall be designed, constructed, and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as shown on the Drawings.

2.02 MATERIALS

- A. Support channel shall be 1-5/8" by 1-5/8" minimum, with 12-gauge material thickness.
- B. Support channel, support channel fittings, and threaded rod shall be furnished with the following material of construction, dependent upon the designation of the area in which they are to be installed. Area designations are indicated on the Drawings.

Area Designation	Material of Construction
Indoor Wet Process Area	Type 304 Stainless Steel
Indoor Dry Process Area	Hot Dipped Galvanized Steel
Indoor Dry Non-process Area	Hot Dipped Galvanized Steel
Indoor Type 1 Chemical Storage/Transfer Area	Fiberglass
Indoor Type 2 Chemical Storage/Transfer Area	Type 304 Stainless Steel
All Outdoor Areas	Type 304 Stainless Steel
All Hazardous Areas	Type 304 Stainless Steel

- C. Fastening hardware (bolts, nuts, washers, and screws) shall be furnished with the following material of construction, dependent upon the designation of the area in which they are to be installed. Area designations are indicated on the Drawings.

Area Designation	Material of Construction
Indoor Wet Process Area	Type 304 Stainless Steel
Indoor Dry Process Area	Type 304 Stainless Steel
Indoor Dry Non-process Area	Type 304 Stainless Steel
Indoor Type 1 Chemical Storage/Transfer Area	Fiberglass
Indoor Type 2 Chemical Storage/Transfer Area	Type 304 Stainless Steel
All Outdoor Areas	Type 304 Stainless Steel
All Hazardous Areas	Type 304 Stainless Steel

PART 3 – EXECUTION

3.01 INSTALLATION

A. Concrete and Masonry Anchors

1. The Contractor shall be responsible for the furnishing and installation of all concrete anchors, masonry anchors, anchor screen tubes, bolts, and similar devices required for installation of equipment furnished under this Contract.
2. Where specific anchor types and sizes are called for on the Drawings, those anchor types and sizes shall be used. Where the Drawings call for anchors but do not have any type or size details shown, the anchors shall be designed and selected by an Engineer currently registered in the State or Commonwealth in which the project is located. Reference Section 05 05 23 – Metal Fastening for anchor product specifications and anchor design requirements.

B. The Contractor shall furnish leveling channels for all switchgear, switchboards, motor control centers, and similar floor mounted equipment. The leveling channels shall be provided for embedment in the equipment housekeeping pads. Coordination of the installation of these channels with the concrete pad is essential and required. Pad height shall be as required to maintain concrete coverage of the reinforcement bars while not causing associated equipment to exceed the maximum mounting height requirements of the NEC.

C. Support Fastening and Locations

1. All equipment fastenings to columns, steel beams, and trusses shall be by beam clamps or welded. No holes shall be drilled in the steel.
2. Unless otherwise indicated on the Drawings or in the Specifications, guards/handrails shall not be utilized as supports for electrical equipment, devices, or appurtenances. Guards/handrails shall not be cut, drilled, or otherwise modified in order to accommodate electrical supports without written approval from the Engineer.
3. All holes made in reflected ceilings for support rods, conduits, and other equipment shall be made adjacent to ceiling grid bars, where possible, to facilitate removal of ceiling panels.
4. Support channel shall be provided wherever required for the support of starters, switches, panels, and miscellaneous equipment.
5. Equipment, devices, and raceways that are installed on the dry side of a water bearing wall shall not be installed directly onto the wall. Support channel shall be used to allow ventilation air to pass behind the equipment, devices, or raceway.

6. All supports shall be rigidly bolted together and braced to make a substantial supporting framework. Where possible, control equipment shall be grouped together and mounted on a single framework.
7. Aluminum support members shall not be installed in direct contact with concrete. Stainless steel or non-metallic "spacers" shall be used to prevent contact of aluminum with concrete.
8. Actual designs for supporting framework should take the nature of a picture frame of support channels and bracket with a plate for mounting the components. The Contractor is responsible for the design of supporting structure; Contractor shall submit design details to the Engineer for acceptance before proceeding with the fabrication.
9. Wherever dissimilar metals come into contact, the Contractor shall isolate these metals as required with neoprene washers, nine (9) mil polyethylene tape, or gaskets. Reference Section 05 10 00 - Metal Materials for guidance on dissimilar metals.
10. For all installations where fiberglass supporting materials are required, the Contractor shall submit structural calculations and the details of the proposed system of support. Structural calculations shall be signed and sealed by a Professional Engineer (P.E.) licensed in the State or Commonwealth in which the project is located.
11. For the following installations where conduits are provided with a support system suspended from the above or attached to a vertical structure, the Contractor shall submit structural calculations and details of the proposed system of support. Structural calculations shall be signed and sealed by a Professional Engineer (P.E.) licensed in the State or Commonwealth in which the project is located.
 - a. A quantity of twelve (12) or more conduits trade size 1" and smaller are proposed for a conduit support rack.
 - b. A quantity of eight (8) or more conduits trade sizes 1 1/2" to 2 1/2" are proposed for a conduit support rack.
 - c. A quantity of four (4) or more conduits trade sizes 3" and larger are proposed for a conduit support rack.
12. Single conduits installed exposed along walls and ceilings shall be secured to the wall or ceiling with a one-hole conduit clamp and clamp-back. Where multiple conduits are installed exposed together, support channel and conduit clamps shall be used.

- D. Equipment, boxes, and enclosures which are factory-constructed with integral mounting provisions (such as brackets, mounting feet, bolt holes, etc.) shall be installed/supported utilizing those mounting provisions. Equipment, boxes and enclosures shall not be field-modified by any means which compromises the UL Listing or NEMA rating of the enclosure/assembly.

END OF SECTION

SECTION 26 05 33.13
CONDUIT FOR ELECTRICAL SYSTEMS

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. The Contractor shall furnish and install conduits, conduit fittings, and appurtenances to complete the installation of all electrically operated equipment as specified herein, indicated on the Drawings, and as required.
- B. Reference Specification Section 26 05 00 – Basic Electrical Requirements.
- C. Requirements for conduit clamps, support systems, and anchoring are not included in this Section. Reference Specification Section 26 05 29 – Hangers and Supports for Electrical Systems, for these requirements.

1.02 CODES AND STANDARDS

- A. All equipment and materials shall be Listed by and shall bear the Label of Underwriter's Laboratories, Incorporated (UL).
- B. Conduits, conduit fittings, and appurtenances shall be designed, manufactured, and/or Listed to the following standards as applicable:
 - 1. American National Standards Institute (ANSI)
 - a. ANSI/ASME B1.20.1 – Pipe Threads, General Purpose.
 - b. ANSI C80.1 – Electrical Rigid Steel Conduit.
 - c. ANSI C80.3 – Steel Electrical Metallic Tubing.
 - d. ANSI C80.5 – Electrical Rigid Aluminum Conduit.
 - e. ANSI/NEMA FB 1 – Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing, and Cable.
 - 2. National Electrical Contractors Association (NECA):
 - a. NECA 1 – Standard for Good Workmanship in Electrical Construction.
 - 3. National Electrical Manufacturer's Association (NEMA):
 - a. NEMA FB 2.40 – Installation Guidelines for Expansion and Expansion/Deflection Fittings.

- b. NEMA RN 1 – PVC Externally Coated Galvanized Rigid Steel Conduit.
 - c. NEMA RV-3 – Application and Installation Guidelines for Flexible and Liquid-tight Flexible Metal and Nonmetallic Conduits.
 - d. NEMA TC-2 – Electrical PVC Conduit.
 - e. NEMA TC-3 – PVC Fittings for Use with Rigid PVC Conduit and Tubing.
4. National Fire Protection Association (NFPA):
- a. NFPA 70 – National Electrical Code (NEC).
5. Underwriters Laboratories (UL):
- a. UL 1 – Standard for Flexible Metal Conduit.
 - b. UL 6 – Electrical Rigid Metal Conduit-Steel.
 - c. UL 6A – Electrical Rigid Metal Conduit-Aluminum, Red Brass, and Stainless Steel.
 - d. UL 360 – Standard for Liquid-tight Flexible Metal Conduit.
 - e. UL 467 – Grounding and Bonding Equipment.
 - f. UL 514B – Conduit, Tubing, and Cable Fittings.
 - g. UL 651 – Standard for Schedule 40 and 80 Conduit and Fittings.
 - h. UL 797 – Electrical Metallic Tubing-Steel.
 - i. UL 1203 – Standard for Explosion-proof and Dust-ignition-proof Electrical Equipment for use in Hazardous (Classified) Locations.
 - j. UL 1479 – Standard for Fire Tests of Penetration Fire Stops.
 - k. UL 1660 – Liquid-tight Flexible Nonmetallic Conduit.
6. Others:
- a. American Concrete Institute (ACI): ACI 318 – Building Code Requirements for Structural Concrete.
 - b. Aluminum Association – Aluminum and It's Alloys.

1.03 SUBMITTALS

- A. In accordance with the procedures and requirements set forth in the General Conditions and Section 01 33 00 – Submittal Procedures, the Contractor shall obtain from the equipment manufacturer and submit the following:
 - 1. Shop Drawings
- B. Each submittal shall be identified by the applicable Specification Section.

1.04 SHOP DRAWINGS

- A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.
- B. Partial, incomplete, or illegible submittals will be returned to the Contractor without review for resubmittal.
- C. Shop drawings shall include but not be limited to:
 - 1. Conduit identification methods and materials.
 - 2. Product data sheets for conduits, fittings, and miscellaneous associated materials.
 - a. The product data sheets for conduits and fittings for up to three (3) manufacturers for each type of conduit specified herein will be reviewed if they are submitted at the same time under the same submittal cover for simultaneous review.
 - b. Despite the number of manufacturers that may be approved, only one manufacturer of PVC coated rigid metal conduit will be permitted to be installed on this project in accordance with the requirements set forth in Part 3 herein.
 - 3. Manufacturer's Warranty Statement for PVC coated rigid metal conduit.
 - 4. Evidence of training for all personnel that will install PVC coated rigid metal conduit.

1.05 DEFINITIONS

- A. Conduits are categorized by the circuit type of the wiring to be installed inside. Conduits are defined as follows:
 - 1. Power Conduits – Conduits that carry AC or DC power wiring from a source to a load. Conduits that carry lighting and receptacle wiring.

2. Control Conduits – Conduits that carry AC or DC discrete control wiring between devices and/or equipment. Also, conduits that carry fiber optic cables between devices and/or equipment.
 3. Instrumentation Conduits – Conduits that carry AC or DC analog signal wiring between devices and/or equipment. Conduits that carry Category 5e or Category 6 unshielded twisted-pair cables.
- B. Conduit categories are indicated on the Drawings by the leading letter of the conduit tag. Conduit tag leading letters are defined as follows:
1. P – Power Conduit
 2. C – Control Conduit
 3. I – Instrumentation Conduit

PART 2 – PRODUCTS

2.01 GENERAL

- A. Conduit and conduit fitting products are specified in the text that follows this article. Reference Part 3 herein for the application, uses, and installation requirements of these conduits and conduit fittings.
- B. All metallic conduit fittings shall be UL 514B and UL 467 Listed and constructed in accordance with ANSI FB 1. All metallic conduit fittings for use in Class I, Division 1 hazardous areas shall be UL 1203 Listed with a visible certification tag on the outside of the fitting. All non-metallic fittings shall be UL 651 Listed and constructed in accordance with NEMA TC-3.
- C. Flexible conduit couplings for use in Class I, Division 1 hazardous areas shall have threaded Type 316 stainless steel end fittings and a flexible braided core. Flexible braid shall be constructed of Type 316 stainless steel where available in the conduit trade size required for the application. Where Type 316 stainless steel braid is not available, the braid shall be provided with a factory-applied PVC coating. No other braid types or materials are acceptable.
- D. Where threading is specified herein for conduit fitting connections, the fittings shall be manufactured to accept conduit that is threaded to ANSI B1.20.1 requirements.
- E. Conduit expansion fittings for all conduit materials of construction shall be capable of 4 inches of movement along the axis of the conduit for trade sizes 2 inches or less. Expansion fittings shall be capable of 8 inches of movement along the axis of the conduit for trade sizes greater than 2 inches.

- F. Conduit deflection fittings for all conduit materials of construction shall be provided with a flexible neoprene outer jacket that permits up to $\frac{3}{4}$ inch of expansion/contraction along the axis of the conduit as well as up to $\frac{3}{4}$ inch of parallel misalignment between the conduit axes. Outer jacket shall be secured to the conduit hubs by Type 304 stainless steel clamps.
- G. Conduit seals shall either be Listed and Labeled for 40% fill, or conduit reducing fittings and a trade size larger conduit seal shall be provided to achieve 25% or less fill within the seal. Percentage fill calculation shall be based on the conductors to be installed. Conduit seals shall be provided with breathers and/or drains where required by the NEC.
- H. Conduit insulating bushings shall be constructed of plastic and shall have internal threading.
- I. Additional conduit and conduit fitting requirements are specified in the articles that follow based on the specific conduit material of construction to be used.

2.02 RIGID GALVANIZED STEEL (RGS) CONDUIT AND ASSOCIATED FITTINGS

A. Conduit

- 1. Conduit shall be hot dip galvanized on the inside and outside and made of heavy wall high strength ductile steel. Conduit shall be manufactured in accordance with ANSI C80.1 and shall be UL 6 Listed.
- 2. Conduit shall be provided with factory-cut $\frac{3}{4}$ inch per foot tapered threads at each end in accordance with ANSI B1.20.1. Threads shall be cut prior to galvanizing to ensure corrosion protection adequately protects the threads. Conduit shall be provided with a matching coupling on one end and a color-coded thread protector on the other.

B. Conduit Bodies for use with Rigid Galvanized Steel

- 1. Conduit bodies shall be constructed of an electro-galvanized malleable iron alloy which is coated with an acrylic paint finish. Conduit bodies shall have integral threaded conduit hubs.
- 2. Conduit bodies for Class I, Division 1 hazardous areas shall be provided with integrally threaded covers constructed of an electro-galvanized malleable iron alloy which is coated with an acrylic paint finish.
- 3. Conduit bodies for all other areas shall be provided with covers that are affixed in place by Type 304 stainless steel screws which thread directly into the conduit body. Covers that utilize wedge nuts or any other method of attachment to the conduit body are not acceptable. Covers shall be constructed of an electro-galvanized malleable iron alloy which is coated with an acrylic paint finish. Covers shall be provided with matching gasket.

C. Conduit Couplings, Nipples, and Unions for use with Rigid Galvanized Steel

1. Couplings and nipples shall be threaded and shall be constructed of hot dipped galvanized steel. Split-type couplings that use compression to connect conduits are not acceptable.
2. Unions shall be threaded, rain-tight, and constructed of an electro-galvanized malleable iron alloy which is coated with an acrylic paint finish.

D. Conduit Expansion and Deflection Fittings for use with Rigid Galvanized Steel

1. Conduit expansion fittings and conduit deflection fittings shall be constructed of bronze or an electro-galvanized malleable iron alloy. Expansion and deflection fittings shall have threaded conduit connections.
2. Expansion fittings shall have an integral bonding jumper and deflection fittings shall have an external bonding jumper.

E. Conduit Seals for use with Rigid Galvanized Steel

1. Conduit seals shall be constructed of an electro-galvanized malleable iron alloy which is coated with an acrylic paint finish. Conduit seals shall have threaded conduit connections.

F. Conduit Termination Fittings for use with Rigid Galvanized Steel

1. Conduit hubs shall be constructed of Type 316 stainless steel and shall have threaded connections to the conduit and enclosure. Hubs shall have a plastic insulated throat and shall be watertight when assembled to an enclosure.
2. Conduit locknuts shall be constructed of zinc plated steel. Locknuts shall have internal threading. Locknuts with integral gasket or seal are not acceptable. Locknuts shall have integral bonding screw where required for proper bonding.
3. Conduit bonding bushings shall be constructed of zinc plated malleable iron. Bonding bushings shall have a threaded conduit connection. Bonding bushing shall be provided with properly sized set screw for connecting bonding conductor and an integral plastic insulator rated for 150 degrees C located in the throat.

2.03 RIGID NONMETALLIC CONDUIT AND ASSOCIATED FITTINGS

A. Conduit

1. Conduit shall be Schedule 40 or 80 (dependent on application) polyvinyl chloride (PVC) construction, manufactured in accordance with NEMA TC-2, UL 651 Listed, and suitable for conductors with 90 degree C insulation.

B. Conduit Bodies for use with Rigid Nonmetallic Conduit

1. Conduit bodies shall be constructed of PVC. Conduit hubs shall be integral to the conduit body and shall be smooth inside to accept a glued conduit connection.
 2. Conduit body shall be provided with cover that is affixed in place by Type 304 stainless steel screws which thread directly into the conduit body. Covers that utilize wedge nuts or any other method of attachment to the conduit body are not acceptable. Covers shall be provided with matching gasket.
- C. Conduit Couplings and Unions for use with Rigid Nonmetallic Conduit
1. Conduit couplings and unions shall be constructed of PVC and shall be smooth inside to accept a glued conduit connection.
- D. Conduit Expansion and Deflection Fittings for use with Rigid Nonmetallic Conduit
1. Conduit expansion fittings and conduit deflection fittings shall be constructed of PVC and shall be smooth inside to accept a glued conduit connection.
- E. Conduit Termination Fittings for use with Rigid Nonmetallic Conduit
1. Conduit hubs (threaded adapters) shall be constructed of PVC and shall be smooth inside to accept a glued conduit connection. Hubs shall have external threads and an accompanying PVC locknut and shall be watertight when assembled to an enclosure.
 2. Conduit locknuts shall be constructed of zinc plated steel. Locknuts shall have internal threading. Locknuts constructed of PVC and locknuts with integral gasket or seal are not acceptable.
 3. Conduit end bells shall be constructed of PVC and shall be smooth inside to accept a glued conduit connection. End bell shall have a smooth inner surface that curves outward towards the edge of the fitting.

2.04 PVC COATED RIGID GALVANIZED STEEL CONDUIT AND ASSOCIATED FITTINGS

A. General

1. Where an external coating of polyvinyl chloride (PVC) is specified for conduit and fittings, the coating shall be 40 mil (minimum) thickness. Where an internal coating of urethane is specified for conduit and fittings, the coating shall be 2 mil (minimum) thickness.
2. All conduit fittings shall have a sealing sleeve constructed of PVC which covers all connections to conduit. Sleeves shall be appropriately sized so that no conduit threads will be exposed after assembly.

3. PVC coated conduit and associated PVC coated fittings shall be Ocal-Blue by ABB, Plasti-Bond by Robroy Industries, or Perma-Cote by Robroy Industries, no substitutions.
4. PVC coated conduit and associated PVC coated fittings shall be provided with a 5-year non-prorated warranty covering manufacturing defects and improper installation by the Contractor.

B. Conduit

1. Conduit shall be hot dip galvanized on the inside and outside and made of heavy wall high strength ductile steel. Conduit shall be manufactured in accordance with ANSI C80.1 and shall be UL 6 Listed.
2. Conduit shall be provided with factory-cut 3/4 inch per foot tapered threads at each end in accordance with ANSI B1.20.1. Threads shall be cut prior to galvanizing to ensure corrosion protection adequately protects the threads. Conduit shall be provided with a matching coupling on one end and a color-coded thread protector on the other.
3. Conduit shall be coated on the exterior with a PVC jacket and coated on the interior with a layer of urethane. Conduit shall be manufactured in accordance with NEMA RN 1.

C. Conduit Bodies for use with PVC Coated Rigid Galvanized Steel Conduit

1. Conduit bodies shall be constructed of an electro-galvanized malleable iron alloy which is coated on the exterior with a PVC jacket and coated on the interior with a layer of urethane. Conduit bodies shall have integral threaded conduit hubs.
2. Conduit bodies for Class I, Division 1 hazardous areas shall be provided with integrally threaded covers constructed of an electro-galvanized malleable iron alloy which is coated on the exterior with a PVC jacket and coated on the interior with a layer of urethane.
3. Conduit bodies for all other areas shall be constructed of an electro-galvanized malleable iron alloy which is coated on the exterior with a PVC jacket and coated on the interior with a layer of urethane. Covers shall be affixed in place by Type 304 stainless steel screws which thread directly into the conduit body and have a plastic encapsulated head. Covers that utilize wedge nuts or any other method of attachment to the conduit body are not acceptable. Covers shall be provided with matching gasket.

D. Conduit Couplings, Nipples, and Unions for use with PVC Coated Rigid Galvanized Steel Conduit

1. Couplings and nipples shall be threaded and shall be constructed of hot dipped galvanized steel which is coated on the exterior with a PVC jacket and coated on the interior with a layer of urethane. Split-type couplings that use compression to connect conduits are not acceptable.
 2. Unions shall be threaded, rain-tight, and constructed of an electro-galvanized malleable iron alloy which is coated on the exterior with a PVC jacket and coated on the interior with a layer of urethane.
- E. Conduit Expansion and Deflection Fittings for use with PVC Coated Rigid Galvanized Steel Conduit
1. Conduit expansion fittings and conduit deflection fittings shall be constructed of bronze or an electro-galvanized malleable iron alloy which is coated on the exterior with a PVC jacket and coated on the interior with a layer of urethane. Expansion and deflection fittings shall have threaded conduit connections.
 2. Expansion fittings shall have an integral bonding jumper and deflection fittings shall have an external bonding jumper.
- F. Conduit Seals for use with PVC Coated Rigid Galvanized Steel Conduit
1. Conduit seals shall be constructed of an electro-galvanized malleable iron alloy which is coated on the exterior with a PVC jacket and coated on the interior with a layer of urethane. Conduit seals shall have threaded conduit connections.
- G. Conduit Termination Fittings for Use with PVC Coated Rigid Galvanized Steel Conduit
1. Conduit hubs shall be constructed of an electro-galvanized malleable iron alloy which is coated on the exterior with a PVC jacket and coated on the interior with a layer of urethane. Hubs shall have threaded connections to the conduit and enclosure. Hubs shall have a plastic insulated throat and shall be watertight when assembled to an enclosure.
 2. Conduit bonding bushings shall be constructed of zinc plated malleable iron which is coated on the exterior with a PVC jacket and coated on the interior with a layer of urethane. Bonding bushings shall have a threaded conduit connection. Bonding bushing shall be provided with properly sized set screw for connecting bonding conductor and an integral plastic insulator rated for 150 degrees C located in the throat.

2.05 RIGID ALUMINUM CONDUIT AND ASSOCIATED FITTINGS

A. Conduit

1. Conduit shall be made of heavy wall high strength 6063 alloy aluminum with temper designation T1 as defined by the Aluminum Association. Conduit shall be manufactured in accordance with ANSI C80.5 and shall be UL 6A Listed.
2. Conduit shall be provided with factory-cut 3/4 inch per foot tapered threads at each end in accordance with ANSI B1.20.1. Threads shall be cut prior to galvanizing to ensure corrosion protection adequately protects the threads. Conduit shall be provided with a matching coupling on one end and a color-coded thread protector on the other.

B. Conduit Bodies for use with Rigid Aluminum Conduit

1. Conduit bodies shall be constructed of copper-free aluminum which is coated with an aluminum enamel finish. Conduit bodies shall have integral threaded conduit hubs.
2. Conduit bodies for Class I, Division 1 hazardous areas shall be provided with integrally threaded covers constructed of copper-free aluminum which is coated with an aluminum enamel finish.
3. Conduit bodies for all other areas shall be provided with stamped copper-free aluminum covers that are affixed in place by Type 304 stainless steel screws which thread directly into the conduit body. Covers that utilize wedge nuts or any other method of attachment to the conduit body are not acceptable. Covers shall be provided with matching gasket.

C. Conduit Couplings, Nipples, and Unions for use with Rigid Aluminum Conduit

1. Couplings and nipples shall be threaded and shall be constructed of heavy wall high strength 6063 alloy aluminum with temper designation T1. Split-type couplings that use compression to connect conduits are not acceptable.
2. Unions shall be threaded, rain-tight, and constructed of copper-free aluminum which is coated with an aluminum enamel finish.

D. Conduit Expansion and Deflection Fittings for use with Rigid Aluminum Conduit

1. Conduit expansion fittings and conduit deflection fittings shall be constructed of copper-free aluminum which is coated with an aluminum enamel finish. Expansion and deflection fittings shall have threaded conduit connections.
2. Expansion fittings shall have an integral bonding jumper and deflection fittings shall have an external bonding jumper.

E. Conduit Seals for use with Rigid Aluminum Conduit

1. Conduit seals shall be constructed of copper-free aluminum which is coated with an aluminum enamel finish. Conduit seals shall have threaded conduit connections.

F. Conduit Termination Fittings for use with Rigid Aluminum Conduit

1. Conduit hubs shall be constructed of copper-free aluminum and shall have threaded connections to the conduit and enclosure. Hubs shall have a plastic insulated throat and shall be watertight when assembled to an enclosure.
2. Conduit locknuts shall be constructed of copper-free aluminum. Locknuts shall have internal threading. Locknuts with integral gasket or seal are not acceptable. Locknuts shall have integral bonding screw where required for proper bonding.
3. Conduit bonding bushings shall be constructed of copper-free aluminum. Bonding bushings shall have a threaded conduit connection. Bonding bushing shall be provided with properly sized set screw for connecting bonding conductor and an integral plastic insulator rated for 150 degrees C located in the throat.

2.06 PVC COATED RIGID ALUMINUM CONDUIT AND ASSOCIATED FITTINGS

A. General

1. Where an external coating of polyvinyl chloride (PVC) is specified for conduit and fittings, the coating shall be 40 mil (minimum) thickness. Where an internal coating of urethane is specified for conduit and fittings, the coating shall be 2 mil (minimum) thickness.
2. All conduit fittings shall have a sealing sleeve constructed of PVC which covers all connections to conduit. Sleeves shall be appropriately sized so that no conduit threads will be exposed after assembly.
3. PVC coated conduit and associated PVC coated fittings shall be Ocal-Blue by ABB, Plasti-Bond by Robroy Industries, or Perma-Cote by Robroy Industries, no substitutions.
4. PVC coated conduit and associated PVC coated fittings shall be provided with a 5-year non-prorated warranty covering manufacturing defects and improper installation by the Contractor.

B. Conduit

1. Conduit shall be made of heavy wall high strength 6063 alloy aluminum with temper designation T1. Conduit shall be manufactured in accordance with ANSI C80.5 and shall be UL 6A Listed.

2. Conduit shall be provided with factory-cut 3/4 inch per foot tapered threads at each end in accordance with ANSI B1.20.1. Threads shall be cut prior to galvanizing to ensure corrosion protection adequately protects the threads. Conduit shall be provided with a matching coupling on one end and a color-coded thread protector on the other.
3. Conduit shall be coated on the exterior with a PVC jacket and coated on the interior with a layer of urethane. Conduit shall be manufactured in accordance with NEMA RN 1.

C. Conduit Bodies for use with PVC Coated Rigid Aluminum Conduit

1. Conduit bodies shall be constructed of copper-free aluminum which is coated on the exterior with a PVC jacket and coated on the interior with a layer of urethane. Conduit bodies shall have integral threaded conduit hubs.
2. Conduit bodies for Class I Division 1 hazardous areas shall be provided with integrally threaded covers constructed of copper-free aluminum which is coated on the exterior with a PVC jacket and coated on the interior with a layer of urethane.
3. Conduit bodies for all other areas shall be constructed of copper-free aluminum which is coated on the exterior with a PVC jacket and coated on the interior with a layer of urethane. Covers shall be affixed in place by Type 304 stainless steel screws which thread directly into the conduit body and have a plastic encapsulated head. Covers that utilize wedge nuts or any other method of attachment to the conduit body are not acceptable. Covers shall be provided with matching gasket.

D. Conduit Couplings, Nipples, and Unions for use with PVC Coated Rigid Aluminum Conduit

1. Couplings and nipples shall be threaded and shall be constructed of copper-free aluminum which is coated on the exterior with a PVC jacket and coated on the interior with a layer of urethane. Split-type couplings that use compression to connect conduits are not acceptable.
2. Unions shall be threaded, rain-tight, and constructed of copper free aluminum which is coated on the exterior with a PVC jacket and coated on the interior with a layer of urethane.

E. Conduit Expansion and Deflection Fittings for use with PVC Coated Rigid Aluminum Conduit

1. Conduit expansion fittings and conduit deflection fittings shall be constructed of copper-free aluminum which is coated on the exterior with a PVC jacket and coated on the interior with a layer of urethane. Expansion and deflection fittings shall have threaded conduit connections.

2. Expansion fittings shall have an integral bonding jumper and deflection fittings shall have an external bonding jumper.

F. Conduit Seals for use with PVC Coated Rigid Aluminum Conduit

1. Conduit seal shall be constructed of copper-free aluminum which is coated on the exterior with a PVC jacket and coated on the interior with a layer of urethane. Conduit seals shall have threaded conduit connections.

G. Conduit Termination Fittings for use with PVC Coated Rigid Aluminum Conduit

1. Conduit hubs shall be constructed of copper-free aluminum which is coated on the exterior with a PVC jacket and coated on the interior with a layer of urethane. Hubs shall have threaded connections to the conduit and enclosure. Hubs shall have a plastic insulated throat and shall be watertight when assembled to an enclosure.
2. Conduit bonding bushings shall be constructed of copper-free aluminum which is coated on the exterior with a PVC jacket and coated on the interior with a layer of urethane. Bonding bushings shall have a threaded conduit connection. Bonding bushing shall be provided with properly sized set screw for connecting bonding conductor and an integral plastic insulator rated for 150 degrees C located in the throat.

2.07 LIQUID TIGHT FLEXIBLE METAL CONDUIT (LFMC) AND ASSOCIATED FITTINGS

A. Conduit

1. Conduit shall be manufactured using a single strip of hot dip galvanized high strength steel alloy, helically formed into a continuously interlocked flexible metal conduit. Trade size 1-1/4 inch and smaller conduits shall be provided with an integrally woven copper bonding strip.
2. Conduit shall be covered with an outside PVC jacket that is UV resistant, moisture-proof, and oil-proof. Conduit shall be UL 360 Listed. Conduits shall be Listed for and marked with maximum temperature ratings as follows:
 - a. 105 degrees C dry, 60 degrees C wet for all conduit installed against or within 2 inches of equipment capable of having a surface temperature of 80 degrees C or greater (e.g., blowers, incinerators, etc.)
 - b. 80 degrees C dry, 60 degrees C wet for all other locations

B. Conduit Termination Fittings for use with LFMC

1. Conduit termination fittings shall be constructed of one of the following:
 - a. Type 304 stainless steel

- b. Copper-free aluminum
 - c. Electro-galvanized malleable iron alloy which is coated on the exterior with a 40 mil (minimum) PVC jacket and coated on the interior with a 2 mil (minimum) layer of urethane. PVC coated fittings shall have a sealing sleeve constructed of PVC which covers the connection to the rigid conduit.
2. Termination fittings shall have a threaded end with matching locknut and sealing ring for termination to equipment. Termination fittings shall have an integral external bonding lug where required to comply with Standard Detail E-26-0104. Termination fittings shall have a plastic insulated throat and shall be watertight when assembled to the conduit and equipment.

2.08 LIQUID TIGHT FLEXIBLE NONMETALLIC CONDUIT (LFNC) AND ASSOCIATED FITTINGS

A. Conduit

1. Conduit shall be constructed of rigid polyvinyl chloride (PVC), fabricated to provide flexibility. Conduit shall be covered with an outside PVC jacket that is UV resistant, moisture-proof, and oil-proof. Conduit shall be UL 1660 Listed and be Type LFNC-B.

B. Conduit Termination Fittings for use with LFNC

1. Conduit termination fittings shall be constructed PVC and shall have a threaded end with matching locknut and sealing ring for termination to equipment. Termination fittings shall be watertight when assembled to the conduit and equipment.

2.09 FLEXIBLE METAL CONDUIT (FMC) AND ASSOCIATED FITTINGS

A. Conduit

1. Conduit shall be manufactured using a single strip of hot dip galvanized high strength steel alloy, helically formed into a continuously interlocked flexible metal conduit. Conduit shall be UL 1 Listed.

B. Conduit Termination Fittings for use with FMC

1. Conduit termination fittings shall be constructed of an electro-galvanized malleable iron alloy. Fittings shall have a threaded end with matching locknut for termination to equipment, and a compression-style connection to the associated conduit.

2.10 ELECTRICAL METALLIC TUBING (EMT) AND ASSOCIATED FITTINGS

1. EMT Conduit is not permitted on this job.

2.11 CONDUIT BENDS

- A. Rigid conduit bends, both factory-fabricated and field-fabricated, shall meet the same requirements listed in the articles above for the respective conduit type and material of construction.
- B. Conduit bend radii for standard radius bends shall be no less than as follows:

Trade Size (inches)	3/4	1	1-1/4	1-1/2	2	2-1/2	3	3-1/2	4	5	6
Min. Radius (inches)	4-1/2	5-3/4	7-1/4	8-1/4	9-1/2	10-1/2	13	15	16	24	30

- C. Conduit bend radii for long radius bends shall be no less than as follows:

Trade Size (inches)	3/4	1	1-1/4	1-1/2	2	2-1/2	3	3-1/2	4	5	6
Min. Radius (inches)	N/A	12	18	24	30	30	36	36	48	48	60

2.12 MISCELLANEOUS

- A. Conduit Periphery Sealing

1. The sealing of the exterior surface of conduits to prevent water and/or air from passing around the conduit periphery from one space to another (where required) shall be through the use of one of the following:
 - a. A conduit sleeve and pressure bushing sealing system. Acceptable products are FSK by OZ-GEDNEY, Link-Seal by Crouse-Hinds, or Engineer approved equal.
 - b. A conduit sleeve that is two trade sizes larger than the conduit being sealed, with 2-hour fire rated UL 1479 Listed caulk filling the entire void between the conduit and sleeve. This method is only suitable for penetrations in non-fire rated walls and floors.
 - c. Conduit penetrations through fire-rated walls and floors shall be made with an approved UL 1479 Listed product specifically intended for the trade size of the conduit.
2. See Part 3 herein for the specific application of the conduit periphery sealing requirements above that are to be used based on what the conduit will be penetrating.

- B. Primer and Cement

1. Nonmetallic conduit shall be cleaned with primer and connected to fittings with the manufacturer's recommended cement that is labeled Low VOC.

C. Galvanizing Compounds

1. Galvanizing compounds for field application shall be the cold-applied type, containing no less than 93% pure zinc.

D. Conduit Interior Sealing

1. For all conduits that have cables inside, the sealing of the inside of the conduits against water ingress shall be achieved through the use of one of the following:
 - a. Two-part expanding polyurethane foam sealing compound, dispensed from a single tube which mixes the two parts as it is injected into the conduit. Expanding foam shall be compatible with the conduit material of construction as well as the outer jacket of the cables in the conduit. Acceptable products are Q-Pak 2000 by Chemque, FST by American Polywater Corporation, or Hydra-seal S-60 by Duraline.
 - b. Inflatable bag that provides seal around cables and around inside diameter of conduit. Provide appropriate quantity of additional fittings for applications with three or more cables in the conduit to be sealed. Acceptable products are Rayflate by Raychem, or Engineer approved equal. This sealing method is only applicable to conduits trade size 2 inch and larger.
 - c. Neoprene sealing ring provided with the required quantity and diameter of holes to accommodate the cables in each conduit. Sealing ring shall be compressed by two Type 304 stainless steel pressure plates. Acceptable products are type CSB by OZ-GEDNEY, or Engineer approved equal. This sealing method is only applicable to metallic conduits containing 4 or less cables.
2. The use of aerosol-based expanding foam sealants or any other method of sealing against water ingress not listed above is not acceptable.
3. For conduits identified as spares, the sealing of the inside of the conduit against water ingress shall be achieved by using appropriately sized rubber expanding-style conduit plugs.

E. Pull Rope

1. Pull ropes for empty and/or spare conduits shall be woven polyester, ½-inch wide, with a minimum tensile strength of 1250 lbs. In addition, pull ropes for conduits that are installed concealed shall also have a 22-AWG (minimum) tin-plated copper conductor woven in to make the rope detectable.

2. Pull ropes for the Contractors use in installing conductors shall be the size and strength required for the pull and shall be made of a non-metallic material.

PART 3 – EXECUTION

3.01 GENERAL

- A. All conduit and associated fittings and appurtenances shall be installed in accordance with NECA 1.
- B. Minimum trade size for all rigid conduits shall be 1 inch if any portion of the conduit is installed in a ductbank and 3/4 inch for all other applications. Conduits installed within ductbanks shall be allowed to be increased in size to trade size 2 inch, at the Contractor's option, to accommodate the saddle size of the ductbank spacers. However, no combining of circuits shall be allowed in the larger conduits.
- C. Minimum trade size for flexible conduits (where specifically allowed herein) shall be 1/2 inch in all applications.
- D. Conduit routing and/or homeruns within structures is not shown on the Drawings. Conduits shall be installed concealed wherever practical and within the limitations specified herein. All other conduits not capable of being installed concealed shall be installed exposed.
- E. Empty and/or spare conduits shall be provided with pull ropes which have no less than 12 inches of slack at each end.
- F. Nonmetallic conduits for installations requiring less than a factory length of conduit shall be field cut to the required length. The cut shall be made square, cleaned of debris, and primer shall be applied to ready each joint for fusing. Conduits shall then be fused together with the conduit manufacturer's approved cement compound.
- G. Metallic conduits for installations requiring less than a factory length of conduit shall be field cut to the required length. The cut shall be made square, be cleaned of all debris and be de-burred, then threaded. Conduit threading performed in the field shall be 3/4 inch per foot tapered threads in accordance with ANSI B1.20.1.
- H. Conduits shall be protected from moisture, corrosion, and physical damage during construction. Install dust-tight and water-tight conduit fittings on the ends of all conduits immediately after installation and do not remove until conductors are installed.
- I. Conduits shall be installed to provide no less than 12 inches clearance from pipes that have the potential to impart heat upon the conduit. Such pipes include, but are not limited to, hot water pipes, steam pipes, exhaust pipes, and blower air pipes. Clearance shall be maintained whether conduit is installed in parallel or in crossing of pipes.

- J. Where non-metallic instrumentation conduits are installed exposed, the following clearances to other conduit types shall be maintained:

Installation Scenario	Clearance
Parallel to conduits with conductors energized at 480V or above	18 inches
Parallel to conduits with conductors energized at 240V and below	12 inches
At right angles to conductors energized at 480V and below	6 inches
At right angles to conductors energized at voltages above 480V	12 inches

- K. Where conduit fittings do not include an integral insulated bushing, an insulated bushing shall be installed at all conduit termination points.
- L. Conduits which serve multi-section equipment shall be terminated in the section where wiring terminations will be made.
- M. Conduits shall not penetrate the floors or walls inside liquid spill containment areas without specific written authorization from the Engineer. Liquid spill containment areas are indicated on the Drawings.
- N. Conduits shall only penetrate the walls of liquid-holding tanks or basins above the maximum liquid elevation. Conduits shall not penetrate walls below this elevation. Maximum liquid elevations are indicated on the Drawings.
- O. Conduits that terminate at roof mounted equipment shall be installed through the roof curb for the associated equipment to avoid additional roof penetrations wherever possible. Conduits that are installed horizontally on roof surfaces shall be supported by roof blocks that do not impact the roof manufacturer's warranty and shall be installed at least 7/8 inch above the roof surface to avoid the need to further de-rate the conductors inside.
- P. In no case shall conduit be supported or fastened to another pipe or be installed in a manner that would prevent the removal of other pipes for repairs. Spring steel fasteners may not be used.
- Q. All field fabricated threads for rigid galvanized steel conduit shall be thoroughly coated with two coats of galvanizing compound, allowing at least two minutes to elapse between coats for proper drying.
- R. The appropriate specialized tools shall be used for the installation of PVC coated conduit and conduit fittings. No damage to the PVC coating shall occur during installation. Conduit and conduit fittings with damaged PVC coating shall be replaced at the Contractor's cost. The use of PVC coating touch-up compounds is not permitted.
- S. If multiple manufacturers of PVC coated conduit and conduit fittings are reviewed and approved for use by the Engineer, only one manufacturer shall be permitted to be used

on the project throughout the entirety of the project. Consistency of a single manufacturer is critical to ensure proper fit and alignment, and to maintain the manufacturer's warranty throughout the PVC coated system. Use of multiple manufacturers' PVC coated products is not acceptable.

- T. Conduits which emerge from within or below concrete encasement shall be PVC coated rigid galvanized steel in accordance with Standard Detail E-26-0102 where the conduit is not protected by an equipment enclosure that surrounds the conduit on all sides at the point where it emerges from the encasement.
- U. Aluminum conduits shall not be installed in direct contact with concrete surfaces. Where aluminum conduits are routed along concrete surfaces, they shall be installed with one-hole electro-galvanized malleable iron alloy straps with matching clamp-backs to space the conduit $\frac{1}{4}$ inch away from concrete surface. Where aluminum conduit passes through concrete, CMU or brick walls, the penetration shall be made such that the aluminum conduit does not come in contact with concrete, CMU, brick or mortar.

3.02 CONCEALED AND EMBEDDED CONDUITS

- A. Conduits are permitted to be installed concealed and/or embedded with the following requirements:
 - 1. Conduits shall not be installed horizontally when concealed within CMU walls, only vertical installation is acceptable.
 - 2. Conduits installed embedded within concrete floors or walls shall be located so as not to affect the designed structural strength of the floor or wall. Embedded conduits shall be installed in accordance with Standard Detail S-03-0403 and ACI 318.
 - 3. Where conduit bends emerge from concrete embedment, none of the curved portion of the bend shall be visible. Only the straight portion of the bend shall be visible. The straight portion shall emerge perpendicular to the embedment (i.e., neatly oriented 90-degrees to floor/slab/grade). Conduits that emerge in a non-perpendicular orientation are not acceptable.
 - 4. Where multiple conduits emerge from concrete embedment or from concealment below a concrete floor, ample clear space shall be provided between conduits to allow for the appropriate and required conduit termination fittings to be installed.
 - 5. Conduits installed embedded within concrete encasement of any kind shall be installed such that conduit couplings for parallel conduits are staggered so that they are not side by side.
- B. Conduits are NOT permitted to be installed concealed and/or embedded for the following situations:

1. Conduits shall not be installed embedded within any water-bearing floors or walls.
2. Conduits shall not be installed embedded within any liquid containment area floors or walls.
3. Conduits shall not be installed concealed within CMU walls or gypsum walls that are adjacent to Class I and II hazardous areas (Division 1 and Division 2).
4. Conduits shall not be installed concealed within CMU walls or gypsum walls that are adjacent to indoor Type 1 or Type 2 chemical storage/transfer areas.

3.03 CONDUIT USES AND APPLICATIONS

A. Rigid Conduit

1. Rigid conduit for non-hazardous areas shall be furnished and installed in the materials of construction as follows:

Rigid Conduit for Non-Hazardous Areas

Installation Area Designation / Scenario	Conduit Category by Wiring / Circuit Type	
	Power and Control	Instrumentation
Exposed in indoor wet process areas	Rigid aluminum conduit	Same as Power and Control
Exposed in indoor dry process areas	Rigid aluminum conduit	Same as Power and Control
Exposed in indoor dry non-process areas	Rigid aluminum conduit	Same as Power and Control
Exposed in indoor Type 1 chemical storage/transfer areas	Schedule 80 rigid non-metallic PVC conduit	Same as Power and Control
Exposed in indoor Type 2 chemical storage/transfer areas	PVC coated rigid aluminum conduit	Same as Power and Control
Exposed in outdoor areas	Rigid aluminum conduit	Same as Power and Control
Concealed within underground concrete-encased ductbanks	Schedule 40 rigid non-metallic PVC conduit	PVC coated rigid aluminum conduit
Direct-buried conduits (where specifically permitted)	Schedule 40 rigid non-metallic PVC conduit	PVC coated rigid aluminum conduit

Rigid Conduit for Non-Hazardous Areas

Installation Area Designation / Scenario	Conduit Category by Wiring / Circuit Type	
	Power and Control	Instrumentation
Concealed within non-elevated (i.e., "slab-on-grade" construction) concrete slabs	Schedule 40 rigid non-metallic PVC conduit	PVC coated rigid aluminum conduit
Concealed within elevated concrete slabs	Schedule 40 rigid non-metallic PVC conduit	PVC coated rigid aluminum conduit
Concealed below concrete slabs (within earth or fill material)	Schedule 40 rigid non-metallic PVC conduit	PVC coated rigid aluminum conduit
Concealed within concrete walls	Schedule 40 rigid non-metallic PVC conduit	PVC coated rigid aluminum conduit
Concealed within CMU walls	Schedule 40 rigid non-metallic PVC conduit or Electrical Metallic Tubing	PVC coated rigid aluminum conduit
Concealed above suspended ceilings	Electrical Metallic Tubing	Same as Power and Control
Concealed within interior walls constructed of metal studs and gypsum wall board	Electrical Metallic Tubing	Same as Power and Control
Emerging from concealment within or below a concrete floor and transitioning to exposed conduit (Reference Detail E-26-0102)	PVC coated rigid aluminum conduit	Same as Power and Control

2. The tables for the materials of construction for rigid conduits are intended to exhaustively cover all possible scenarios and installation areas under this Contract. However, if a scenario or installation area is found that is not explicitly governed by these tables, it shall be assumed for bid purposes that the conduit material of construction is to be PVC Coated Rigid Aluminum. This discrepancy shall be brought to the attention of the Engineer (in writing) immediately for resolution.

B. Conduit Bends

1. All conduit bends shall be the same material of construction as the rigid conduit listed in the tables above, with the following exceptions:

- a. All 90-degree bends or combinations of adjacent bends that form a 90-degree bend where concealed within concrete or below a concrete slab shall be PVC Coated Rigid Aluminum.
2. Field fabricated bends of metallic conduit shall be made with a bending machine and shall have no kinks. Field fabricated standard radius and long radius bends shall have minimum bending radii in accordance with the associated tables in Part 2 herein.
3. Field bending of non-metallic conduits is not acceptable, factory fabricated bends shall be used.
4. Long radius bends shall be furnished and installed for the following specific applications, all other bends shall be standard radius:
 - a. All conduits containing medium voltage cable.
 - b. All conduits containing fiber optic cable.
 - c. All conduits located in ductbanks.
 - d. Where specifically indicated on the Drawings.

C. Flexible Conduit

1. Flexible conduit shall only be installed for the limited applications specified herein. Flexible conduit shall not be installed in any other application without written authorization from the Engineer. Acceptable applications are as follows:
 - a. Connections to motors and engine-generator sets (and similar vibrating equipment)
 - b. Connections to solenoid valves and limit switches
 - c. Connections to lighting fixtures installed in suspended ceilings
 - d. Connections to lighting transformers and combination power units
 - e. Connections to pre-fabricated equipment skids
 - f. Connections to HVAC equipment
 - g. Connections to instrument transmitters and elements
 - h. Where specifically indicated in the Standard Details
 - i. Where specifically required by the installation instructions from the manufacturer of the equipment to which the conduit terminates

2. Flexible conduit length shall be limited to three (3) feet, maximum. Flexible conduit shall not be installed buried or embedded within any material.
3. Unless otherwise specified herein, flexible conduits shall be installed in accordance with the Installation Guidelines published within NEMA RV-3.
4. Flexible conduit for non-hazardous areas shall be furnished and installed in the materials of construction as follows:

Flexible Conduit for Non-Hazardous Areas

Installation Area Designation / Scenario	Conduit Category by Wiring / Circuit Type	
	Power and Control	Instrumentation
Exposed in indoor wet process areas	Liquid-tight flexible metal conduit	Same as Power and Control
Exposed in indoor dry process areas	Liquid-tight flexible metal conduit	Same as Power and Control
Exposed in indoor dry non-process areas	Flexible metal conduit	Same as Power and Control
Exposed in indoor Type 1 chemical storage/transfer areas	Liquid-tight flexible non-metallic conduit	Same as Power and Control
Exposed in indoor Type 2 chemical storage/transfer areas	Liquid-tight flexible metal conduit	Same as Power and Control
Exposed in outdoor areas	Liquid-tight flexible metal conduit	Same as Power and Control
Concealed above suspended ceilings (all indoor areas)	Same material as exposed conduit in same area	Same as Power and Control

3.04 CONDUIT FITTING USES AND APPLICATIONS

A. General

1. Conduit fittings shall be furnished and installed in the materials of construction as indicated in Part 2, herein. Conduit fitting materials of construction are dependent on the material of construction used for the associated conduit.
2. Conduit fittings shall be provided in the trade size and configuration required to suit the application.

B. Conduit Bodies

1. Conduit bodies shall be installed where wire pulling points are desired or required, or where changes in conduit direction or breaking around beams is required.
2. Where conduit bodies larger than trade size 2 inches are intended to be used as a pull-through fitting during wire installation, oversized or elongated conduit bodies shall be used. Oversized or elongated conduit bodies shall not be required if the conduit body is intended to be used as a pull-out point during wire installation.

C. Conduit Nipples and Unions

1. Conduits with running threads shall not be used in place of 3-piece couplings (unions) or close nipples. After installation of a conduit fitting of any kind, there shall be no more than $\frac{1}{4}$ inch of exposed threads visible. Factory fabricated all-thread nipples may be used between adjacent enclosures, however, the same restriction applies regarding the length of exposed threads that are visible.

D. Conduit Expansion and Deflection Fittings

1. Conduit expansion fittings shall be installed where required by the NEC and where indicated on the Drawings. Expansion fittings shall also be installed for exposed straight metallic conduit runs of more than 75 feet, in both indoor and outdoor locations. Expansion fittings for runs of non-metallic conduit shall be installed in accordance with the NEC.
2. Conduit deflection fittings shall be installed where required by the NEC and where conduits are installed (exposed and concealed) across structural expansion joints.
3. Unless otherwise specified herein, conduit expansion and deflection fittings shall be installed in accordance with the Installation Guidelines published within NEMA FB 2.40.

E. Conduit Seals

1. Conduit seals shall be installed for conduits installed within or associated with hazardous areas and other areas as required by the NEC. In addition, conduit seals shall also be furnished and installed as follows:
 - a. All conduits entering or leaving enclosed areas which store or distribute chlorine gas.
 - b. All conduits entering or leaving enclosed areas which store or distribute sulfur dioxide gas.

F. Conduit Termination Fittings

1. Where conduits terminate at enclosures with a NEMA 4, 4X, or 3R rating and the enclosure does not have integral conduit hubs, an appropriately sized watertight

conduit hub shall be installed to maintain the integrity of the enclosure. The use of locknuts with integral gasket in lieu of watertight conduit hubs is not acceptable.

2. Where conduits terminate at enclosures that do not require conduit hubs, a two-locknut system shall be used to secure the conduit to the enclosure. One locknut shall be installed on the outside of the enclosure, and the other inside, drawn tight against the enclosure wall. The locknut on the interior of the enclosure shall be the type with integral bonding lug, or a conduit bonding bushing may be used in place of the interior locknut.
3. Conduits shall not be installed such that conduit fittings penetrate the top of any enclosure located outdoors, except in cases where specifically required by the serving electric utility. Conduits which serve outdoor equipment or an enclosure from above shall instead be routed into the side of the enclosure at the bottom. The conduit termination fitting shall be provided with a conduit drain to divert moisture from the raceway away from the enclosure.

3.05 MISCELLANEOUS

A. Conduit Periphery Sealing

1. Unless otherwise indicated on the Drawings, below-grade conduit penetrations through exterior walls shall be sealed around the periphery using the appropriate products specified in Part 2 herein.
2. Unless otherwise indicated on the Drawings, all conduit penetrations through interior walls and floors and above-grade exterior walls shall be sealed using conduit sleeves and caulk as specified in Part 2 herein. Alternatively, where concrete or masonry walls/floors are penetrated, mortar may be used to seal around the conduit periphery for conduit penetrations through interior walls and floors and above-grade exterior walls.
3. Conduit penetrations through fire-rated walls as floors shall be made with the appropriate fire rated penetration product.

B. Conduit Interior Sealing

1. All conduits (including spares) entering a structure below grade shall be sealed on the interior of the conduit against water ingress. Sealing shall be at an accessible location in the conduit system located within the building structure and shall be via one of the methods specified in Part 2 herein. If conduit sealing cannot be achieved at an accessible location within the building structure, sealing shall be placed in the conduits in the nearest manhole or handhole outside the structure.
2. Conduit interior sealing shall not be installed until conductors inside are tested and test results are deemed acceptable by the Engineer. Conduit interior sealing shall be installed prior to energization of the conductors inside.

3.06 CONDUIT IDENTIFICATION

- A. Exposed conduits shall be identified at the source, load, and all intermediate components of the raceway system. Examples of intermediate components include but are not limited to junction boxes, pull boxes, and disconnect switches. Identification shall be by means of an adhesive label with the following requirements:
1. Labels shall consist of an orange background with black text. Text for the label shall be the conduit number as indicated in the conduit and wire schedules.
 2. In addition, at the source end of the conduit, a second line of text shall be included to indicate the load equipment name. This second line shall consist of the word "TO:" and the text in the 'TO' column of the conduit and wire schedule (e.g., TO: Backwash Pump No. 1). At the load end of the conduit, a second line of text shall be included to indicate the source equipment name. This second line shall consist of the word "FROM:" and the text in the 'FROM' column of the conduit and wire schedule (e.g., FROM: MCC-SPS). This requirement applies only to the source and load ends of the conduit, and not anywhere in between.
 3. For conduits trade sizes 3/4 inch through 1-1/2 inch, the text shall be a minimum 18-point font. For conduits trade size 2 inch and larger, the text shall be a minimum 24-point font.
 4. Label height shall be 3/4 inch minimum, and length shall be as required to fit required text. The label shall be installed such that the text is parallel with the axis of the conduit. The label shall be oriented such that the text can be read without the use of any special tools or removal of equipment.
 5. Labels shall be installed after each conduit is installed and, if applicable, after painting. Labels shall be printed in the field via the use of a portable label printing system using thermal transfer technology. Handwritten labels are not acceptable.
 6. Labels shall be made of permanent vinyl with adhesive backing. Labels made of any other material are not acceptable.
- B. Conduits that are not exposed but installed beneath free standing equipment enclosures shall be identified by means of a plastic tag with the following requirements:
1. The tag shall be made of white Tyvek material, and have an orange label with black text, as described above, adhered to it. Text for the label shall be the conduit number as indicated in the conduit and wire schedules.
 2. The tag shall be affixed to the conduit by means of a nylon cable tie. The tag shall be of suitable dimensions to achieve a minimum text size of 18 points.
- C. Conduits for lighting and receptacle circuits shall not require identification.

- D. Any problems or conflicts with meeting the requirements above shall immediately be brought to the attention of the Engineer for a decision.

3.07 TESTING

- A. All tests shall be performed in accordance with the requirements of the General Conditions and Division 01. The following tests are required:
 - 1. All conduit installed below grade or concrete encased shall be tested to ensure continuity and the absence of obstructions by pulling through each conduit a swab followed by a mandrel 85% of the conduit inside diameter. After testing, all conduits shall be capped after installation of a suitable pulling rope.

3.08 TRAINING OF INSTALLATION PERSONNEL

- A. All Contractor personnel that install PVC coated rigid metal conduit shall be trained by the PVC coated conduit manufacturer. Training shall include proper conduit system assembly techniques, use of tools appropriate for coated conduit systems, and field bending/cutting/threading of coated conduit. Training shall have been completed within the past 24 months prior to the Notice to Proceed on this Contract to be considered valid. Contractor personnel not trained within this timeframe shall not be allowed to install coated conduit or shall be trained/re-trained as required prior to commencement of conduit installation.

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SECTION 26 05 33.16
BOXES FOR ELECTRICAL SYSTEMS

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. The Contractor shall furnish and install all pull boxes, junction boxes, and outlet boxes as specified herein, indicated on the Drawings, and as required. Requirements for other boxes and enclosures are not necessarily included in this Section. Reference each specific equipment specification section for requirements related to that equipment's respective enclosure.
- B. Reference the following Specification Sections:
 - 1. Section 26 05 00 – Basic Electrical Requirements
 - 2. Section 26 05 33.13 – Conduit for Electrical Systems
 - 3. Section 26 05 53 – Identification for Electrical Systems
 - 4. Section 26 27 26 – Wiring Devices

1.02 CODES AND STANDARDS

- A. All boxes shall be Listed by and shall bear the Label of Underwriter's Laboratories, Incorporated (UL).
- B. Boxes shall be designed, manufactured, and/or Listed to the following standards as applicable:
 - 1. National Electrical Manufacturers Association (NEMA):
 - a. ANSI/NEMA 250 – Enclosures for Electrical Equipment.
 - 2. National Fire Protection Association (NFPA):
 - a. NFPA 70 – National Electrical Code (NEC).
 - 3. Underwriters Laboratories (UL):
 - a. UL 50 – Enclosures for Electrical Equipment, Non-environmental Considerations.

- b. UL 50E – Enclosures for Electrical Equipment, Environmental Considerations.
- c. UL 514A – Metallic Outlet Boxes.
- d. UL 514C – Standard for Non-metallic Outlet Boxes, Flush Device Boxes, and Covers.
- e. UL 1203 – Standard for Explosion-proof and Dust-ignition-proof Electrical Equipment for use in Hazardous (Classified) Locations.

1.03 SUBMITTALS

- A. In accordance with the procedures and requirements set forth in the General Conditions and Section 01 33 00 – Submittal Procedures, the Contractor shall obtain from the equipment manufacturer(s) and submit the following:
 - 1. Shop Drawings
- B. Each submittal shall be identified by the applicable Specification Section.

1.04 SHOP DRAWINGS

- A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.
- B. Partial, incomplete, or illegible Submittals will be returned to the Contractor without review for resubmittal.
- C. Shop drawings shall include but not be limited to:
 - 1. Product data sheets for boxes, terminal strips, and all accessories
 - 2. Overall bill of material for all boxes included under this Contract to summarize exactly what is being submitted for review. Bill of material shall at a minimum show each box type (i.e., pull, junction, or outlet), quantity, material of construction, dimensions, and proposed installation location.

1.05 OPERATION AND MAINTENANCE MANUALS

- A. The Contractor shall submit operation and maintenance manuals in accordance with the procedures and requirements set forth in the General Conditions and Division 01.
- B. As-built drawings showing dimensions, internal box layout, terminal strip information, and terminal strip identification information shall be provided for all junction boxes. As-built drawings are not required for pull boxes or outlet boxes.

1.06 IDENTIFICATION

- A. Each pull and junction box shall be identified with the box name as indicated on the Contract Drawings (e.g., PPB-GAC, CJB-GAC) or as directed by the Engineer. A nameplate shall be securely affixed in a conspicuous place on each box. Nameplates shall be as specified in Section 26 05 53 – Identification for Electrical Systems.

PART 2 – PRODUCTS

2.01 MANUFACTURERS

- A. The equipment covered by this Specification is intended to be standard equipment of proven performance as manufactured by reputable concerns. Equipment shall be designed, constructed, and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as shown on the Drawings.

2.02 PULL AND JUNCTION BOXES

A. General

1. All pull and junction boxes shall be UL Listed and Labeled.
2. Pull and junction boxes shall not be provided with eccentric or concentric knockouts.
3. Pull and junction boxes mounted embedded in concrete shall be UL Listed for embedment.
4. Where metallic boxes are used, they shall be of all welded construction. Tack welded boxes are not acceptable.

B. Pull Boxes

1. Metallic pull boxes in non-hazardous locations and in hazardous locations where general-purpose enclosures are permitted (e.g., Class I, Division 2 locations) shall be provided with a matching gasketed cover. For covers with dimensions of less than 12 inches by 12 inches, the cover shall be held in place by stainless steel machine screws. Other screw types are not acceptable. For covers with dimensions 12 inches by 12 inches and larger, the cover shall be hinged and held in place by 1/4-turn style latches. Latch mechanism shall be all stainless steel. Hinge pins shall be removable.
2. Metallic pull boxes in hazardous locations where general-purpose enclosures are not permitted (e.g., Class I, Division 1 locations) shall be provided with a matching gasketed cover. Cover shall be hinged and held in place by stainless steel bolts.

Hinge pins shall be removable. Covers shall be installed and bolts torqued in accordance with manufacturer requirements to maintain the hazardous location rating of the enclosure.

3. Non-metallic pull boxes shall be provided with a matching gasketed cover. The cover shall be hinged and held in place by quick-release (e.g., "flip") latches. Latch material of construction shall match the box material, and include stainless steel hasps. For covers with dimensions 24 inches by 24 inches and larger, a 3-point latching mechanism with external pad-lockable handle may be substituted. Latch mechanism and handle shall be all stainless steel. Hinge pins shall be removable.
4. Pull boxes shall not have any wire terminations inside, other than those for grounding/bonding. A ground bar shall be provided with the necessary number of screw type terminals. Twenty (20) percent of the total amount of terminals otherwise required for the pull box (minimum of two) shall be provided as spare terminations. Boxes requiring any other wire terminations shall be furnished and installed in accordance with the requirements for junction boxes herein.
5. Pull boxes shall be 6 inches wide by 6 inches tall by 4 inches deep, minimum. For applications requiring larger boxes, the box shall be sized in accordance with the fill requirements and dimensional requirements of the NEC.
6. Barriers shall be provided in pull boxes to isolate conductors of different voltages, types, and functions. Barrier material of construction shall match that of the box. Isolation shall be provided between the following groups:
 - a. Power wiring
 - b. AC control wiring
 - c. DC control wiring
 - d. Instrumentation wiring

C. Junction Boxes

1. Metallic junction boxes in non-hazardous locations shall be provided with a matching gasketed cover. For covers with dimensions of less than 12 inches by 12 inches, the cover shall be held in place by stainless steel machine screws. Other screw types are not acceptable. For covers with dimensions 12 inches by 12 inches and larger, the cover shall be hinged and held in place by 1/4-turn style latches. Latch mechanism shall be all stainless steel. Hinge pins shall be removable.
2. Metallic junction boxes in hazardous locations shall be provided with a matching gasketed cover. Cover shall be hinged and held in place by stainless steel bolts.

Hinge pins shall be removable. Covers shall be installed and bolts torqued in accordance with manufacturer requirements to maintain the hazardous location rating of the enclosure.

3. Non-metallic junction boxes shall be provided with a matching gasketed cover. The cover shall be hinged and held in place by quick-release (e.g., "flip") latches. Latch material of construction shall match the box material and include stainless steel hasps. For covers with dimensions 24 inches by 24 inches and larger, a 3-point latching mechanism with external pad-lockable handle may be substituted. Latch mechanism and handle shall be all stainless steel. Hinge pins shall be removable.
4. Barriers shall be provided in junction boxes to isolate conductors and terminal blocks of different voltages, types, and functions. Barrier material of construction shall match that of the box. Isolation shall be provided between the following groups:
 - a. Power wiring
 - b. AC control wiring
 - c. DC control wiring
 - d. Instrumentation wiring
5. Junction boxes used for lighting and receptacle circuits only shall be allowed to have screw-on (wire nut) type connectors for wire terminations/junctions.
6. Junction boxes for all uses other than lighting and receptacle circuits shall be provided with terminal strips, consisting of the necessary number of screw type terminals. Current carrying parts of the terminal blocks shall be of ample capacity to carry the full load current of the circuits connected, with a 10A minimum capacity. Terminal strips shall be rated for the voltage of the circuits connected. A separate ground bar shall be provided with the necessary number of screw type terminals. Twenty (20) percent of the total amount of terminals otherwise required for the junction box (minimum of two) shall be provided as spare terminations. When barriers are provided within the box, separate terminal strips shall be provided in each barrier area. Terminals shall be lettered and/or numbered to conform to the wiring labeling scheme in place on the project.
7. Junction boxes shall be 6 inches wide by 6 inches tall by 4 inches deep, minimum. For applications requiring larger boxes, the box shall be sized in accordance with the fill requirements and dimensional requirements of the NEC. Terminal blocks (including spare terminals) shall be considered when sizing the junction box.

D. Enclosure Types and Materials

1. In non-hazardous locations, pull and junction boxes shall be furnished with the following enclosure type and material of construction, dependent upon the designation of the area in which they are to be installed. Area designations are indicated on the Drawings.

Area Designation	Enclosure Type and Material
Indoor Wet Process Area	NEMA 4X, Type 304 Stainless Steel
Indoor Dry Process Area	NEMA 12, Painted Steel
Indoor Dry Non-Process Area	NEMA 1, Painted Steel
Indoor Type 1 Chemical Storage/Transfer Area	NEMA 4X, Fiberglass or PVC
Indoor Type 2 Chemical Storage/Transfer Area	NEMA 4X, Type 304 Stainless Steel
All Outdoor Areas	NEMA 4X, Type 304 Stainless Steel

2.03 OUTLET BOXES

A. General

1. Outlet boxes shall be provided with a trim appropriate for the wiring device installed inside. Reference Section 26 27 26 – Wiring Devices for outlet box trim requirements. An appropriate outlet box trim is required to achieve the NEMA rating of the outlet boxes as specified herein.

B. Surface Mount Outlet Boxes

1. Outlet boxes shall be the deep type, no less than 2.5 inches deep, and be provided with a ground screw inside.
2. Outlet boxes shall be provided in single or multi-gang configuration as required, sized in accordance with the requirements of the NEC.
3. In non-hazardous locations, outlet boxes shall be furnished with the following enclosure type and material of construction, dependent upon the designation of the area in which they are to be installed. Area designations are indicated on the Drawings.

Area Designation	Enclosure Type and Material
Indoor Wet Process Area	NEMA 4X, Cast Aluminum
Indoor Dry Process Area	NEMA 1, Cast Aluminum

Indoor Dry Non-process Area	NEMA 1, Cast Aluminum
Indoor Type 1 Chemical Storage/Transfer Area	NEMA 4X, PVC
Indoor Type 2 Chemical Storage/Transfer Area	NEMA 4X, Cast Aluminum
All Outdoor Areas	NEMA 4X, Cast Aluminum

4. Outlet boxes shall be provided with integral threaded conduit hubs mounted external to the box. Boxes with threaded conduit hubs mounted internal to the box or as a part of the box wall are not acceptable.
5. Outlet boxes for NEMA 4X applications shall be furnished with integral external mounting lugs that are accessible from outside the box.

C. Flush Mount Outlet Boxes

1. Outlet boxes shall be no less than 2-1/8 inches deep, and 4-11/16 inches square. Boxes shall be UL Listed and labeled. Pre-punched single diameter conduit knockouts are acceptable; however, concentric and eccentric knockouts are not acceptable.
2. Outlet boxes mounted flush in CMU walls shall be made of galvanized, tack welded steel, and suitable for installation in masonry walls. Sectional type boxes are not acceptable for this application.
3. Outlet boxes mounted flush in gypsum walls shall be made of galvanized pressed steel. Tack welded boxes are not acceptable for this application. Sectional type boxes are not acceptable for this application.
4. Outlet boxes mounted cast into concrete shall be concrete tight and made of galvanized steel or PVC.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Pull and Junction Boxes

1. Pull boxes and junction boxes shall be solidly attached to structural members prior to installation of conduit and set true and plumb. Boxes shall not be supported by their associated conduits.
2. Wooden plugs are not permitted for securing boxes to concrete. Appropriately rated anchors specifically suited for use in concrete shall be used.

3. Box penetrations for conduits shall be made with a punch tool, and penetrations shall be of the size required for the conduit entry and/or hub. Oversized penetrations in boxes are not acceptable.
4. Watertight conduit hubs shall be provided for boxes where a NEMA 4X enclosure rating is specified. Reference Section 26 05 33.13 – Conduit for Electrical Systems for conduit hub requirements.
5. Pull and junction boxes may be installed flush mounted in gypsum, concrete, or CMU walls where appropriate provided that covers are easily removed or opened.
6. Pull and junction boxes shall be provided in the enclosure type and material of construction required for the area in which it is installed. Reference the requirements in Part 2 herein, and the area designations indicated on the Drawings.

B. Outlet Boxes

1. Outlet boxes shall be solidly attached to structural members prior to installation of conduit and set true and plumb. Boxes shall not be supported by their associated conduits. Boxes with integral external mounting lugs shall be attached with the lugs and shall not be drilled.
2. Wooden plugs are not permitted for securing boxes to concrete. Appropriately rated anchors specifically suited for use in concrete shall be used.
3. Flush mounted outlet boxes shall be arranged and located so that tile and grout lines fit closely around the boxes, and so placed that the cover or device plate shall fit flush to the finished wall surface.
4. Outlet boxes shall be flush mounted in finished areas and other areas where practical. Flush mounted outlet boxes shall not be installed in hazardous areas and type 1 or 2 chemical storage/transfer areas.
5. Depending on the type of wiring device to be installed in the outlet box, mounting heights from the finished floor or finished grade (as applicable) to the center of the box shall be as follows, unless otherwise specified herein, indicated on the Drawings, or required by the Americans with Disability Act (ADA):
 - a. Light switches, 48 inches
 - b. Receptacles in indoor dry process/non-process areas, 18 inches
 - c. Receptacles in indoor wet process areas and all indoor chemical storage/transfer areas, 42 inches in open areas, or 6 inches (minimum) above adjacent surfaces (e.g., countertops, tables, etc.) where applicable

- d. Receptacles in outdoor locations, 26 inches
 - e. Flush mounted outlet boxes in CMU walls shall be adjusted to a slightly greater height than required above to align the center of the box with the center of the CMU block.
6. Outlet boxes shall be provided in the material of construction required for the area in which it is installed. Reference the requirements in Part 2 herein, and the area designations indicated on the Drawings.

END OF SECTION

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SECTION 26 05 53
IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. All electrical equipment shall be properly identified in accordance with these Specifications and the Contract Drawings. All electrical equipment shall be identified in the manner described, or in an equally approved manner.
- B. The types of electrical identification specified in this Section include, but are not limited to, the following:
 - 1. Operational instructions and warnings.
 - 2. Danger signs.
 - 3. Equipment/system identification signs.
 - 4. Nameplates.

1.02 SIGNS

- A. "DANGER-HIGH-VOLTAGE" signs shall be securely mounted on the entry doors of all electrical rooms.

1.03 LETTERING AND GRAPHICS

- A. The Contractor shall coordinate names, abbreviations, and other designations used in the electrical identification work with the corresponding designations shown, specified, or scheduled. Provide numbers, lettering, and wording as indicated or, if not otherwise indicated, as recommended by manufacturers or as required for proper identification and operation/maintenance of the electrical systems and equipment.

1.04 SUBMITTALS

- A. In accordance with the procedures and requirements set forth in the General Conditions and Section 01 33 00 – Submittal Procedures, the Contractor shall obtain from the equipment manufacturer and submit shop drawings. Each submittal shall be identified by the applicable Specification Section.

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1.05 SHOP DRAWINGS

- A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.
- B. Partial, incomplete, or illegible submittals will be returned to the Contractor without review for resubmittal.
- C. Shop drawings shall include but not be limited to:
 - 1. Product data sheets.

PART 2 – PRODUCTS

2.01 MANUFACTURERS

- A. The material covered by these Specifications is intended to be standard material of proven performance as manufactured by reputable concerns. Material shall be fabricated, constructed, and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as specified herein and shown on the Drawings.

2.02 NAMEPLATES

- A. Nameplates shall be engraved, high pressure plastic laminate, white foreground with black lettering.
- B. Nameplates shall be attached to NEMA 4X enclosures utilizing UL-recognized mounting kits designed to maintain the overall UL Type rating of the enclosure. Mounting kit fasteners shall be stainless steel Type AHK10324X as manufactured by Hoffman, or Engineer approved equal.

2.03 HIGH VOLTAGE SIGNS

- A. Standard "DANGER" signs shall be of baked enamel finish on 20 gauge steel; of standard red, black, and white graphics; 14 inches by 10 inches size except where 10 inches by 7 inches is the largest size which can be applied where needed, and except where a larger size is needed for adequate identification.

2.04 CONDUIT IDENTIFICATION

- A. Conduit identification shall be as specified in Section 26 05 33.13 – Conduit for Electrical Systems.

2.05 WIRE AND CABLE IDENTIFICATION

- A. Field installed wire and cable identification shall be as specified in Section 26 05 19 – Low Voltage Conductors and Cable and Section 26 05 13 – Medium Voltage Cables.
- B. A plastic laminate nameplate shall be provided at each panelboard, motor control center, switchgear assembly, and switchboard assembly. This nameplate shall be used to clearly convey the conductor identification means used at that piece of equipment (i.e., Phase A=Brown, Phase B=Orange, C = Yellow).
- C. Wiring identification for factory installed wiring in equipment enclosures shall be as specified in the respective Section.

2.06 BOX IDENTIFICATION

- A. Pull, junction and device box identification shall be as specified in Section 26 05 33.16 – Boxes for Electrical Systems.

PART 3 – EXECUTION

3.01 NAMEPLATES

- A. Nameplates shall be attached to the equipment enclosures with two (2) stainless steel sheet metal screws for nameplates up to 2-inches wide. For nameplates over 2-inches wide, four (4) stainless steel sheet metal screws shall be used, one (1) in each corner of the nameplate. The utilization of adhesives is not permitted.

3.02 OPERATIONAL IDENTIFICATION AND WARNINGS

- A. Wherever reasonably required to ensure safe and efficient operation and maintenance of the electrical systems and electrically connected mechanical systems and general systems and equipment, including prevention of misuse of electrical facilities by unauthorized personnel, install plastic signs or similar equivalent identification, instruction, or warnings on switches, outlets, and other controls, devices, and covers or electrical enclosures. Where detailed instructions or explanations are needed, provide plasticized tags with clearly written messages adequate for the intended purposes. Signs shall be attached as specified above for nameplates.

3.03 POWER SOURCE IDENTIFICATION

- A. After installation of all field equipment (e.g., valves, motors, fans, unit heaters, instruments, etc.) install nameplates at each power termination for the field equipment. Nameplate data shall include equipment designation (tag number), power source (MCC

number, panelboard, etc.), circuit number, conduit number from schedule and voltage/phase.

- B. Contractor to coordinate with the Engineer and the Owner regarding exact nameplate placement during construction.
- C. Nameplates shall be as specified herein.

END OF SECTION

SECTION 26 05 60
LOW-VOLTAGE ELECTRIC MOTORS

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. The Contractor shall furnish all labor, materials, tools and equipment necessary for furnishing, installing, connecting, testing and placing into satisfactory operation all low voltage electric motors as shown on the Drawings and specified herein. All motors required for this Contract shall comply with this Section unless otherwise noted.

1.02 CODES AND STANDARDS

- A. Motors and related accessories shall be designed, manufactured, and/or listed to the following standards as applicable:
1. Institute of Electrical and Electronics Engineers (IEEE)
 - a. IEEE 112 – Standard Test Procedure for Polyphase Induction Motors and Generators
 2. National Electrical Manufacturer's Association (NEMA)
 - a. NEMA MG 1 – Motors and Generators
 3. Underwriters Laboratories (UL)
 - a. UL 547 – Standard for Safety Thermal Protectors for Motors
 - b. UL 674 – Electric Motors and Generators for Use in Hazardous (Classified) Locations
 - c. UL 1004-1 – Standard for Rotating Electrical Machines
 - d. UL 1004-3 – Standard for Thermally Protected Motors
 - e. UL 1004-8 – Standard for Inverter Duty Motors

1.03 SUBMITTALS

- A. In accordance with the procedures and requirements set forth in the General Conditions and Section 01 33 00 – Submittal Procedures, the Contractor shall obtain from the equipment manufacturer and submit the following:

1. Shop Drawings.
 2. Spare Parts List.
- B. Each submittal shall be identified by the applicable Specification Section.

1.04 SHOP DRAWINGS

- A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.
- B. Partial, incomplete or illegible submittals will be returned to the Contractor without review for resubmittal.
- C. Individual shop drawings for electric motors shall be submitted in accordance with the procedures and requirements set forth in the General Conditions and Section 01 33 00 – Submittal Procedures, unless submitted as a part of the shop drawings for the driven equipment.
- D. Shop drawings for electric motors shall include motor data sheets, dimensioned drawings, wiring diagrams for devices such as space heaters, temperature devices, and shaft grounding rings. Shop drawings shall identify electric characteristics and design, mechanical construction, manufacturer's name, type and pertinent specifications for the use intended, along with the name of the equipment to be driven. For motors rated 50 horsepower or greater, submittal of motor data for acceptance shall include, as a minimum, the following:
1. Manufacturer's type and frame designation
 2. Horsepower rating
 3. Time rating (per NEMA Standards)
 4. Ambient temperature rating
 5. Motor winding insulation system designation
 6. RPM at rated load
 7. Frequency
 8. Number of phases
 9. Rated-load amperes
 10. Voltage

11. Code letter (starting KVA per horsepower)
12. Design letter for integral horsepower induction motors (per NEMA Standards)
13. Service factor
14. Temperature rise at full load and at service factor load
15. Efficiency at 1/4, 1/2, 3/4 and full load
16. Power factor at 1/4, 1/2, 3/4 and full load
17. Motor outline, dimensions and weight
18. Motor winding insulation system description
19. Horsepower required by connected machine at specified conditions (load curves) shall be supplied for all compressors, propeller and positive displacement pumps.
20. The foregoing data shall also be verified after manufacture and shall be included with the information to be furnished in the operation and maintenance manuals specified.

- E. The shop drawing information shall be complete and organized in such a way that the Engineer can determine if the requirements of these Specifications are being met. Copies of technical bulletins, technical data sheets from "soft-cover" catalogs, and similar information which is "highlighted" or somehow identifies the specific equipment items the Contractor intends to provide are acceptable and shall be submitted.

1.05 SPARE PARTS

- A. All spare parts as recommended by the equipment manufacturer shall be furnished to the Owner by the Contractor.

PART 2 – PRODUCTS

2.01 MANUFACTURERS

- A. The equipment covered by this Specification is intended to be standard equipment of proven performance as manufactured by reputable concerns. Equipment shall be designed, constructed and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as shown on the Drawings.
- B. Electric motors shall be manufactured by Baldor/Reliance Electric Company; Nidec Motors; Toshiba Industrial and Power Systems, Inc.; Siemens Energy & Automation, Inc.; General Electric Company; or equal.

2.02 MATERIALS AND CONSTRUCTION

A. Motors shall be built in accordance with the latest standards of NEMA, including, but not limited to MG-1 and MG-2, IEEE, ANSI and to the requirements specified herein.

B. Type

1. Unless otherwise noted, motors specified herein shall be polyphase squirrel cage, NEMA Design B, or single phase capacitor or repulsion start induction motors. Special equipment requiring a motor drive with unusual characteristics shall be equipped with a definite purpose motor to meet the necessary requirements.
2. Unless otherwise shown or specified, all motors 1/2 horsepower or larger shall be three- phase, 60 Hertz, NEMA Design B, squirrel cage induction motors designed for operation at 480 volts or greater as specified herein or shown on the Drawings.
3. Unless otherwise specified in the individual equipment specification for the driven equipment, or as required by the dynamic characteristics of the load as determined by the manufacturer of the machine to be driven, all polyphase squirrel cage motors shall be designed to withstand the starting voltage shown on the Drawings and shall have torque and locked rotor current characteristics as specified for NEMA Design B motors.
4. All motors 2 horsepower and smaller shall have windings encapsulated with a flexible epoxy compound, or insulated with a flexible epoxy compound, or insulated with the manufacturer's premium quality system which shall be subject to acceptance by the Engineer.
5. All motors above 250 horsepower shall have stator windings vacuum impregnated with a polyester insulation compound.
6. Unless otherwise noted, all motors smaller than 1/2 horsepower shall be standard single-phase capacitor start or repulsion start induction type designed for operation on 120 volts or 208 volts, 60 Hz alternating current. The motor shall deliver rated load without exceeding a 80 degrees C temperature rise while operating in a 40 degrees C ambient temperature. Small fan motors less than 1/4 HP may be split-phase or shaded pole type. Shaded pole motors rated more than 1/4 horsepower are not acceptable. Fractional horsepower motors shall be completely equipped with all necessary auxiliary components for starting and labeled as "Thermally Protected". Insulation shall be Class B, except that submersible motors shall have epoxy encapsulation. Unless otherwise noted, the motors shall be totally enclosed. Small fan motors may be of the open type where they are suitably protected from moisture dripping and lint accumulation. Motors shall be provided with sealed ball bearings lubricated for 10 years of normal use.

7. Where specified, vertical hollowshaft motors shall be designed to carry the motors', pumps', and associated equipment's full thrust. The motors shall be equipped with grease lubricated spherical roller thrust bearings and lower radial guide bearings. Vertical hollowshaft motors shall be fitted with nonreversing ratchet assemblies where required by equipment specifications. Vertical adjustment shall be provided by means of a lockable nut at the top of the shaft.
8. Vertical hollowshaft motors shall have adequate thrust bearings to carry all motor loads and any other operating equipment loads. Horizontal motors shall not be installed where subjected to external thrust loads.

C. Rating

1. Each motor shall develop ample torque for its required service through its acceleration range and throughout its rated load range. The rating of the motors offered shall in no case be less than the horsepower shown on the Drawings or elsewhere specified. It should be noted that the motor sizes indicated on the Drawings or as otherwise specified herein, are motor sizes required to operate the specific equipment which is specified. Higher rated motor sizes may be determined from the actual equipment submitted, approved, purchased, and installed. Protective devices, motor starters, disconnect switches, and other necessary equipment shall be furnished and installed for the actual motor sizes required at no additional cost.
2. Motor ratings shall be based on continuous operation. The maximum temperature rise for open and drip proof type motors shall not exceed 90 degrees C, and for totally enclosed type motors shall not exceed 80 degrees C.

D. Motor Winding Insulation

1. Insulation shall be as specified for each particular type or class of motor. The insulation system shall provide a high dielectric strength, long life covering for the windings which may be required to operate in a continually damp, corrosive, and/or chemically contaminated environment. The insulation shall be resistant to attack by moisture, acids, alkalies, abrasives, and mechanical and thermal shock. Leads shall be sealed with a non-wicking, non-hydroscopic insulation material.
2. Motor insulation resistance may be checked at any time after delivery to the job site or during the warranty period. Encapsulated motor stators may be subjected to insulation testing while completely submerged in water. Any motor not meeting the requirements specified herein will be rejected and shall be promptly replaced at no cost to the Owner.
3. Torque and locked rotor current characteristics for three phase motors shall be NEMA Design B. The locked rotor KVA/HP input at full voltage for 10 horsepower.

motors and larger shall not exceed that permitted for Code Letter "J", except for specialized equipment requiring a motor drive with special definite characteristics.

4. Unless otherwise specified, non-inverter duty motors shall be furnished with a Class F insulation system. Unless otherwise specified, inverter duty motors shall be furnished with a Class H insulation system. In either case, temperature rise shall be limited to that for Class B insulation. Output torque and speed characteristics of each motor shall be suitable to operate the driven equipment through the full range of acceleration and operating load conditions without exceeding the nameplate current rating, and/or temperature rise.

E. Nameplates

1. The motor manufacturer's nameplate shall be engraved, embossed, or stamped on a stainless steel sheet and fastened to the motor frame with No. 4 or larger oval head stainless steel screws or drive pins. Printed or laser-etched nameplates are not acceptable.
2. Nameplates shall include as a minimum, Items 1 through 14 as listed in Article 1.04 D in addition to that required by NEMA standards. The nameplate shall be positioned so as to be readily visible for inspection as installed in the facility.

F. Design

1. Motors shall be designed to accelerate and drive the connected equipment under all normal operating conditions without exceeding nameplate ratings.
2. Motors specified for operation with variable frequency drives shall be inverter duty rated. Motors shall be considered inverter duty rated only if they meet all of the requirements for NEMA MG-1 Part 31.
3. Motors shall be designed to output 100 percent of nameplate horsepower under continuous duty service without exceeding the temperature rise specified herein when controlled by the actual drives furnished. Inverter duty motors shall be designed to operate down to 10% of full load speed without the need for a line powered cooling fan.
4. Unless otherwise specified, electric motors shall be furnished with service factors in accordance with NEMA MG-1 as follows:

Type of Motor	Service Factor
Non-inverter Duty	1.15
Inverter Duty	1.0

5. Design selection with respect to the driven machine shall be such that the requirements do not exceed 85 percent of the motors' maximum rating modified by service factor, ambient temperature, enclosure, altitude and electrical service. The electrical service conditions shall be assumed to be 10 percent undervoltage, 5 percent underfrequency, and 3 percent voltage unbalance. Altitude shall be assumed to be the project site elevation plus 10 percent. Ambient temperature shall be assumed to be 95 degrees F in exterior locations, 104 degrees F (40 degrees C) in interior locations, and 122 degrees F (50 degrees C) within housings or enclosures; except where higher temperatures may be encountered within or on individual items of equipment. The applicable paragraphs of NEMA MG-1 shall be used in making the design selection.
6. Motors used with belt drives shall have sliding bases to provide for belt take up.
7. Terminal boxes shall be of sufficient size to accommodate the required quantity and size of conduits. Gasketed terminal boxes shall be furnished with all splash-proof and totally enclosed motors. NEMA ratings of the terminal boxes shall be suited for the application. Motors located in hazardous locations shall be furnished with terminal boxes suitable for the specific Class, Division, and Group suitable for the application. Terminal boxes shall be sized to accommodate accessory equipment such as motor differential current transformers, where required.
8. Terminal boxes for horizontal motors shall be located on the lefthand side when viewing the motor from the drive shaft end and shall be so designed that conduit entrance can be made from above, below, or either side of the terminal box.
9. Motors larger than 250hp shall be manufactured with the six stator coil leads wired to a suitably sized motor junction box for application in a differential relay scheme. Current transformers shall be provided by the motor manufacturer and installed in the factory. All ground connections and current transformer connections shall be made in the factory.

G. Construction

1. Frames, mounting means, and shafts shall meet NEMA Standards for the horsepower, RPM, and enclosure selected. Enclosures shall be selected according to the degree of mechanical protection required and shall not be of aluminum construction. All motors shall have a manufacturer's standard shop machinery finish, consisting of a rustresisting priming coat of zinc chromate and a finish coat of alkyd machinery enamel. Reference Section 09 90 00 – Painting.
2. Motors shall have cast iron frames and a heavy gauge steel terminal box, with neoprene gaskets between the frame and the box and between the box and its cover. A grounding lug(s) shall be provided inside the terminal box.

3. Motors weighing more than 50 pounds shall be equipped with at least one lifting eye. All lifting hardware shall be corrosion resistant.
4. Motors located in hazardous locations shall be totally enclosed and suitable for the specific Class, Division, and Group suitable for the application.
5. Motors located in Class I or II, Division 1 hazardous locations shall bear a U.L.-674 label and shall be provided with a breather/drain approved for the hazardous location. The U.L. listed breather/drain shall prevent the entrance of contaminants while allowing moisture to drain out of the motor.
6. When located outdoors, or elsewhere if specified, motors shall be totally enclosed, nonventilated (TENV) or totally enclosed, fancooled (TEFC) machines, unless otherwise noted. Totally enclosed motors shall be provided with two (2) 1/4 inch drain holes drilled through the bottom of the frame, which allows complete drainage of the frame. Where specified, TEFC motors controlled by a variable frequency drive shall be provided with a separately powered cooling fan motor that runs at 60HZ to ensure proper cooling of the motor at low speeds. Cooling fan motor shall be suitable for 120VAC, single phase operation. Vertically oriented motors located outdoors shall be provided with a drip cover over the fan end to prevent accumulation of precipitation.
7. Unless otherwise specified, motors rated 100 horsepower or greater located outdoors, in unheated structures, in below grade areas, or as otherwise indicated, shall be furnished with space heaters and embedded motor winding high temperature switches with leads brought out of the motor terminal box. Space heaters shall be suitable for 120VAC operation and for a maximum surface temperature of less than 200 degrees C. Space heaters shall be of sufficient wattage to maintain the internal temperature of the motor at approximately 10 degrees C above the ambient temperature when the motor is not running.
 - a. Embedded motor winding temperature switches shall operate at temperatures well below the temperature rating of the motor winding insulation system. Motor winding temperature switches are not required where other temperature monitoring devices (e.g. RTD's) are required.
8. Unless otherwise specified in the equipment specifications, motors rated 200HP or greater that are controlled by a VFD shall be furnished with resistance thermal detectors (RTD's) embedded in the stator windings, two per phase. RTD's shall be pre-wired to terminal blocks located in a separate terminal box as specified herein.
9. Unless otherwise specified in the equipment specifications, motors rated less than 200HP that are controlled by a VFD shall be furnished with motor winding high temperature switches embedded in the stator windings with the leads brought out to the motor terminal box.

10. If so specified and when located in indoor areas which are heated and weatherproof, motors shall be open drip-proof machines. Ventilation openings shall be arranged to prevent the entrance of drops of liquid or solid particles at any angle from zero to 15 degrees downward from vertical.
11. Unless otherwise specified, or required, motors rated less than 200 horsepower shall be furnished with bearings of the grease lubricated, antifriction ball type with conveniently located grease fittings and drain plugs. A means of preventing bearings from becoming over-greased shall be provided. Bearings shall have a minimum B-10 life of 20,000 hours.
12. Rotors shall be statically and dynamically balanced. Rotor windings shall be one-piece cast aluminum. Where applicable, rotors shall be constructed with integral fins.
13. Externally mounted motor shaft grounding rings shall be provided to protect motors against motor shaft and bearing currents. Grounding rings shall be provided for all motors controlled by VFDs, with the following exceptions:
 - a. Motors located in hazardous areas
 - b. Motors rated less than 1 horsepower
 - c. Submersible motors
14. All motors shall be provided with factory-installed one-hole terminations (ring terminals) on the ends of all motor leads. Terminations shall be identified for use with cables that have stranding other than Class B and shall be the irreversible compression type.

H. Power Factor and Efficiency

1. All motors, including vertical hollowshaft motors, in the range of 1-500 horsepower, inclusive, shall be designed specifically for energy efficiency and high power factor. The motor efficiency and power factor shall meet or exceed the values listed in the table below when the motors are tested in accordance with the NEMA preferred test method IEEE 112A, Method B, Dynamometer. Each motor shall meet the minimum guaranteed efficiency value indicated in the table below. All tests shall be performed in accordance with the procedures contained in NEMA Standard MG1-12.58.

Table 12-11
FULL-LOAD EFFICIENCIES OF ENERGY EFFICIENT MOTORS
ENCLOSED MOTORS

HP	2 POLE		4 POLE		6 POLE		8 POLE	
	Nominal Efficiency	Minimum Efficiency	Nominal Efficiency	Minimum Efficiency	Nominal Efficiency	Minimum Efficiency	Nominal Efficiency	Minimum Efficiency
1	75.5	72	82.5	80	80	77	74	70
1.5	82.5	80	84	81.5	85.5	82.5	77	74
2	84	81.5	84	81.5	86.5	84	82.5	80
3	85.5	82.5	87.5	85.5	87.5	85.5	84	81.5
5	87.5	85.5	87.5	85.5	87.5	85.5	85.5	82.5
7.5	88.5	86.5	89.5	87.5	89.5	87.5	85.5	82.5
10	89.5	87.5	89.5	87.5	89.5	87.5	88.5	86.5
15	90.2	88.5	91	89.5	90.2	88.5	88.5	86.5
20	90.2	88.5	91	89.5	90.2	88.5	89.5	87.5
25	91	89.5	92.4	91	91.7	90.2	89.5	87.5
30	91	89.5	92.4	91	91.7	90.2	91	89.5
40	91.7	90.2	93	91.7	93	91.7	91	89.5
50	92.4	91	93	91.7	93	91.7	91.7	90.2
60	93	91.7	93.6	92.4	93.6	92.4	91.7	90.2
75	93	91.7	94.1	93	93.6	92.4	93	91.7
100	93.6	92.4	94.5	93.6	94.1	93	93	91.7
125	94.5	93.6	94.5	93.6	94.1	93	93.6	92.4
150	94.5	93.6	95	94.1	95	94.1	93.6	92.4
200	95	94.1	95	94.1	95	94.1	94.1	93
250	95.4	94.5	95	94.1	95	94.1	94.5	93.6
300	95.4	94.5	95.4	94.5	95	94.1		
350	95.4	94.5	95.4	94.5	95	94.1		
400	95.4	94.5	95.4	94.5				
450	95.4	94.5	95.4	94.5				
500	95.4	94.5	95.8	95				

Table 12-12
FULL-LOAD EFFICIENCIES FOR NEMA PREMIUM™ EFFICIENCY ELECTRIC MOTORS
RATED 600 VOLTS OR LESS (RANDOM WOUND)
OPEN MOTORS

HP	2 POLE		4 POLE		6 POLE	
	Nominal Efficiency	Minimum Efficiency	Nominal Efficiency	Minimum Efficiency	Nominal Efficiency	Minimum Efficiency
1	77	74	85.5	82.5	82.5	80
1.5	84	81.5	86.5	84	86.5	81.5
2	85.5	82.5	86.5	84	87.5	81.5
3	85.5	82.5	89.5	84	88.5	86.5
5	86.5	84	89.5	84	89.5	87.5
7.5	88.5	86.5	91	89.5	90.2	88.5
10	89.5	87.5	91.7	90.2	91.7	90.2
15	90.2	88.5	93	91.7	91.7	90.2
20	91	89.5	93	91.7	92.4	91
25	91.7	90.2	93.6	92.4	93	91.7
30	91.7	90.2	94.1	93	93.6	92.4
40	92.4	91	94.1	93	94.1	93
50	93	91.7	94.5	93.6	94.1	93
60	93.6	92.4	95	94.1	94.5	93.6
75	93.6	92.4	95	94.1	94.5	93.6
100	93.6	92.4	95.4	94.5	95	94.1
125	94.1	93	95.4	94.5	95	94.1
150	94.1	93	95.8	95	95.4	94.5
200	95	94.1	95.8	95	95.4	94.5
250	95	94.1	95.8	95	95.4	94.5
300	95.4	94.5	95.8	95	95.4	94.5
350	95.4	94.5	95.8	95	95.4	94.5
400	95.8	95	95.8	95	95.8	95
450	95.8	95	96.2	95.4	96.2	95.4
500	95.8	95	96.2	95.4	96.2	95.4

NOTES:

(Motor data for continuous duty, NEMA Design B, 1.15 service factor, 40 degrees Celsius ambient, Class F insulation, 3 phase, 460 volt, at listed speed rating.

(TEFC efficiencies apply to both horizontal and vertical motors.

2. Motors rated 50 horsepower or greater shall be individually tested at the factory before shipment, with a copy of test results provided for the Engineer, to assure compliance with the efficiency and power factor specifications.

I. Power Factor Correction

1. The power factor shall be corrected as necessary to achieve 85% (minimum) with capacitors sized and installed per manufacturer's recommendations. Capacitors shall be installed such that the motor shall not be damaged by overvoltage or excessive transient electrical torque. The capacitor(s) shall be connected as close as possible or directly to the motor terminals. Any power factor corrections shall not decrease the motor efficiency below the stated minimum requirement of this Specification. All power factor corrections shall be noted on the Shop Drawings submitted to the Engineer for approval. POWER FACTOR CORRECTION, TO ACHIEVE 85%, SHALL BE PROVIDED ON ALL MOTORS ABOVE 15 HORSEPOWER EXCEPT FOR THOSE MOTORS CONTROLLED BY VARIABLE FREQUENCY DRIVES (VFD'S).
2. When required, power factor correction capacitors shall be connected on the line side of any type of reduced voltage starting motor controller (e.g. RVAT, RVSS, Part-Winding, Wye-Delta, etc.).

PART 3 – EXECUTION

3.01 INSTALLATION

- A. Motors shall be installed as shown on the Drawings and in accordance with the manufacturer's installation instructions.

3.02 DELIVERY, STORAGE, AND HANDLING

- A. Motors shall be properly protected from weather hazards. Motors shall not be allowed to be wrapped tightly in plastic while outdoors. Motors delivered to the site which will not be put in service for a time in excess of 30 calendar days, whether in storage or installed, shall have the shafts rotated a minimum of five (5) rotations every 30 days.
- B. Motors provided with space heaters shall have temporary power applied to the heaters no later than 30 calendar days after delivery to the site until permanent power can be applied to the heaters.
- C. Motors that, in the opinion of the Engineer, have not been properly protected shall be inspected by the manufacturer's representative. Any required electrical corrections for testing shall be made at the Contractor's expense prior to acceptance and/or use.

- D. All motors shall operate without any undue noise or vibration and shall show no signs of phase unbalance.

3.03 TESTING

- A. All tests shall be performed in accordance with the requirements of the General Conditions and Division 01. The following tests are required:

- 1. Witnessed Shop Tests

- a. All motors shall be shop tested and inspected in accordance with the equipment manufacturer's standard procedures. Shop tests for motors 100 horsepower and larger may be witnessed by the Engineer. The manufacturer's testing and inspection procedures shall demonstrate that the equipment tested conforms to the requirements specified, all other applicable requirements, and shall be approved by the Engineer. At least 10 days' notice shall be given the Engineer prior to tests and inspection dates.
- b. In addition to the efficiency and power factor testing specified herein, each motor shall be tested to determine compliance with the applicable requirements of the IEEE, ANSI and NEMA. Tests shall be as follows:

- 1) Motors less than 50 HP:

- a) Each motor shall be subjected to a standard, short commercial test including the following:
 - i. Running current, no load
 - ii. Locked rotor current
 - iii. High potential
 - iv. Winding resistance
 - v. Bearing inspection

- 2) Motors between 50 and 100 HP

- a) Each motor shall be subjected to the above tests and shall be furnished with certified test results.

- 3) Motors larger than 100 HP

- a) Each motor shall be furnished with certified test results. Each motor shall be subjected to a complete test consisting of full load heat run, percent slip, running load current, locked rotor current, breakdown torque (calculated), starting torque, winding

resistance, high potential, secondary current and voltage at collector rings (wound rotor), efficiencies at 100, 75 and 50 percent of full load, power factors at 100, 75 and 50 percent of full load and bearing inspection. Tests will be witnessed by the Engineer where specifically indicated.

4) Test Reports

- a) All test results for motors over 100 horsepower shall be submitted to the Engineer for approval. Copies of witnessed test raw data shall be submitted to the Engineer immediately upon completion of such tests.

2. Field Tests

- a. Field tests shall be performed in accordance with the requirements specified in the General Conditions, Division 01, and Section 26 05 00 – Basic Electrical Requirements.
- b. All electric motors furnished for this project one (1) horsepower or larger shall have the information required in the following tabulation completed. See Exhibit "A" on following page.
- c. All field testing shall be witnessed by the Engineer.

(EXHIBIT A)

MOTOR TEST RECORD					
Motor Identification Remarks	Location	Specified Horsepower	Nameplate Horsepower	Nameplate Amperage (FLA)	Measured Amperage Under Normal Operating Conditions

END OF SECTION

SECTION 26 09 16
ELECTRIC CONTROLS AND RELAYS

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. The Contractor shall furnish, install, test, and place in satisfactory operation all electric controls and relays as specified herein and indicated on the Drawings.
- B. Electrical control and relay systems shall be assembled using NEMA rated components. Components designed and built to International Electrotechnical Commission (IEC) standards are not recognized. Equipment designed, manufactured, and Labeled in compliance with IEC standards is not acceptable.
- C. Reference the following Specification Sections:
 - 1. Section 26 05 00 – Basic Electrical Requirements
 - 2. Section 26 05 53 – Identification for Electrical Systems

1.02 CODES AND STANDARDS

- A. Products specified herein shall be designed, manufactured, and/or Listed to the following standards as applicable:
 - 1. American National Standards Institute (ANSI)/International Society of Automation (ISA):
 - a. ANSI/ISA 12.12.01 – Nonincendive Electrical Equipment for Use in Class I and II, Division 2 and Class III, Divisions 1 and 2 Hazardous (Classified) Locations.
 - 2. National Electrical Manufacturers Association (NEMA):
 - a. NEMA 250 – Enclosures for Electrical Equipment.
 - 3. National Fire Protection Association (NFPA):
 - a. NFPA 70 – National Electrical Code (NEC).
 - 4. Underwriters Laboratories (UL):
 - a. UL 508A – Standard for Industrial Control Panels.

- b. UL-1203 – Standard for Explosion-proof and Dust-ignition-proof Electrical Equipment for use in Hazardous (Classified) Locations.

1.03 SUBMITTALS

- A. In accordance with the procedures and requirements set forth in the General Conditions and Section 01 33 00 – Submittal Procedures, the Contractor shall obtain from the equipment manufacturer and submit the following:
 - 1. Shop Drawings
 - 2. Spare Parts List
- B. Each submittal shall be identified by the applicable Specification Section.

1.04 SHOP DRAWINGS

- A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.
- B. Partial, incomplete, or illegible submittals will be returned to the Contractor without review for resubmittal.
- C. Shop drawings shall include but not be limited to:
 - 1. Product data sheets.
- D. The shop drawing information shall be complete and organized in such a way that the Engineer can determine if the requirements of these Specifications are being met. Copies of technical bulletins, technical data sheets from "soft-cover" catalogs, and similar information which is "highlighted" or somehow identifies the specific equipment items the Contractor intends to provide are acceptable and shall be submitted.

1.05 SPARE PARTS

- A. All spare parts as recommended by the equipment manufacturer shall be furnished to the Owner by the Contractor. In addition to the manufacturer recommended spare parts, the following spare parts shall be provided for the local control stations:
 - 1. One (1) contact block of each type furnished on the project
 - 2. One (1) indicating light lens of each color furnished on the project
 - 3. One (1) LED lamp of each color furnished on the project

- B. Reference Section 26 05 00 – Basic Electrical Requirements for spare parts delivery and handling requirements.

PART 2 – PRODUCTS

2.01 CONTROL COMPONENTS

A. Manufacturers

- 1. Control components shall be manufactured by The Square D Company, GE by ABB, Allen-Bradley, Siemens Energy and Automation, or Engineer approved equal.

B. Pilot Devices

1. General

- a. All pilot devices shall be provided with a legend plate. Legend plates shall have a white background and black lettering and indicate the function of the respective pilot device. The text shown on the Drawings or indicated in the specifications shall be used as the basis for legend plate engraving (e.g., HAND-OFF-AUTO, RUN, EMERGENCY STOP, etc.).
- b. All pilot devices shall be selected and properly installed to maintain the NEMA 250 rating of the enclosure in which they are installed. All pilot devices shall be UL 508 Listed.
- c. All pilot devices shall be 30.5mm in diameter, unless otherwise indicated. 22mm devices are not acceptable.
- d. Pilot devices for all electrical equipment under this Contract shall be of the same type and manufacturer unless otherwise specified herein or indicated on the Drawings.
- e. In Class I Division 2 hazardous locations, pilot devices shall be the hermetically-sealed type, constructed in accordance with ANSI/ISA 12.12.01.

2. Pushbuttons

- a. Pushbuttons shall be non-illuminated, black in color, and have momentary style operation unless otherwise indicated on the Drawings.
- b. Pushbuttons shall have the quantity of normally closed and/or normally open contacts as indicated on the Drawings and as required. In addition to the required contacts, one (1) spare normally open and one (1) spare normally closed contact shall be installed at each pushbutton. Contacts shall be rated

for 5A at 250VAC/DC (minimum), but no less than required for the application.

- c. Pushbuttons shall be provided with a full guard around the perimeter of the button. Where a lockout style pushbutton is specified or indicated on the Drawings, provide a padlockable guard.

3. Selector Switches

- a. Selector switches shall be non-illuminated, black in color, and have the number of maintained positions as indicated on the Drawings and as required. Handles shall be the extended type that provide a greater surface area for operation.
- b. Selector switches shall have the quantity of normally closed and/or normally open contacts as indicated on the Drawings and as required. In addition to the required contacts, one (1) spare normally open and one (1) spare normally closed contact shall be installed at each selector switch. Contacts shall be rated for 5A at 250VAC/DC (minimum), but no less than required for the application.
- c. Where indicated in the Drawings or Specifications, provide spring return positions.
- d. Selector switches shall be provided with an indexing component that fits into the keyed portion of the cutout for the device and prevents the switch from spinning when operated.

4. Indicating Lights

- a. Indicating lights shall be LED type, with the proper voltage rating to suit the application, and push-to-test feature.
- b. Indicating light lens colors shall be as required in equipment specifications and/or as indicated on the Drawings. If lens colors are not indicated, the following colors shall be used:

Color	Designation
Red	"Run", "On", "Open"
Green	"Off", "Closed"
Amber	"Alarm", "Fail"
White	"Control Power On"

5. Emergency Stop and Tagline Switches

- a. Emergency stop switches shall be non-illuminated, red in color, with a minimum 35mm diameter mushroom head. Once activated, switch shall maintain its position and require a manual pull to release/reset.
- b. Tagline switches shall have a plunger that activates upon tension from the associated safety cable. Once activated, switch shall maintain its position and require a manual release/reset.
- c. Emergency stop and tagline switches shall have the quantity of normally closed and/or normally open contacts as indicated on the Drawings and as required. In addition to the required contacts, one (1) spare normally open and one (1) spare normally closed contact shall be installed at each switch. Contacts shall be rated for 5A at 250VAC/DC (minimum), but no less than required for the application.

C. Relays and Timers

1. General

- a. Relays and timers shall be furnished with an integral pilot light for positive indication of coil energization.
- b. Relays and timers shall have tubular pin style terminals with matching 11-pin DIN rail mount socket. Spade or blade style terminals are not acceptable.
- c. Relays and timers for all electrical equipment under this Contract shall be of the same type and manufacturer unless otherwise specified herein or indicated on the Drawings.

2. Control and Pilot Relays

- a. Relays shall have a clear or translucent housing that allows the contacts to be visually inspected without disassembly.
- b. Relays shall have coil voltage as required to suit the application and/or as indicated on the Drawings.
- c. Relays shall be provided with contacts rated for 10A (resistive), minimum, at 120/240 VAC and 28 VDC. Relays shall have 3-pole, double-throw (3PDT) contact arrangement.

3. Time Delay Relays

- a. Timers delay relays shall utilize electronic timing technology. Mechanical timing devices are not acceptable.
 - b. Relays shall have coil voltage as required to suit the application and/or as indicated on the Drawings.
 - c. Relays shall be provided with contacts rated for 10A (resistive), minimum, at 120/240 VAC and 28 VDC. Relays shall have double-pole double-throw (DPDT) contact arrangement.
 - d. Time delay ranges shall be as indicated on the Drawings and/or as required to suit the application. Timing range shall be adjustable from the front of the relay. On delay and off delay timer configurations shall be provided as indicated on the Drawings and/or as required to suit the application.
4. Elapsed Time Meters
- a. Elapsed time meters shall be non-resettable type with no less than a four (4) digit display. Coil voltage shall be as required to suit the application and/or as indicated on the Drawings.

D. Control Terminal Blocks

- 1. Control terminal blocks shall be assembled on non-current carrying galvanized steel DIN mounting rails securely bolted to the enclosure or subpanel. Terminals shall be tubular screw type with pressure plate that will accommodate wire size range of #22 – #8 AWG.
- 2. Control terminal blocks shall be single tier with a minimum rating of 600 volts and 20A. Separate terminal strips shall be provided for each type of control used (e.g., 120VAC vs. 24VDC). Quantity of terminals shall be provided as required to suit the application. In addition, there shall be a sufficient quantity of terminals for the termination of all spare conductors.
- 3. Terminals shall be marked with a permanent, continuous marking strip, with each terminal numbered. One side of each terminal shall be reserved exclusively for incoming field conductors. Common connections and jumpers required for internal wiring shall not be made on the field side of the terminal.

2.02 LOCAL CONTROL STATIONS

- A. Local control stations shall be furnished and installed complete with pushbuttons, selector switches, indicating lights, and other devices as indicated on the Drawings.
- B. Specific devices installed in local control stations shall be provided in accordance with the requirements specified elsewhere in this Section.

- C. In non-hazardous locations, local control stations shall be furnished with the following enclosure type and material of construction, dependent upon the designation of the area in which they are to be installed. Area designations are indicated on the Drawings.

Area Designation	Enclosure Type and Material
Indoor Wet Process Area	NEMA 4X, Type 304 Stainless Steel
Indoor Dry Process Area	NEMA 12, Die Cast Zinc
Indoor Dry Non-process Area	NEMA 12, Die Cast Zinc
Indoor Type 1 Chemical Storage/Transfer Area	NEMA 4X, Fiberglass or Thermoplastic Polyester
Indoor Type 2 Chemical Storage/Transfer Area	NEMA 4X, Type 304 Stainless Steel
All Outdoor Areas	NEMA 4X, Type 304 Stainless Steel

- D. Non-metallic enclosures, NEMA 7 enclosures, and NEMA 9 enclosures shall be provided with threaded integral conduit hubs. Conduit hubs shall be external to the enclosure. Where located outdoors or in indoor wet process areas, NEMA 7 and NEMA 9 enclosures shall also carry a NEMA 4X rating.
- E. Local control stations for use in non-hazardous locations shall be UL-508 Listed. Local control stations for use in Class I, Division 1 and Class II, Divisions 1/2 hazardous locations shall be UL-1203 Listed. Local control stations for use in Class I, Division 2 hazardous locations shall be in accordance with ANSI/ISA 12.12.01-2013.
- F. Provide a nameplate on each local control station in accordance with Section 26 05 53 – Identification for Electrical Systems. The name and/or number of the equipment associated with each control station shall be engraved on the nameplate, followed by the words “LOCAL CONTROL STATION”.

PART 3 – EXECUTION

3.01 INSTALLATION

- A. Local control stations shall be provided in the enclosure type and material of construction required for the area in which it is installed. Reference the requirements in Part 2 herein, and the area designations indicated on the Drawings.
- B. Local control stations shall be mounted, nominally, at 4ft 6in above finished floor or finished grade to the centerline of the enclosure, at the equipment height where appropriate and permitted by the NEC, or as shown otherwise on the Drawings.

- C. All control components shall be mounted in a manner that will permit servicing, adjustment, testing, and removal without disconnecting, moving, or removing any other component. Components mounted on the inside of panels shall be mounted on removable plates and not directly to the enclosure. Mounting shall be rigid and stable unless shock mounting is required otherwise by the manufacturer to protect equipment from vibration. Component's mounting shall be oriented in accordance with the component manufacturer's and industries' standard practices.
- D. Pilot devices shall be properly bonded to the equipment enclosure door where they are installed. If proper bonding cannot be achieved through the locknuts that affix the device in place, a green colored bonding screw shall be provided on the pilot device. The device shall be bonded to the equipment enclosure with an insulated green bonding conductor.
- E. Local control station covers shall be bonded to the local control station enclosure with an insulated green bonding conductor.
- F. Wiring to devices at each local control station shall be provided with enough slack to permit the local control station cover to be removed and pulled at least 6 inches away from the enclosure.
- G. Terminal strips, relays, timers, and similar devices shall not be installed on the rear of the panel/cabinet doors. Terminal strips, relays, timers, and similar devices shall not be installed on the side walls of panel/cabinet interiors without written permission from the Engineer.

END OF SECTION

SECTION 26 22 00
LOW VOLTAGE TRANSFORMERS

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. The Contractor shall furnish, install, test, and place in satisfactory operation transformers for power and lighting distribution systems as specified herein, as indicated on the Drawings, and as required to complete the electrical installations.
- B. Reference the following Specification Sections:
 - 1. Section 26 05 00 – Basic Electrical Requirements
 - 2. Section 26 05 53 – Identification for Electrical Systems
- C. All equipment specified in this Section shall be furnished by the transformer manufacturer who shall be responsible for the suitability and compatibility of all included equipment.

1.02 CODES AND STANDARDS

- A. All equipment shall be Listed by and shall bear the Label of Underwriter's Laboratories, Incorporated (UL).
- B. Transformers shall be designed, manufactured, and/or Listed to the following standards as applicable:
 - 1. American National Standards Institute (ANSI)/Institute of Electrical and Electronic Engineers (IEEE):
 - a. ANSI/IEEE C57.12.01 – Standard for General Requirements for Dry -Type Distribution and Power Transformers.
 - 2. National Electrical Manufacturers Association (NEMA):
 - a. NEMA ST 20 – Dry Type Transformers for General Applications.
 - 3. National Fire Protection Association (NFPA):
 - a. NFPA 70 – National Electrical Code (NEC).
 - 4. Underwriters Laboratories (UL):

- a. UL 1561 – Dry-Type General Purpose and Power Transformers.
- 5. U.S. Department of Energy 2016 Efficiency Standards

1.03 SUBMITTALS

- A. In accordance with the procedures and requirements set forth in the General Conditions and Division 01, the Contractor shall obtain from the equipment manufacturer and submit the following:
 - 1. Shop Drawings.
 - 2. Operation and Maintenance Manuals.
 - 3. Spare Parts List.
 - 4. Reports of Certified Shop Field Tests.
- B. Each submittal shall be identified by the applicable Specification Section.

1.04 SHOP DRAWINGS

- A. Each submittal shall be complete in all respects, incorporating all information and data listed herein, and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.
- B. Partial, incomplete, or illegible submittals will be returned to the Contractor without review for resubmittal.
- C. Shop drawings shall include but not be limited to:
 - 1. Product data sheets.
 - 2. Drawings showing clearly marked dimensions and weight for each transformer.
 - 3. Sample equipment nameplate diagram.
- D. The submittal information shall reflect the specific equipment identification number as indicated on the Drawings (e.g., TX-LP-GAC).
- E. The shop drawing information shall be complete and organized in such a way that the Engineer can determine if the requirements of these Specifications are being met. Copies of technical bulletins, technical data sheets from "soft-cover" catalogs, and similar information which is "highlighted" or somehow identifies the specific equipment items that the Contractor intends to provide are acceptable and shall be submitted.

1.05 OPERATION AND MAINTENANCE MANUALS

- A. The Contractor shall submit operation and maintenance manuals in accordance with the procedures and requirements set forth in the General Conditions and Division 01.

1.06 SPARE PARTS

- A. All spare parts as recommended by the equipment manufacturer shall be furnished to the Owner by the Contractor.
- B. Reference Section 26 05 00 – Basic Electrical Requirements for spare parts delivery and handling requirements.

1.07 IDENTIFICATION

- A. Each transformer shall be identified with the equipment item number indicated on the Contract Drawings and the accepted Shop Drawings. A nameplate shall be securely affixed in a conspicuous place on each transformer. Nameplates shall be as specified in Section 26 05 53 – Identification for Electrical Systems.

PART 2 – PRODUCTS

2.01 MANUFACTURERS

- A. The equipment covered by this Specification is intended to be standard equipment of proven performance as manufactured by reputable concerns. Equipment shall be designed, constructed, and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as shown on the Drawings.
- B. Dry type distribution transformers shall be Energy Star compliant and manufactured by the Square D Company, GE by ABB, or Siemens Energy and Automation, Inc.

2.02 DRY TYPE TRANSFORMERS

- A. Furnish and install single-phase and three-phase general purpose, dry-type transformers, as specified herein and indicated on the Drawings. The transformers shall be 60 Hz, self-cooled, quiet-design insulated of the two-winding type.
- B. The transformers shall be UL 1561 Listed.
- C. The primary windings shall be rated 480 VAC for use on 3-phase systems and connected delta unless indicated otherwise on the Drawings. KVA ratings shall be as shown on the Drawings. Furnish transformers with two 2-1/2% primary taps above, and four 2-1/2% primary taps below rated voltage for transformers 15 KVA and above, and two 2-1/2% primary taps above, and two 2-1/2% primary taps below rated voltage for transformers less than 15 kVA. All taps shall be full capacity rated.

- D. The ratings of the secondary windings shall be as indicated on the Drawings.
- E. Transformers shall be designed for continuous operation at rated KVA, 24 hours a day, 365 days a year, with normal life expectancy as defined in ANSI/IEEE C57.96. This performance shall be obtainable without exceeding 150 degrees Celsius average temperature rise by resistance or 180 degrees Celsius hot spot temperature rise in a 40 degrees Celsius maximum ambient and 30 degrees Celsius average ambient. The maximum coil hot spot temperature shall not exceed 220 degrees Celsius. All insulating materials shall be flame retardant and shall not support combustion as defined in ASTM Standard Test Method D 635. All insulating materials shall be in accordance with NEMA ST 20 Standard for a 220 degrees Celsius UL component recognized insulation system.
- F. Transformer coils shall be of the continuous wound copper construction and shall be impregnated with non-hygroscopic, thermosetting varnish.
- G. All cores are to be constructed of high grade, non-aging, grain-oriented silicon steel with high magnetic permeability and low hysteresis and eddy current losses. Magnetic flux densities are to be kept well below the saturation point. The core laminations shall be tightly clamped and compressed with structural steel angles. The completed core and coil shall then be bolted to the base by means of vibration-absorbing mounts to minimize sound transmission. There shall be no metal-to-metal contact between the core and coil assembly and the enclosure.
- H. All transformers shall be equipped with a wiring compartment suitable for conduit entry and large enough to allow convenient wiring. The maximum temperature of the enclosure shall not exceed 90 degrees Celsius. Transformers shall be furnished with lugs of the size and quantity required and suitable for termination of the field wiring.
- I. The core of the transformer shall be visibly grounded to the enclosure by means of a flexible grounding conductor sized in accordance with applicable NEMA, IEEE, and ANSI standards.
- J. Transformers shall have core and coil assemblies mounted on rubber isolation pads to minimize the sound levels. Transformers shall not exceed the sound levels listed in NEMA ST-20.
- K. Transformers shall be furnished with the following enclosure type and material of construction, dependent upon the designation of the area in which they are to be installed. Area designations are indicated on the Drawings.

Area Designation	Enclosure Type and Material
Indoor Wet Process Area	NEMA 3R, Painted Steel
Indoor Dry Process Area	NEMA 2, Painted Steel

Area Designation	Enclosure Type and Material
Indoor Dry Non-Process Area	NEMA 2, Painted Steel
All Outdoor Areas	NEMA 3R, Painted Steel

- L. The enclosure shall be made of heavy gauge steel and shall be degreased, cleaned, primed, and finished with a baked weather-resistant enamel using the manufacturer's standard painting process. Color shall be ANSI 49 or 61 grey.

PART 3 – EXECUTION

3.01 INSTALLATION

- A. The transformers shall be furnished and installed as shown on the Drawings and as recommended by the equipment manufacturer.
- B. Conduit routed to and from the transformer shall be arranged for easy removal of the transformer access covers.
- C. Where transformers 50 kVA and smaller are shown to be wall mounted, a transformer manufacturer supplied wall mounting kit shall be used. The lowest point of the wall mounting bracket shall be no lower than 7'-0" above the finished floor. Field fabricated mounting hardware is not acceptable unless reviewed and approved in writing by the Engineer.
- D. Prior to final completion of the work, all metal surfaces of the equipment shall be cleaned thoroughly, and all scratches and abrasions shall be retouched with the same lacquer as used for shop finishing coats.

3.02 TESTING

- A. All tests shall be performed in accordance with the requirements of the General Conditions and Division 01. The following tests are required:
 - 1. Certified Shop Tests
 - a. The transformers shall be given routine factory tests in accordance with the requirements of the ANSI and NEMA standards. Temperature rises may be certified from basic design.
 - b. As a minimum, the following tests shall be made on all transformers:
 - 1) Ratio tests on the rated voltage connection and on all tap connections.

- 2) Polarity and phase-relation tests on the rated voltage connection.
- 3) Applied potential tests.
- 4) Induced potential tests.
- 5) No-load and excitation current at rated voltage on the rated voltage connection.

2. Field Tests

- a. Field testing shall be done in accordance with the requirements specified in the General Conditions, Division 01, and NETA Acceptance Testing Specifications, latest edition.
- b. Insulation between windings shall be tested by 1000 VDC Megohmmeter for one (1) minute. Resistance value shall be no less than 100 Megaohms.

END OF SECTION

SECTION 26 24 13
LOW VOLTAGE SWITCHBOARDS

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. The Contractor shall furnish, install, test, and place in satisfactory operation the low voltage switchboards (SWBDs) as specified herein and indicated on the Drawings.
- B. Reference the following Specification Sections:
 - 1. Section 26 05 00 – Basic Electrical Requirements
 - 2. Section 26 05 53 – Identification for Electrical Systems
 - 3. Section 26 29 20 – Low Voltage Active Harmonic Filter System
 - 4. Section 26 09 16 – Electric Controls and Relays
 - 5. Section 26 43 13 – Surge Protective Devices
- C. The SWBD line-ups shall contain circuit breakers, metering equipment, control devices, and all accessories as specified herein, indicated on the Drawings, and as required to result in a complete and operable power distribution equipment assembly.
- D. The Contractor shall obtain the SWBDs from one manufacturer who shall also manufacture the structure and major equipment components, which includes, but is not limited to, circuit breakers, power monitoring equipment, meters, relays, instrument transformers, controls, and other components of the equipment assembly. Sub-contracting of wiring is not acceptable.
- E. The SWBDs shall be assembled using NEMA rated components. Components designed and built to International Electrotechnical Commission (IEC) standards are not recognized. Equipment designed, manufactured, and labeled in compliance with IEC standards is not acceptable.

1.02 CODES AND STANDARDS

- A. All equipment shall be Listed by and shall bear the Label of Underwriter's Laboratories, Incorporated (UL).
- B. The equipment shall be designed, manufactured, and/or Listed to the following standards as applicable:

1. American National Standards Institute (ANSI)/Institute of Electrical and Electronic Engineers (IEEE):
 - a. ANSI/IEEE C12.1 – Code for Electricity Metering.
 - b. ANSI/IEEE C57.13 – Instrument Transformers.
2. National Electrical Manufacturers Association (NEMA):
 - a. NEMA PB 2 – Deadfront Distribution Switchboards.
3. National Fire Protection Association (NFPA):
 - a. NFPA 70 – National Electrical Code (NEC).
4. Underwriters Laboratories (UL):
 - a. UL 98 – Enclosed and Dead -Front Switches.
 - b. UL 489 – Molded Case Circuit Breakers, Molded Case Switches, and Circuit Breaker Enclosures.
 - c. UL 891 – Switchboards.
 - d. UL 1066 – Low-Voltage AC and DC Power Circuit Breakers Used in Enclosures.

1.03 SUBMITTALS

- A. In accordance with the procedures and requirements set forth in the General Conditions and Section 01 33 00 – Submittal Procedures, the Contractor shall obtain from the equipment manufacturer and submit the following:
 1. Shop Drawings
 2. Operation and Maintenance Manuals
 3. Spare Parts List
 4. Proposed Testing Methods
 5. Reports of Certified Shop and Field Tests
 6. Manufacturer's Representatives Installation Certification
- B. Each submittal shall be identified by the applicable Specification Section.

1.04 SHOP DRAWINGS

- A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.
- B. Partial, incomplete, or illegible submissions will be returned to the Contractor without review for resubmittal.
- C. Shop drawings for each SWBD assembly shall include but not be limited to:
 - 1. A Compliance, Deviations, and Exceptions (CD&E) letter. If the shop drawings are submitted without this CD&E letter, the submittal will be rejected. The letter shall include all comments, deviations, and exceptions taken to the Drawings and Specifications by the Contractor AND Equipment Manufacturer/Supplier. This letter shall include a copy of this Specification Section. In the left margin beside each and every paragraph/item, a letter "C", "D", or "E" shall be typed or written in. The letter "C" shall be for full compliance with the requirement. The letter "D" shall be for a deviation from the requirement. The letter "E" shall be for taking exception to a requirement. Any requirements with the letter "D" or "E" beside them shall be provided with a full typewritten explanation of the deviation/exception. Handwritten explanation of the deviations/exceptions is not acceptable. The CD&E letter shall also address deviations and exceptions taken to each Drawing related to this Specification Section.
 - 2. Bill of material list for each SWBD assembly including each SWBD compartment.
 - 3. Equipment specifications and product data sheets identifying all electrical ratings. This information shall include all equipment and devices comprising the SWBD.
 - 4. Complete assembly, layout, anchoring, and installation drawings with clearly marked dimensions. Plan, front, and side view drawings, including overall dimensions of the SWBD assembly. Identify shipping splits and show conduit stub-up area locations on the Drawings.
 - 5. Approximate total shipping weight of each shipping split and/or equipment assembly, and total assembled equipment line-up weight.
 - 6. Complete, custom one-line diagram and complete three-line diagram for the SWBD line-up. The diagrams shall indicate the devices comprising the SWBD assembly including, but not limited to, circuit breakers, control power and instrument transformers, meters, relays, control devices, and other equipment comprising the complete assembly. Clearly indicate electrical ratings of all devices.
 - 7. Complete, custom internal wiring diagram of each SWBD compartment/assembly. Each wiring diagram shall include wire identification and terminal numbers.

8. Internal compartment-to-compartment interconnection wiring diagrams including wiring identification and terminal numbers.
 9. Example equipment nameplate data sheet.
 10. Nameplate schedule for each compartment.
 11. Key interlock scheme drawing and sequence of operations.
 12. Manufacturer's installation instructions.
 13. Manufacturer's written warranty statement.
- D. The shop drawing information shall be complete and organized in such a way that the Engineer can determine if the requirements of these specifications are being met. Copies of technical bulletins, technical data sheets from "soft-cover" catalogs, and similar information which is "highlighted" or somehow identifies the specific equipment items the Contractor intends to provide are acceptable and shall be submitted.

1.05 OPERATIONS AND MAINTENANCE MANUALS

- A. The Contractor shall submit operation and maintenance manuals in accordance with the procedures and requirements set forth in the General Conditions and Division 01. The manuals shall include:
1. Instruction books and/or leaflets.
 2. Spare parts list.
 3. Final as-built construction drawings (updated from those included in the shop drawings) incorporating all changes made in the manufacturing and installation process.
 4. All other drawings, product information, and other materials originally included in the shop drawings, updated as necessary to reflect as-built conditions.

1.06 SPARE PARTS

- A. The SWBDs shall be furnished with all spare parts as recommended by the equipment manufacturer. Spaces in SWBDs shall be furnished with installed spare circuit breakers where indicated on the Drawings.
- B. In addition to the spare parts recommended by the manufacturer, the Contractor shall furnish the following minimum spare parts for each SWBD assembly:

Number Required	Description
1 set	Fuses of each size and type provided.
1	Control power transformer of each size and type provided.
2	Lamps and lenses for indicating lights, each color.
2	Indicating lamp sockets for each type provided.
2	Pilot devices (e.g., pushbutton, selector switch, etc.) complete with contact blocks and legend plates for each type, color, size, and rating provided.

- C. Reference Section 26 05 00 – Basic Electrical Requirements for spare parts delivery and handling requirements.

1.07 IDENTIFICATION

- A. Each SWBD line-up shall be identified with the identification name and/or number indicated on the Drawings (e.g., SWBD-GAC). A nameplate shall be securely affixed in a conspicuous place on the SWBD.
- B. Nameplates shall be as specified in Section 26 05 53 – Identification for Electrical Systems.

1.08 WARRANTY

- A. Contractor and Manufacturer shall warrant that the material and workmanship of all components and the operation of the equipment is in accordance with the latest design practices and meets the requirements of this Specification.
- B. Warranty shall include, but not be limited to the following:
1. Replace equipment/components found to be faulty, make changes in equipment arrangement, and/or make adjustments necessary to meet the equipment or functional requirements of this Specification.
 2. System rewiring and component substitution/rebuild.
 3. All accessories and appurtenances provided by the equipment manufacturer.
- C. Warranty for each SWBD line-up shall be in effect for a period of 24 months following final acceptance of the SWBD.

PART 2 – PRODUCTS

2.01 MANUFACTURERS

- A. The equipment covered by these specifications is intended to be standard equipment of proven performance as manufactured by reputable concerns. Equipment shall be designed, constructed, and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as shown on the Drawings.
- B. It is the intent of these specifications that the SWBDs be manufactured and assembled by a single manufacturer who shall be responsible for matching all components and providing equipment which functions together as a system. Subcontracting of wiring and/or third-party assembly is not acceptable.
- C. The SWBDs shall be Reliagear LVSB by ABB, QED-2 LV Series as manufactured by The Square D Company, or Siemens Energy & Automation, Inc. equivalent.

2.02 SWITCHBOARDS

- A. General
 - 1. SWBD assemblies shall be UL 891 Listed and bear a UL label indicating the UL File Number. Where indicated on the Drawings, SWBD shall be suitable for use as service equipment and shall be marked as such externally on the equipment enclosure.
 - 2. The SWBD manufacturer shall provide all of the proper cable lugs for all cable connections as required to avoid field modifications. Cable lugs for connecting to SWBD bus and/or circuit breakers 1600A and larger shall be irreversible compression type, lugs for all smaller bus connections shall be mechanical type lugs. Reference the Drawings for the quantity and size of conductors.
 - 3. Circuit breakers shall be power circuit breakers (drawout or fixed type) or molded-case circuit breakers as indicated on the Drawings and as specified herein.
 - 4. Provide key interlocks as indicated on the Drawings and as specified herein.
- B. Ratings
 - 1. Voltage rating shall be as indicated on the Drawings. The entire assembly shall be suitable for 600 volts maximum AC service.
 - 2. The equipment assemblies shall be suitable for operation at the available fault current, 65,000 amperes rms symmetrical (minimum), unless indicated otherwise on the Drawings. The equipment assemblies shall be labeled to indicate the maximum available fault current rating, taking into account the structure, bussing,

main/tie circuit breaker(s), and feeder/branch circuit devices. The short circuit current rating shall not be less than that specified herein or indicated on the Drawings. All overcurrent protective devices in the SWBD assembly shall be fully rated, series rated systems are not acceptable.

3. Circuit breakers shall be 100% rated where indicated on the Drawings.

C. Structures

1. SWBDs shall be deadfront type, completely metal enclosed, with self-supporting sections that are NEMA Type 1 industrial use enclosures. The sections shall be totally accessible from the front and the sides. Equipment assemblies requiring rear access are not acceptable. The framework shall be of UL gauge steel. Ventilation shall be provided as required.
2. Enclosure interior and exterior finish paint color shall be ANSI 49 or 61 grey, using the manufacturer's standard painting process. The color of the back panels located within the enclosure shall be white.
3. All wire troughs shall have hinged doors.
4. Structure front covers shall not obscure any portion of the rating information or trip unit of any circuit breaker.
5. Unless otherwise noted, the Contractor is responsible for coordinating structure top or bottom conduit entry requirements with the SWBD manufacturer.
6. Main Metering and Power Monitoring Compartment
 - a. Where indicated on the Drawings, the SWBD assembly shall include a main meter including all CTs, PTs, and other equipment required to provide customer side metering of the following:
 - 1) Current (all phases).
 - 2) Voltage (all phases).
 - 3) KW, KVAR, KVA.
 - 4) Power Factor.
 - b. Each power meter shall be powered from the best source selector switch circuit, listed later in the specification. The power meter shall be Schweitzer SEL-735, no substitutions are allowed. The meters shall be provided with the following accessories:
 - 1) Easily Extractable Meter (EXM) kit.

- 2) 5-inch color touchscreen.
 - 3) USB Type C port.
 - 4) Ethernet connection kit, including gateway module to connect with plant's Ethernet/IP network if necessary.
7. Main Lug Section(s): Where indicated on the Drawings, the SWBD assembly shall include main lug section(s).
- a. Main lug sections shall have adequate space to terminate the quantity and size of conductors shown on the Drawings and shall be configured for top or bottom conduit entry as required.
8. Main/Tie Circuit Breaker Section(s): Where indicated on the Drawings, the SWBD assembly shall include main and tie circuit breaker section(s).
- a. Main and tie sections shall have grounded vertical steel barriers to provide separation from adjacent sections.
 - b. Main circuit breakers shall be configured for top or bottom conduit entry as required.
9. The distribution sections shall include group-mounted and/or individually mounted feeder/branch circuit breakers which shall be totally front accessible and front connectable. The circuit breaker connections to the distribution panel bussing shall be bolt-on design such that the connections grip the bus bars firmly under high-fault conditions.

D. Bus

1. All bus shall be tin-plated copper. The bussing shall be of sufficient cross-sectional area in accordance with UL 891 to limit the temperature rise on any current carrying part to a maximum of 65 degrees C above a maximum ambient of 40 degrees C. The fully rated main bus shall have an ampacity as indicated on the Drawings, be 100 percent rated, and extend the full length of the equipment. The ground bus shall be sized per UL 891 and installed in the entire length of the equipment assembly.
2. Where 3-wire bus is indicated on the Drawings, the SWBD shall be furnished with 3 phase busses and a ground bus. In addition, if a transformer with a grounded wye secondary is shown on the Drawings to be supplying a 3-wire SWBD, a neutral landing pad shall be furnished within the SWBD for each incoming supply to provide a place to terminate the grounded conductor. Providing a 4-wire bus (3 phases plus neutral) for a 3-wire system is not acceptable.

3. Where a 4-wire bus is indicated on the Drawings, the SWBD shall be furnished with 3 phase busses, a neutral bus of equal ampacity to the phase bus, and a ground bus.
4. The distribution SWBD bus shall be rated as required by the rating of the mounted feeder/branch devices, including spares or spaces. Full height vertical bus shall be provided to accommodate future circuit breakers. Less than full height vertical bus which will only accommodate the circuit breakers included for this project is unacceptable.
5. Where required by the NEC, a bonding jumper, sized in accordance with the NEC, shall be installed between the SWBD ground bus and the neutral bus or neutral landing pad.

E. Molded-Case Circuit Breakers

1. Unless otherwise shown on the Drawings, circuit breakers shall be manually operated molded case type, UL 489 Listed, rated 480 VAC, 3 pole, and have 100 ampere or larger frames. The interrupting rating shall match that of the SWBD short circuit rating at 480V.
2. Overload protection shall be provided on all poles with trip settings as indicated on the Drawings. Where indicated on the Drawings, breakers shall have solid-state electronic trip units (ETUs) with features and adjustable segments as shown.
 - a. Long-time, short-time, and ground fault segments shall have both adjustable pickup and adjustable delay.
 - b. Instantaneous segments shall have an adjustable pickup in addition to any high-fault trip override.
 - c. Trip units shall be Square D Micrologic 5.0A/6.0A, ABB Ekip Touch, or Siemens ETU 576/586.
 - d. For circuit breakers of frame size 250A or larger, ETUs shall be field interchangeable.
 - e. All main and tie circuit breaker trip units (regardless of size) as well as feeder circuit breaker trip units for circuit breakers 1200A frame or larger shall be provided with an arc energy reduction mode to reduce arc-flash energy. Arc energy reduction mode shall be activated by a factory-wired illuminated selector switch mounted on the SWBD door with lockable cover (or switch-and-cover with separate indicator light). Provide dry contact from the trip unit to make arc energy reduction mode status available for remote monitoring.

3. Where indicated on the Drawings, shunt trip devices shall be provided to trip a circuit from a remote location by means of a trip coil energized from a separate circuit. A 120V shunt trip shall be capable of operating 55% or more of rated voltage. All other shunt trips shall be capable of operating at 75% or more of rated voltage.
4. Circuit breakers shall be provided with permanently mounted hardware for padlocking the circuit breaker in the open position.

F. Power Circuit Breakers

1. Where specifically indicated on the Drawings, circuit breakers shall be insulated case type power circuit breakers.
2. Power circuit breakers shall be UL 1066 Listed for application at 100 percent of their continuous current rating, rated 480 VAC, 3 pole. The interrupting rating shall match that of the SWBD short circuit rating at 480V.
3. Power circuit breakers shall utilize a two-step stored-energy mechanism to charge the closing springs. The closing of the circuit breaker shall automatically charge the opening springs. Power circuit breakers of equal rating shall be completely interchangeable.
4. Power circuit breakers shall be manually operated unless electrically operated (E.O.) is indicated on the Drawings. All power circuit breakers shall be provided with a manual handle for manually charging the closing springs.
5. Electrically operated power circuit breakers shall be furnished with a 120 VAC powered spring charging motor, shunt trip device, and electrically operated spring release device.
6. Each power circuit breaker faceplate shall include a spring charge indicator, push-to-trip button, push-to-close mechanism release button, and open-close indicator.
7. Power circuit breakers shall be fixed-mount or drawout type as indicated on the Drawings.
 - a. Equip each drawout circuit breaker with self-coupling primary and secondary disconnect contacts and a disconnect mechanism for moving it physically between the CONNECTED and DISCONNECTED positions.
 - b. Provide a TEST position for each drawout circuit breaker, interlocked to ensure proper sequence and safe operation.
 - c. Provide interlocking to prevent a closed circuit breaker from racking to or from any position. Provide an additional interlock to assure automatic

discharging of the closing springs upon insertion or removal of the circuit breaker into or out of the compartment.

- d. Each drawout circuit breaker faceplate shall include a drawout position indicator.
8. Equip each power circuit breaker with padlocking provisions to prevent manual or electric closure of the circuit breaker.
9. Equip each power circuit breaker with current sensors and a self-powered microprocessor-based trip device to sense overload and short circuit conditions.
- a. Trip devices shall be removable and interchangeable so that any trip device can be used with any frame size power circuit breaker.
 - b. The device shall measure true RMS currents. Peak sensing devices will not be accepted. All adjustment setting switches shall be digitally encoded type with gold contacts.
 - c. Trip units shall have adjustable segments as indicated on the Drawings. Long-time, short-time, and ground fault segments shall have both adjustable pickup and adjustable delay. Instantaneous segments shall have an adjustable pickup in addition to any high-fault trip override.
 - d. All main and tie circuit breaker trip units (regardless of size) as well as feeder circuit breaker trip units for circuit breakers 1200A frame or larger shall be provided with an arc energy reduction mode to reduce arc-flash energy. Arc energy reduction mode shall be activated by a factory-wired illuminated selector switch mounted on the SWBD door with lockable cover (or switch-and-cover with separate indicator light). Provide dry contact from the trip unit to make arc energy reduction mode status available for remote monitoring.
 - e. Trip units shall have programmable alarm relays that activate based on threshold and time delay values associated with any of the measured parameters. Alarm output operation shall be recorded in an event log that is saved in the trip unit's memory.
 - f. The trip unit shall include an integral test pushbutton. A keypad shall be provided to enable the user to select the values of test currents within a range of available settings. The protection functions shall not be affected during test operations. The breaker shall be able to be tested in the TRIP or NO TRIP test mode.
 - g. Trip units shall be furnished complete with all additional modules required to facilitate all trip unit functions. Trip units shall be the Square D Micrologic 5.0X/6.0X, ABB Ekip Touch, or Siemens ETU 776.

10. Provide a minimum of two (2) normally open and two (2) normally closed auxiliary contacts for remote indication of power circuit breaker open/closed status.

G. Key Interlocks

1. Normally the two 480V bus sections will operate independently with the main circuit breakers in the CLOSED position and the bus tie circuit breaker in the OPEN position.
2. The main circuit breakers shall be interlocked with the bus tie circuit breaker by key interlocks. Key interlocks shall be accessible without opening the circuit breaker compartment door and shall function as follows:
 - a. Permit closing one or both main circuit breakers when the bus tie circuit breaker is OPEN.
 - b. Prevent closing the bus tie circuit breaker when both main circuit breakers are CLOSED.
 - c. Permit closing the bus tie circuit breaker when one or both main circuit breakers are OPEN.
 - d. Permit closing of only one circuit main breaker when the bus tie circuit breaker is CLOSED.

H. Current Transformers (CTs)

1. Ring type current transformers (CTs) shall be dry type, for indoor service, insulated for 600 volts, 10 kV BIL. Design shall have a mechanical and thermal rating to withstand short-circuit current, stresses, and heating effects equal to the rating of the circuit breaker of the application.
2. Current ratio shall be as indicated on the Drawings.
3. Instrument transformers shall be rated in accordance with ANSI Standard C37.20.1 and IEEE C57.13, accuracy class 0.3. Furnish CTs with metering burden designation B-0.3, minimum. The CTs shall be sized for the necessary burden for the required devices, minimum.
4. Identify the CTs for polarity with standard marking or symbols. The CTs shall be capable of carrying rated primary current continuously without damage.
5. Run secondary wiring from CTs in suitable wiring trough, or conduit, to proper short-circuiting type terminal blocks for connection to relays, instruments, and other devices.

6. Door mounted test blocks for all CTs in the SWBD shall be provided.

I. Potential Transformers (PTs)

1. Potential transformers (PTs) shall be indoor dry type, single-phase, 60 hertz.
2. PTs shall have a 10kV BIL and an accuracy classification determined according to ANSI Standards. The PTs shall be suitable for 0.3 metering accuracy at the burden to be served for the required devices plus 20 percent. Primary and secondary voltages shall be as indicated on the Drawings.
3. Connect secondaries to potential buses as required. Protect PTs with primary and secondary fuses. Protect primary side with current-limiting fuses.
4. Door mounted test switches for all PTs in the SWBD shall be provided. Test switch wiring shall be plainly marked to indicate the respective circuits to each pole of the switch. No 480VAC is permitted to be present directly on the test switches.

J. Control Power Transformers (CPTs)

1. Provide 480 to 120 VAC control power transformers as required with adequate capacity for the load to be served. For SWBD assemblies with more than one bus (e.g. main-tie-main systems), provide a control power transformer for each bus with the secondaries tied together through best-source selection hardware.
2. Protect control power transformers with both primary and secondary fuses. Protect primary side with current limiting fuses. Provide a manual disconnect ahead of the primary fuses.
3. Control power transformers shall each be sized to supply the following control circuits:
 - a. Constant power for all trip unit displays in the assembly.
 - b. Spring charging mechanisms for all electrically operated circuit breakers, sized to operate two spring charging mechanisms simultaneously.
4. Provide separate control power transformers for space heaters, lighting, receptacles and other ancillary loads separate from those used for the control circuits identified above.

K. Control Wiring and Control Terminal Blocks

1. Wire and factory test SWBD to satisfy the requirements of the operation described or as necessary.

2. All control wiring shall be No. 14 AWG (minimum). Power wiring shall be sized to suit the maximum load rating of unit; No. 12 AWG (minimum). For current transformer (CT) circuits, minimum wire size shall be No. 12 AWG (number 10 AWG or larger wire shall be used to decrease resistance as required). Wiring shall be type MTW rated for 105°C.
3. Route control wires for outgoing or "compartment-to-compartment" interconnecting wiring to master terminal blocks with suitable numbering strips numbered in agreement with the manufacturer's detailed wiring diagrams. Provide a minimum of 10 percent (10%) spare terminal blocks for each circuit breaker and auxiliary compartment.
4. Terminal blocks for control wiring shall be provided in accordance with Section 26 09 16 – Electric Controls and Relays.
5. Number wiring with shrink-type tag devices at both ends consistent with the manufacturer's detailed wiring diagrams. Duplication of wire numbers and terminal block numbers is not acceptable.

L. Power Monitoring, Instruments, and Control Devices

1. Where indicated on the Drawings, provide power monitors matching the power meters specified earlier in this section.
2. Furnish instruments, meters, and control devices complete with devices and associated circuitry necessary to perform the required functions in accordance with these Specifications.
3. Furnish and install control devices as required and/or shown on the Drawings. The following control devices shall be provided as specified in Section 26 09 16 – Electric Controls and Relays:
 - a. Pilot devices (e.g., switches, indicating lights, etc.).
 - b. Relays and timers, if required.

M. Nameplates and Legend Plates

1. Provide engraved plastic nameplates to identify each SWBD, each compartment, and associated door mounted devices and internal components. Nameplates shall be as specified in Section 26 05 53 – Identification for Electrical Systems.
2. Equipment names and/or numbers and device identification text shown on the Drawings shall be used as the basis to engrave the nameplates and legend plates. Where the equipment identification text would exceed the capacity of the SWBD manufacturer's standard nameplate/legend plate size, the manufacturer shall

provide larger nameplates and/or additional nameplates as necessary. Abbreviating equipment names/numbers and device identification text is not acceptable.

3. Provide a master nameplate listing SWBD designation, voltage rating, ampere rating, short circuit rating, manufacturer's name, general order number, and item number.
4. Control components mounted as part of the assembly, such as fuse blocks, control relays, pushbuttons, switches, and similar devices, shall be suitably marked for identification corresponding to appropriate designations on the manufacturer's wiring diagrams.

N. Warning Signs

1. Provide a minimum of two (2) warning signs on the front of the SWBD line-up (and two (2) on the rear, where the rear of the line-up is accessible).
 - a. Red laminated plastic engraved with white letters approximately ½-inch high.
 - b. Signs shall read "DANGER HIGH VOLTAGE"

O. Source Quality Control

1. Completely assemble, wire, and test SWBDs at the factory. Detailed inspections before and after assembly shall assure correctness of design and workmanship. Provide groups of wires leaving the shipping-assembled equipment with terminal blocks with suitable numbering strips.
2. After assembly, provide the SWBDs with lifting channels having eyebolts for attachment of crane slings to facilitate lifting and handling each shipping-assembly unit. These lifting channels shall be removable after equipment is placed on permanent foundations.

P. Accessories

1. SWBD accessories shall be provided as follows:
 - a. For drawout circuit breakers: an auxiliary power module to provide power for testing the trip unit when the breaker is in the DISCONNECTED or REMOVED position.
 - b. Test plugs for draw-out relays and meters, if applicable.
 - c. A 4" infrared inspection port in the front door of each main/tie circuit breaker section. IR ports shall be located to allow IR observation of the cable

terminations within the compartment. IR ports shall meet requirements of IEEE C37.20.2, shall maintain NEMA rating of SWBD enclosure when in use.

Q. Surge Protective Devices

1. Surge protective devices (SPD) shall be provided either integral to the SWBD enclosure or as a separate unit external to the SWBD enclosure, as indicated on the Drawings. See Section 26 43 13 – Surge Protective Devices for SPD requirements.

PART 3 – EXECUTION

3.01 INSTALLATION

- A. The SWBD shall be furnished and installed as shown on the Drawings and in accordance with the manufacturer's installation instructions. One (1) copy of these instructions shall be included with the equipment at time of shipment. The equipment shall be suitably protected until accepted by the Owner.
- B. The equipment shall be installed and checked in accordance with the manufacturer's recommendations. This shall include but not limited to:
 1. Checking to ensure that the pad location is level to within .125 inches over 3 feet in any direction.
 2. Checking to ensure that all bus bars are torqued to the manufacturer's recommendations.
 3. Assemble all shipping sections, remove all shipping braces, and connect all shipping split mechanical and electrical connections.
 4. Secure assemblies to foundation or floor channels.
 5. Inspect and install all circuit breakers in their proper places.
 6. Install power cable lashing as outlined in the manufacturer's installation instructions for the equipment.

3.02 PAINTING

- A. Prior to final completion of the work, all metal surfaces of the equipment shall be cleaned thoroughly, and all scratches and abrasions shall be retouched with the same coating as used for factory finishing coats.

3.03 TESTING

- A. All tests shall be performed in accordance with the requirements of the General Conditions and Division 01. The following tests are required:
 - 1. Witness Shop Tests
 - a. Not required.
 - 2. Certified Shop Tests and Reports
 - a. Submit description of proposed testing methods, procedures, and apparatus.
 - b. Submit notarized and certified copies of all test reports. As a minimum, the entire SWBD assembly shall go through a quality inspection before shipment. This inspection shall include, but is not limited to, the following:
 - 1) Physical inspection of the structure and the electrical conductors including bussing, general wiring, and units.
 - 2) General electrical tests including power circuit phasing, control circuit wiring, instrument transformers, meters, ground fault system, and device electrical operation.
 - 3) AC dielectric tests of the power circuits and control circuits.
 - 4) Markings/labels, including instructional type, Underwriters Laboratory (UL), and inspector's stamps.
 - c. The manufacturer shall use integral quality control checks throughout the manufacturing process to maintain the correctness of the SWBD.
 - 3. Field Tests
 - a. Field testing shall be done in accordance with the requirements specified in the General Conditions, Division 01, NETA Acceptance Testing Specifications, and Section 26 05 00 – Basic Electrical Requirements.

3.04 SERVICES OF MANUFACTURER'S REPRESENTATIVE

- A. The Contractor shall provide the services of a qualified, factory-trained manufacturer's technical representative who shall adequately supervise the installation and testing of all equipment furnished under this Contract. The manufacturer's representative shall certify in writing that the equipment has been installed in accordance with the manufacturer's recommendations. No further testing or equipment startup may take place until this certification is accepted by the Owner.

- B. The manufacturer's technical representative shall perform startup and functional testing of the SWBD as specified herein.
- C. The Contractor shall provide training for Owner personnel. Training shall be conducted by the manufacturer's factory-trained representative who shall instruct Owner personnel in operation and maintenance of all equipment provided under this Section. Training shall be provided for two (2) sessions of four (4) hours each. Training shall not take place until after all SWBD units have been installed and energized. Training shall be at times coordinated with the Owner.
- D. The services of the manufacturer's representative shall be provided for a period of not less than as follows:
 - 1. One (1) trip of two (2) working days during the installation of the SWBD.
 - 2. One (1) trip of two (2) working days for the testing and startup of the SWBD.
 - 3. One (1) trip of one (1) working day to perform training as specified herein.
 - 4. One (1) trip of one (1) working day two (2) months before the warranty expiration to identify any issues to be corrected under warranty.
- E. Any additional time required to achieve successful installation and operation shall be at the expense of the Contractor.

3.05 FIELD ADJUSTMENTS

- A. All adjustable settings of circuit breakers shall be set in the field by the entity responsible for protective device setting and testing as specified in Section 26 05 00 – Basic Electrical Requirements, in accordance with the settings designated in the coordination study.

END OF SECTION

SECTION 26 24 16
PANELBOARDS

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. The Contractor shall furnish, install, test, and place in satisfactory operation panelboards as specified herein and indicated on the Drawings. Panelboards shall be furnished with circuit breaker ratings, number of breakers, number of poles, and arrangements/locations conforming to the panelboard schedules shown on the Drawings.
- B. Reference the following Specification Sections:
 - 1. Section 26 05 00 – Basic Electrical Requirements
 - 2. Section 26 05 53 – Identification for Electrical Systems
 - 3. Section 26 43 13 – Surge Protective Devices

1.02 CODES AND STANDARDS

- A. All equipment shall be Listed by and shall bear the Label of Underwriter's Laboratories, Incorporated (UL).
- B. The equipment shall be designed, manufactured, and/or Listed to the following standards as applicable:
 - 1. National Electrical Contractors Association (NECA):
 - a. NECA 407 – Standards for Installing and Maintaining Panelboards.
 - 2. National Electrical Manufacturers Association (NEMA):
 - a. NEMA PB 1 – Panelboards.
 - 3. National Fire Protection Association (NFPA):
 - a. NFPA 70 – National Electrical Code (NEC).
 - 4. Underwriters Laboratories (UL):
 - a. UL 50 – Enclosures for Electrical Equipment, Non-environmental Considerations.

- b. UL 67 – Standard for Panelboards.
- c. UL 489 – Molded Case Circuit Breakers, Molded Case Switches, and Circuit Breaker Enclosures.
- d. UL 943 – Ground Fault Circuit Interrupters.

1.03 SUBMITTALS

- A. In accordance with the procedures and requirements set forth in the General Conditions and Section 01 33 00 – Submittal Procedures, the Contractor shall obtain from the equipment manufacturer and submit the following:
 - 1. Shop Drawings.
 - 2. Spare Parts List.
 - 3. Operation and Maintenance Manuals.
 - 4. Reports of Field Tests.
- B. Each submittal shall be identified by the applicable Specification Section.

1.04 SHOP DRAWINGS

- A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.
- B. Partial, incomplete, or illegible submittals will be returned to the Contractor without review for resubmittal.
- C. Shop drawings shall include but not be limited to:
 - 1. Product data sheets.
 - 2. Complete assembly, layout, and installation drawings with clearly marked dimensions for each panelboard.
 - 3. Complete panelboard schedules indicating circuit designations as shown on the Drawings for each panelboard.
 - 4. The submittal information shall reflect the specific equipment identification number as indicated on the Drawings (e.g., LP-GAC, PP-GAC, etc.).

1.05 OPERATIONS AND MAINTENANCE MANUALS

- A. The Contractor shall submit operation and maintenance manuals in accordance with the procedures and requirements set forth in the General Conditions and Division 01. The manuals shall include:
 - 1. Instruction books and/or leaflets.
 - 2. Recommended spare parts list.
 - 3. Final as-built construction drawings included in the shop drawings incorporating all changes made in the manufacturing process and during field installation.

1.06 SPARE PARTS

- A. For each panelboard, the Contractor shall furnish to the Owner all spare parts as recommended by the equipment manufacturer. All spaces in the panelboards shall be furnished with a spare breaker as indicated in the panelboard schedules shown on the Drawings.
- A. Reference Section 26 05 00 – Basic Electrical Requirements for spare parts delivery and handling requirements.

1.07 IDENTIFICATION

- A. Each panelboard shall be identified with the identification name/number indicated on the Drawings. A nameplate shall be securely affixed in a conspicuous place on each panelboard. Nameplates shall be as specified in Section 26 05 53 – Identification for Electrical Systems.

PART 2 – PRODUCTS

2.01 MANUFACTURERS

- A. The Equipment shall be designed, constructed, and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as shown on the Drawings.
- B. It is the intent of these specifications that the panelboards be produced by a single manufacturer who shall be responsible for matching all components and providing equipment which functions together as a system.
- C. Distribution panelboards, those identified with a prefix “DP” on the Drawings, shall be the I-Line Series by Square D, GE by ABB equivalent, or Siemens Energy and Automation, Inc. equivalent.

- D. Power panelboards, those identified with prefix "PP" on the Drawings, shall be the NF Series by Square D, GE by ABB equivalent, or Siemens Energy and Automation, Inc. equivalent.
- E. Lighting and instrument panelboards, those identified with prefix "LP" and "IP" respectively on the Drawings, shall be the NQ Series by Square D, GE by ABB equivalent, or Siemens Energy and Automation, Inc. equivalent.
- F. Combination power units shall be Mini-Power Zone Series by Square D, GE by ABB equivalent, or Siemens Energy and Automation, Inc. equivalent.

2.02 PANELBOARDS

A. General

- 1. Panelboards shall be dead-front type and shall be of the configuration and rating as specified herein and indicated on the Drawings. Panelboards shall be UL 67 Listed and shall be constructed to NEMA PB1 standards.
- 2. Where specified herein, indicated on the Drawings, or required, panelboards shall be rated for service entrance and bear a service entrance label.
- 3. Panelboards shall be equipped with a main circuit breaker or main lugs complete with branch circuit breakers, as indicated on the Drawings. The panelboards shall be suitable for flush or surface mounting as indicated on the Drawings.
- 4. Panelboards shall be fully rated and shall have a minimum short circuit rating of 22,000 amperes symmetrical for units rated 240VAC and below, and 42,000 amperes symmetrical for units rated above 240VAC, unless otherwise indicated on the Drawings.

B. Enclosures

- 1. Enclosures shall be UL 50 Listed and have a NEMA rating as indicated on the Drawings. An Underwriter's Laboratories, Inc. inspection label shall appear on the interior of the cabinet. Enclosures designated as NEMA 4X shall be constructed of 304 stainless steel. Enclosures with all other NEMA ratings shall be constructed of No. 12 U.S.S. code gauge galvanized steel, painted ANSI 49 or 61 gray. The enclosure shall have wiring gutters on the sides and shall be at least 5-3/4 inches deep. Wiring gutters shall be large enough to allow compliance with NEC minimum bending radius requirements for all cables to be terminated, including future cables sized for any spare circuit breakers that are shown on the Drawings.
- 2. All panelboards shall be provided with a dead front style trim. Additional trim requirements are as follows:

- a. Distribution panelboards with enclosures that are rated other than NEMA 12 shall have hinged covers over each vertical wiring gutter to allow access to all branch mounted device terminations without removing the panel trim.
 - b. Power, lighting, and instrumentation panelboards with enclosures that are rated other than NEMA 12 shall be provided with a full height hinge where it is attached to the panelboard box. Trim shall be attached to the panelboard enclosure using concealed trim clamps. Resultant trim assembly shall allow work inside the enclosure without the need to remove the panel trim from the enclosure.
3. Panelboard trims shall include a door over the dead front area to provide access to the circuit breakers and other devices. The access door shall be fastened to the trim with concealed hinges and be equipped with flush-type catches. Access doors exceeding 40 inches in height shall be equipped with a vertical bolt three-point locking mechanism, all other doors shall have a single-point mechanism. All locks shall be keyed alike.
4. The panelboard shall be provided with an information label. The information label shall include the panelboard designation, voltage, phase, number of wires, and bus ratings.

C. Bus Work

1. Where 3-wire bus is indicated on the Drawings, the panelboard shall be furnished with 3 phase busses and a ground bus. In addition, if a transformer with a grounded wye secondary is shown on the Drawings to be supplying a 3-wire panelboard, a neutral landing pad shall be furnished within the panelboard to provide a place to terminate the grounded conductor. Providing a 4-wire bus (3 phases plus neutral) for a 3-wire system is not acceptable.
2. Where a 4-wire bus is indicated on the Drawings, the panelboard shall be furnished with 3 phase busses, a neutral bus of equal ampacity to the phase bus, and a ground bus.
3. Main bus bars shall be sized in accordance with UL 67 to limit the temperature rise on any current carrying part to a maximum of 65 degrees C above a maximum ambient of 40 degrees C.
4. A separate ground bus shall be provided with lugs for termination of equipment grounding conductors.
5. Branch bus work shall be rated to match the maximum branch circuit breaker which may be installed in the standard space.

6. All bus shall be tin-plated copper and shall extend the entire useable length of the panelboard, including spaces.
7. Where required by the NEC, a bonding jumper, sized in accordance with the NEC, shall be installed between the panelboard ground bus and the neutral bus or neutral landing pad.

D. Circuit Breakers

1. Main and branch circuit breakers shall be bolt-on, UL 489 Listed molded-case type with trip ratings as indicated on the Drawings. Unless otherwise indicated, circuit breakers shall be manually operable, with automatic trip-free operation, and shall provide inverse-time-limit overload and instantaneous short-circuit protection. All circuit breakers shall have quick-make, quick-break, toggle mechanisms for manual as well as automatic operation.
2. Main circuit breakers shall be individually mounted. Branch-mounted main circuit breakers are not acceptable unless specifically indicated on the Drawings. Coordinate top or bottom mounting of main circuit breaker with incoming conduit location(s).
3. Tandem or half-size circuit breakers are not acceptable.
4. Circuit breaker voltage ratings shall meet or exceed the panelboard voltage indicated on the Drawings. The number of poles and trip ratings shall be as indicated on the Drawings. Where a trip rating is not indicated on the Drawings, provide a 20A circuit breaker.
5. Circuit breakers for panelboards rated 240VAC and below shall have an interrupting rating at 240 VAC that matches the panelboard short circuit rating. Circuit breakers for panelboards rated above 240VAC shall have an interrupting rating at 480 VAC that matches the panelboard short circuit rating.
6. Unless indicated otherwise on the Drawings, circuit breakers with smaller than 225-ampere frames shall be the thermal-magnetic type. Thermal and magnetic trip elements may be fixed or adjustable.
7. Where indicated on the Drawings, and for circuit breakers of 225-ampere frames and larger, circuit breakers shall have interchangeable electronic trip units (ETU) and adjustable trip elements and time delays. Provide electronic trip units with the adjustable functions indicated on the Drawings (e.g., Long, Short, Instantaneous, Ground, etc.).
8. Where indicated on the Drawings, or where required by Code, circuit breakers shall be equipped with integrally mounted ground fault circuit interrupters (i.e., GFI/GFCI) complete with "TEST" push button, and shall be of a type which fit

standard panelboard spaces for the breaker continuous current rating required. Ground fault circuit interrupter style circuit breakers shall be UL 943 Listed. Circuit breakers used for lighting circuit switching shall be approved for the purpose and shall be marked "SWD". Where required by Article 440 of the NEC, circuit breakers installed for air conditioning units shall be HACR type.

9. Where indicated on the Drawings, circuit breakers shall be 100% rated.
10. Where indicated on the Drawings, main circuit breakers shall be provided with a shunt trip device to trip the breaker from a remote location by means of a trip coil energized from a separate circuit. A 120 VAC shunt trip shall be capable of operating at 55% or more of rated voltage. All other shunt trips shall be capable of operating at 75% or more of rated voltage.
11. Where indicated on the Drawings, or as required, circuit breakers shall be provided with a padlockable hasp or handle padlock attachment (lock-off device) for padlocking in the "OFF" position as required to meet the NEC requirement for disconnecting means and/or OSHA lock-out/tagout standard. Locking hardware shall remain in place even when the padlock is removed. Where indicated on the Drawings, or as required, branch circuit breakers shall be provided with a similar attachment (lock-on device) for padlocking in the "ON" position for critical circuits (e.g., fire alarm control panel circuits) which must remain energized.

E. Directories

1. Approved directories with noncombustible plastic cover, and with typewritten designations of each branch circuit, shall be furnished and installed in each panelboard (including both new panelboards and existing panelboards modified under this project). The Contractor shall maintain in each panelboard, during the duration of the Contract, a handwritten directory clearly indicating the circuit breakers in service. This directory shall be updated as work progresses, and final, typewritten directories, as specified above, shall be installed at the end of the project. Designations and circuit locations shall conform to the panelboard schedules on the Drawings, except as otherwise authorized by the Engineer.

2.03 SURGE PROTECTIVE DEVICES

- A. Surge protective devices (SPD) shall be provided either integral to the panelboard or as a separate unit external to the panelboard enclosure, as indicated on the Drawings. See Section 26 43 13 – Surge Protective Devices for SPD requirements.
- B. Integral SPDs shall be installed within the panelboard enclosure in a location that allows the required quantity and rating of branch circuit breakers to be installed. Reducing the quantity of branch circuit breakers to less than that required by the panel schedules is not acceptable.

PART 3 – EXECUTION

3.01 INSTALLATION

- A. Panelboards shall be furnished and installed as shown on the Drawings and as recommended by the equipment manufacturer, and as required by NECA 407.
- B. Panelboards shall be set true and plumb in locations as shown on the Drawings. The top of panelboard enclosure shall not exceed six (6) feet above finished floor elevation.
- C. Enclosures shall not be fastened to concrete or masonry surfaces with wooden plugs. Appropriate cadmium plated or galvanized steel bolts shall be used with expansion shields or other metallic type concrete insert for mounting on concrete or solid masonry walls. Cadmium plated or galvanized steel toggle bolts shall be used for mounting on concrete block or other hollow masonry walls. Bolt diameter shall be as required considering the size and weight of the completed panelboard and enclosure to provide adequate structural support.
- D. The Contractor shall not use factory furnished knockouts with surface mounted back boxes. The Contractor shall punch or drill required openings during installation and shall equip flush mounted back boxes with manufacturer's standard pattern of knockouts.
- E. The Contractor shall install cabinets (and other enclosure products) in plumb with the building construction. Flush mounted enclosures shall be installed so that the trim will rest against the surrounding surface material and around the entire perimeter of the enclosure.
- F. Bus loads in all panelboards shall be balanced between phases to within a tolerance of one (1) KVA. Convenience receptacles shall be distributed evenly among all phase buses as much as practical.
- G. Prior to final completion of the work, all metal surfaces of the equipment shall be cleaned thoroughly, and all scratches and abrasions shall be retouched with the same lacquer as used for shop finishing coats.

3.02 TESTING

- A. All tests shall be performed in accordance with the requirements of the General Conditions and Division 01. The following tests are required:
 - 1. Field Tests
 - a. Prior to termination of any conductors to the circuit breakers, all bus work and circuit breakers shall be tested from phase to phase and phase to ground with a 1000 VDC megohmmeter for 1 minute in accordance with

NECA 407. Resistance values shall be recorded and shall not be less than 100 megohms.

- b. Prior to terminating any wires to the circuit breakers, the resistance of the connection between the bus work and each circuit breaker shall be tested through the use of a low-resistance ohmmeter. Record the resistance values for each circuit breaker.

END OF SECTION

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SECTION 26 27 26
WIRING DEVICES

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. The Contractor shall furnish and install all switches, and receptacles as shown on the Drawings.
- B. All switches and receptacles shall be furnished and installed in outlet boxes. Reference Section 26 05 33.16 – Boxes for Electrical Systems for outlet box requirements.
- C. Reference Section 26 05 00 – Basic Electrical Requirements and Section 26 05 19 – Low-Voltage Conductors and Cables.

1.02 CODES AND STANDARDS

- A. All equipment shall be Listed by and shall bear the Label of Underwriter's Laboratories, Incorporated (UL).
- B. Wiring devices shall be designed, manufactured, and/or Listed to the following standards as applicable:
 - 1. National Fire Protection Association (NFPA):
 - a. NFPA 70 – National Electrical Code (NEC).
 - 2. Underwriters Laboratories (UL):
 - a. UL 20 – General Use Snap Switches.
 - b. UL 498 – Standard for Attachment Plugs and Receptacles.
 - c. UL 943 – Ground Fault Circuit Interrupters.
 - d. UL 1203 – Standard for Explosion-proof and Dust-ignition-proof Electrical Equipment for use in Hazardous (Classified) Locations.

1.03 SUBMITTALS

- A. In accordance with the procedures and requirements set forth in the General Conditions and Section 01 33 00 – Submittal Procedures, the Contractor shall obtain from the equipment manufacturer and submit shop drawings. Each submittal shall be identified by the applicable Specification Section.

1.04 SHOP DRAWINGS

- A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.
- B. Partial, incomplete, or illegible submittals will be returned to the Contractor without review for resubmittal.
- C. Shop drawings shall include, but not be limited to:
 - 1. Product data sheets.

1.05 SPARE PARTS

- A. The Contractor shall furnish 10% (minimum of 1) spare of each receptacle, switch, and plug furnished and installed for this project.
- B. Reference Section 26 05 00 – Basic Electrical Requirements for spare parts delivery and handling requirements.

1.06 IDENTIFICATION

- A. Each switch and receptacle shall be identified with the equipment item number, manufacturer's name or trademark, and such other information as the manufacturer may consider necessary, or as specified, for complete identification.

PART 2 – PRODUCTS

2.01 MANUFACTURERS

- A. The equipment covered by these Specifications is intended to be standard equipment of proven performance as manufactured by reputable concerns. Equipment shall be designed, constructed, and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as shown on the Drawings.
- B. The Contractor shall use the products of a single manufacturer for each type of wiring device.
- C. The Contractor shall use the products of a single manufacturer for all device plates. Plate variations are allowed for the following devices:
 - 1. Where the selected plate manufacturer does not manufacture a suitable finish plate.
 - 2. For heavy-duty receptacles rated at more than 30A.

- 3. Where non-standard plates are required, specified, or shown.
- D. The Contractor shall furnish and install all wiring devices and device plates.
- E. In non-hazardous areas, provide specification grade devices manufactured by Appleton, Crouse-Hinds, Leviton, Hubbell, Pass & Seymour, or Engineer approved equal.
- F. In hazardous areas, provide devices manufactured by Appleton, Cooper Crouse-Hinds, Hubbell-Killark, or Engineer approved equal.

2.02 WIRING DEVICES

- A. Wall switches for non-hazardous areas shall be rated for the current required to suit the application, but not less than 20A. Double -pole, three-way, and four-way switches shall be provided where indicated on the Drawings, and as required. Switches shall be rated for 120-277VAC and shall be UL 20 Listed.
- B. Convenience receptacles for non-hazardous areas shall be rated for 20A at 125VAC and shall be UL 498 Listed. Receptacles shall be weather -resistant where installed in wet or damp locations.
- C. Special purpose receptacles (e.g., welders, lab equipment, etc.) shall be provided with the proper NEMA configuration and ampacity as indicated on the Drawings. The coordinating plug for each special purpose receptacle shall be provided with the equipment which it is serving.
- D. Ground fault circuit interrupter receptacles shall be rated for 20A at 125VAC and shall be UL 943 Listed. Receptacles shall be weather -resistant where installed in wet or damp locations.
- E. Wall switches for hazardous areas shall be the factory sealed type, UL 1203 Listed for use in the hazardous area. Wall switches shall be rated for 120-277VAC, and shall be rated for the current required to suit the application, but not less than 20A.
- F. Receptacles for hazardous areas shall be rated 20A at 120-240VAC. Receptacles shall be UL 1203 listed for use in the hazardous area, utilizing delayed-action construction.
- G. Wiring devices shall be approved for use with stranded conductors if stranded conductors are to be used with the device. Reference Section 26 05 19 – Low-Voltage Conductors and Cable for conductor requirements

2.03 DEVICE PLATES

- A. Device plates for indoor flush-mounted receptacles and switches shall be made of Type 304 stainless steel, not less than 0.032 of an inch thick, with beveled edges and milled

on the rear so as to lie flat against the wall. Device plates shall be provided with a gasket.

- B. Device plates for outdoor installations, indoor wet process areas, and chemical storage/transfer areas shall be Appleton Type FSK-1VS-A, Crouse-Hinds #DS185, or Engineer approved equal for wall switches. Device plates for receptacles shall be "in-use" style, and shall be fully closable when a plug/cord is inserted. "In-use" weatherproof covers shall be rugged, minimum 3 ¼" depth, die-cast aluminum as manufactured by Thomas & Betts "Red Dot," Intermatic International, Inc., or Engineer approved equal.
- C. Device plates for indoor dry process and non-process areas with surface mounted boxes shall be Crouse-Hinds DS32 or Engineer approved equal for switches, and Crouse-Hinds DS23 or Engineer approved equal for receptacles.

2.04 PLUGS

- A. The Contractor shall furnish suitable plugs with equipment furnished under the respective Specification Section. Plugs shall be black rubber or plastic. For waterproof receptacles, the plugs shall be similar in construction to the receptacles and shall be encased in corrosion resistant yellow housing provided with clamping nuts and stuffing gland cable outlets.

2.05 PROCESS INSTRUMENTS

- A. The Contractor shall furnish and install a local disconnect switch at each process instrument (e.g., level transmitter, flow transmitter, analytical instrument, etc.) to disconnect the 120VAC power supply to the instrument. The device shall be a NSSC series manual motor starting switch without overload protection as manufactured by Crouse-Hinds, Appleton equivalent, or Engineer approved equal. For hazardous locations, the device shall be UL 1203 Listed.

PART 3 – EXECUTION

3.01 INSTALLATION

- A. Where more than one (1) switch occurs at one (1) location, gang plates shall be used.
- B. All device plates shall be set true and plumb and shall fit tightly against the finished wall surfaces and outlet boxes.
- C. Wiring device box (outlet box) mounting heights shall be as specified in Section 26 05 33.16 – Boxes for Electrical Systems.

- D. When indicated height would place any of the equipment at an unsuitable location such as at a molding or break in wall finish, the Contractor shall bring it to the attention of the Engineer for a decision.
- E. Receptacles installed in toilet, locker, and bathrooms, and within 6 feet of a sink, shall be of ground fault circuit interrupter (GFCI) type. GFCI receptacles shall also be furnished and installed in additional locations where indicated on the Drawings, and as required by the NEC.
- F. All receptacles shall have a self-adhesive label installed on the top at the respective device plate that indicates which panel and which circuit number the receptacle is supplied from. Labels shall have a white background and black lettering in 14-point font.

3.02 CIRCUITING

- A. Convenience receptacles shall be grouped on circuits separate from the lighting circuits. A maximum of eight (8) convenience receptacles are permitted per 20A, 120V circuit, unless otherwise indicated on the Drawings.

END OF SECTION

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SECTION 26 28 16.16
ENCLOSED SWITCHES

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. The Contractor shall furnish, install, test, and place in satisfactory operation separately mounted, individual disconnect switches as specified herein and indicated on the Drawings.
- B. Disconnect switches for process instruments are not included in the scope of this Section and shall be as specified in Section 26 27 26 – Wiring Devices.
- C. Reference the following Specification Sections:
 - 1. Section 26 05 00 – Basic Electrical Requirements
 - 2. Section 26 05 53 – Identification for Electrical Systems

1.02 CODES AND STANDARDS

- A. All equipment shall be Listed by and shall bear the Label of Underwriter's Laboratories, Incorporated (UL).
- B. Disconnect switches shall be designed, manufactured, and/or Listed to the following standards as applicable:
 - 1. National Electrical Manufacturers Association (NEMA):
 - a. NEMA 250 – Enclosures for Electrical Equipment.
 - b. NEMA KS 1 – Heavy Duty Enclosed and Dead-Front Switches (600 Volts Maximum).
 - 2. National Fire Protection Association (NFPA):
 - a. NFPA 70 – National Electrical Code (NEC).
 - 3. Underwriters Laboratories (UL):
 - a. UL 98 – Enclosed and Dead-Front Switches.
 - b. UL 1203 – Standard for Explosion-proof and Dust-ignition-proof Electrical Equipment for use in Hazardous (Classified) Locations.

1.03 SUBMITTALS

- A. In accordance with the procedures and requirements set forth in the General Conditions and Section 01 33 00 – Submittal Procedures, the Contractor shall obtain from the equipment manufacturer and submit the following:
 - 1. Shop Drawings
 - 2. Spare Parts List
 - 3. Each submittal shall be identified by the applicable Specification Section.

1.04 SHOP DRAWINGS

- A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.
- B. Partial, incomplete, or illegible submittals will be returned to the Contractor without review for resubmittal.
- C. Shop drawings shall include but not be limited to:
 - 1. Product data sheets.
 - 2. Complete layout and installation drawings with clearly marked dimensions for each type/size/rating of disconnect switch.
 - 3. Assembled weight of each unit.
- D. The shop drawing information shall be complete and organized in such a way that the Engineer can determine if the requirements of these Specifications are being met. Copies of technical bulletins, technical data sheets from "soft-cover" catalogs, and similar information which is "highlighted" or somehow identifies the specific equipment items that the Contractor intends to provide are acceptable and shall be submitted.

1.05 SPARE PARTS

- A. The equipment shall be furnished with all spare parts as recommended by the equipment manufacturer.
- B. One (1) complete set of spare fuses for each ampere rating installed shall be furnished and delivered to the Owner at the time of final inspection.
- C. Reference Section 26 05 00 – Basic Electrical Requirements for spare parts delivery and handling requirements.

1.06 IDENTIFICATION

- A. Each equipment item shall be identified with a nameplate. The nameplate shall be engraved indicating the equipment name with which it is associated (e.g., Pump No.1 DSW). Equipment identification shall be in accordance with Section 26 05 53 – Identification for Electrical Systems.

PART 2 – PRODUCTS

2.01 MANUFACTURERS

- A. The equipment covered by this Specification is intended to be standard equipment of proven performance as manufactured by reputable concerns. Equipment shall be designed, constructed, and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as shown on the Drawings.
- B. Switches shall be manufactured by the Square D Company, the GE by ABB, Rockwell Automation (Allen-Bradley), or Siemens Energy and Automation, Inc.

2.02 DISCONNECT SWITCHES

- A. Disconnect switches shall be heavy-duty type and/or as specified in these Specifications. Switches shall be furnished and installed as shown on the Drawings and as required by the NEC. Handles shall be lockable.
- B. Disconnect switches for non-hazardous areas shall be UL 98 Listed. Disconnect switches for hazardous areas shall be UL 1203 Listed.
- C. Switches shall meet NEMA Standard KS 1 type HD requirements, be, single-throw, be externally operated, and be fused or non-fused as indicated on the Drawings. Switches shall have the number of the poles, voltage, and ampere ratings as shown on the Drawings.
- D. Enclosure Types and Materials
 - 1. In non-hazardous locations, disconnect switches shall be furnished with the following enclosure type and material of construction, dependent upon the designation of the area in which they are to be installed. Area designations are indicated on the Drawings.

Area Designation	Enclosure Type and Material
Indoor Wet Process Area	NEMA 4X, Type 304 Stainless Steel
Indoor Dry Process Area	NEMA 12, Painted Steel

Area Designation	Enclosure Type and Material
Indoor Dry Non-Process Area	NEMA 1, Painted Steel
Indoor Type 1 Chemical Storage/Transfer Area	NEMA 4X, Fiberglass
Indoor Type 2 Chemical Storage/Transfer Area	NEMA 4X, Type 304 Stainless Steel
All Outdoor Areas	NEMA 4X, Type 304 Stainless Steel

- E. Disconnect switches shall be quick-make, quick-break and with an interlocked cover which cannot be opened when switch is in the "ON" position and capable of being locked in the "OPEN" position.
- F. A complete set of fuses for all switches shall be furnished and installed as required. Time-current characteristic curves of fuses serving motors or connected in series with circuit breakers shall be coordinated for proper operation. Fuses shall have voltage rating not less than the circuit voltage.
- G. Disconnect switches shall be furnished with a factory installed internal barrier kit that helps prevent accidental contact with live parts and provides "finger-safe" protection when the door of the enclosed switch is open.
- H. Disconnect switches shall be furnished with a manufacturer-supplied ground lug kit for termination of equipment grounding conductors. Where a grounded (neutral) conductor is shown on the Drawings in the conduits connected to the disconnect switch, a manufacturer-supplied neutral bar shall be furnished for termination of the grounded conductors. Third party ground lug and neutral lug kits not supplied by the disconnect switch manufacturer are not acceptable.
- I. Fused disconnect switches shall be furnished for motor operated valve and gate actuators where shown on the Drawings. The Contractor shall coordinate the supply of these fused switches with the specific requirements of the actuator. Fuses with fast fault clearing times may be required for modulating valve actuators.
- J. Disconnect switches for all motors connected to variable frequency drives (VFDs) shall be furnished with a factory installed electrical interlock kit that includes one (1) early-break auxiliary contact rated for 5A (minimum) at 120 VAC to be used to open the control circuit before the main switch blades break.
- K. Disconnect switches for use on circuits utilizing shielded VFD cable(s), shielded submersible pump cable(s), or similar special cable constructions, shall be furnished with the configuration, accessories, and/or appurtenances necessary for use with such cables as described in Part 3 herein.

PART 3 – EXECUTION

3.01 INSTALLATION

- A. Disconnect switches shall be mounted, nominally, at 4ft 6in above finished floor or finished grade to the centerline of the operating handle mechanism (and not to exceed 6ft 7in to the center of the operating handle grip when in its highest position), at the equipment height where appropriate and permitted by the NEC, or where shown otherwise.
- B. Disconnect switches shall be provided in the enclosure type and material of construction required for the area in which it is installed. Reference the requirements in Part 2 herein, and the area designations indicated on the Drawings.
- C. Where disconnect switches are shown on the Drawings to be installed on circuits utilizing shielded VFD cable(s), shielded submersible pump cable(s), or similar special cable constructions, the Contractor shall coordinate the configuration and installation of the disconnect switches with the switch manufacturer and respective cable and/or pump/equipment manufacturer(s). These types of cables require special methods to be utilized for termination, grounding, etc., and may also require the addition of isolated (from other ground conductors, enclosure/raceway grounding, etc.) ground/shield termination provisions in the disconnect switch for pass-through of the cable internal shield/ground conductor(s). Properly coordinating and executing the configuration and installation of disconnect switches with these cable types shall be the sole responsibility of the Contractor.

3.02 TESTING

- A. All tests shall be performed in accordance with the requirements of the General Conditions and Division 01. The following tests are required:
 - 1. Field Tests
 - a. Field testing shall be done in accordance with the requirements specified in the General Conditions, Division 01, and NETA Acceptance Testing Specifications, latest edition.

END OF SECTION

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SECTION 26 29 13.13
LOW-VOLTAGE ENCLOSED MOTOR CONTROLLERS – FULL VOLTAGE

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. The Contractor shall furnish, install, test, and place in satisfactory operation separately mounted, full voltage individual motor controllers as specified herein and indicated on the Drawings. Individual motor controllers specified in this Section include magnetic motor starters and manual motor starters.
- B. Reference the following Specification Sections:
 - 1. Section 26 05 00 – Basic Electrical Requirements
 - 2. Section 26 05 19 – Low Voltage Conductors and Cables
 - 3. Section 26 05 53 – Identification for Electrical Systems
 - 4. Section 26 09 16 – Electric Controls and Relays

1.02 CODES AND STANDARDS

- A. All equipment shall be Listed by and shall bear the Label of Underwriter's Laboratories, Incorporated (UL).
- B. Enclosed motor controllers shall be designed, manufactured, and/or Listed to the following standards as applicable:
 - 1. National Electrical Manufacturers Association (NEMA):
 - a. NEMA 250 – Enclosures for Electrical Equipment.
 - b. NEMA ICS 1 – Industrial and Control Systems General Requirements.
 - c. NEMA ICS 2 – Industrial Control and Systems Controllers, Contactors and Overload Relays Rated 600 Volts.
 - 2. National Fire Protection Association (NFPA):
 - a. NFPA 70 – National Electrical Code (NEC).
 - 3. Underwriters Laboratories (UL):
 - a. UL 489 – Molded Case Circuit Breakers, Molded Case Switches, and Circuit Breakers.

- b. UL 508A – Standard for Industrial Control Panels.

1.03 SUBMITTALS

- A. In accordance with the procedures and requirements set forth in the General Conditions and Section 01 33 00 – Submittal Procedures, the Contractor shall obtain from the equipment manufacturer and submit the following:
 - 1. Shop Drawings.
 - 2. Spare Parts.
 - 3. Reports of Certified Shop and Field Tests.
 - 4. Operation and Maintenance Manuals.
- B. Each submittal shall be identified by the applicable Specification Section.

1.04 SHOP DRAWINGS

- A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.
- B. Partial, incomplete, or illegible submittals will be returned to the Contractor without review for resubmittal.
- C. Shop drawings shall include but not be limited to:
 - 1. Product data sheets.
 - 2. Complete layout and installation drawings with clearly marked dimensions for each type/size/rating of individual motor controller.
 - 3. Custom wiring diagrams for each individual motor controller. Standard wiring diagrams that are not custom created by the manufacturer for the individual motor controllers for this project are not acceptable. One wiring diagram which is typical for an equipment group (e.g. exhaust fans) is not acceptable. Each wiring diagram shall include wire identification and terminal numbers. Indicate all devices, regardless of their physical location, on the diagrams. Identify on each respective wiring diagram specific equipment names and equipment numbers consistent with those indicated on the Drawings.
 - 4. Bill of material list for each individual motor controller.
 - 5. Nameplate schedule for each individual motor controller.
 - 6. Manufacturer's installation instructions.

7. Manufacturer's Warranty Statement
 8. Table listing all motor loads connected to the motor controller. Table shall include the full load amps and locked rotor amps of the APPROVED motors. Final approval of motor controller shop drawings cannot be given until all motor loads associated with each motor controller have been reviewed, approved, and shown in this table.
 9. Time-current curves for each type and size protective device if requested by the Engineer.
- D. The shop drawing information shall be complete and organized in such a way that the Engineer can determine if the requirements of these Specifications are being met. Copies of technical bulletins, technical data sheets from "soft-cover" catalogs, and similar information which is "highlighted" or somehow identifies the specific equipment items that the Contractor intends to provide are acceptable and shall be submitted.

1.05 OPERATION AND MAINTENANCE MANUALS

- A. The Contractor shall submit operation and maintenance manuals in accordance with the procedures and requirements set forth in the General Conditions and Division 01. The manuals shall include, but not be limited to:
1. Instruction books and/or leaflets.
 2. Spare parts list.
 3. Final as-built construction drawings (updated from those included in the Shop Drawings) incorporating all changes made in the manufacturing and installation process.
 4. All other drawings, product information, and other materials originally included in the Shop Drawings, updated as necessary to reflect as-built conditions.

1.06 SPARE PARTS

- A. All spare parts as recommended by the equipment manufacturer shall be furnished to the Owner by the Contractor. The Contractor shall furnish the following additional spare parts:
1. Two (2) spare fuses for each size and type used.
- B. Reference Section 26 05 00 – Basic Electrical Requirements for spare parts delivery and handling requirements.

1.07 IDENTIFICATION

- A. Each equipment item shall be identified with a nameplate. The nameplate shall be engraved with the equipment name and/or number with which it is associated.

Equipment identification shall be in accordance with Section 26 05 53 – Identification for Electrical Systems.

1.08 WARRANTY

- A. Contractor and Manufacturer shall warrant that the material and workmanship of all components and the operation of the equipment is in accordance with the latest design practices and meets the requirements of this Specification.
- B. Warranty shall include, but not be limited to the following:
 - 1. Replace equipment/components found to be faulty, make changes in equipment arrangement, and/or make adjustments necessary to meet the equipment or functional requirements of this Specification.
 - 2. System rewiring and component substitution/rebuild.
 - 3. All accessories and appurtenances provided by the equipment manufacturer.
- C. Warranty for each individual motor controller shall be in effect for a period of 24 months following final acceptance of the motor controller.

PART 2 – PRODUCTS

2.01 MANUFACTURERS

- A. The equipment covered by this Specification is intended to be standard equipment of proven performance as manufactured by reputable concerns. Equipment shall be designed, constructed, and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as shown on the Drawings.

2.02 INDIVIDUAL MAGNETIC MOTOR STARTERS

- A. **The Contractor** is fully responsible for the review of the full Contract Documents to determine specified motor speed, horsepower and full load ampere requirements for each motor-driven load.
- B. Individual magnetic motor starters shall be combination type complete with motor circuit protectors (MCPs). Starters shall be rated 480 VAC, 3-pole, sized for the intended load unless otherwise indicated. Motor starters shall conform to NEMA Standard ICS 1 and shall be for across-the-line starting, unless otherwise indicated. In no case shall a starter smaller than a NEMA Size 1 be used. Each starter shall be furnished with a minimum of two (2) spare auxiliary contacts. Starters shall have separately replaceable contacts and coils. NEMA-Rated IEC type starters are not acceptable.
- C. Motor branch circuits shall be protected by a motor circuit protector (MCP). MCP sizes shall be selected by the manufacturer based on the motor nameplate information

gathered and listed in the table required herein. MCP shall have an adjustment range that allows for between 800% and 1200% of motor nameplate FLA.

- D. Starters shall be provided with all coils and controls for 120 VAC operation, unless otherwise indicated on the Drawings.
- E. The motor controller manufacturer is advised to review the total Contract Documents for additional requirements for space heaters, power factor correction capacitors, and similar equipment which may not be specified in this Division or shown on the Drawings. Control power transformers shall be fused on both the primary and secondary sides. The minimum control power transformer VA requirements are as shown below. Control power transformers shall be sized as required for the connected loads, plus 25% spare capacity.
1. Size 1-150 VA
 2. Size 2-150 VA
 3. Size 3-200 VA
 4. Size 4-300 VA
 5. Size 5-500 VA
- F. Each starter shall be supplied with a manual reset overload relay. Manual reset shall be accomplished by a door mounted overload reset pushbutton. The relays shall be solid state type, with at least one isolated normally open and one isolated normally closed auxiliary contact that operates when a trip condition has occurred. Relays shall be self-powered, have a visible trip indicator, have a trip test function, and have selectable Class 10 or 20 operation. Overload relays shall be set for Class 10 operation unless otherwise directed by the Engineer. Overload relay shall have phase loss protection built in to trip the unit and protect the motor against single phasing. The Contractor shall provide the overload relay model with the correct current range for each application. Overload relay shall have adjustable current range dial. Eutectic alloy and bi-metallic type overload relays are not acceptable.
- G. Enclosures
1. In non-hazardous locations, motor starters shall be furnished with the following enclosure type and material of construction, dependent upon the designation of the area in which they are to be installed. Area designations are indicated on the Drawings.

Area Designation	Enclosure Type and Material
Indoor Wet Process Area	NEMA 4X, Type 304 Stainless Steel
Indoor Dry Process Area	NEMA 12, Painted Steel

Area Designation	Enclosure Type and Material
Indoor Dry Non-Process Area	NEMA 1, Painted Steel
Indoor Type 1 Chemical Storage/Transfer Area	NEMA 4X, Fiberglass
Indoor Type 2 Chemical Storage/Transfer Area	NEMA 4X, Type 304 Stainless Steel
All Outdoor Areas	NEMA 4X, Type 304 Stainless Steel

2. Each motor controller enclosure in non-hazardous areas shall be supplied with an industrial, heavy-duty flange-mount handle mechanism for the operation of the motor controller disconnecting means as follows:
 - a. The mechanism shall be engaged with the disconnect device at all times as an integral part of the unit regardless of the unit door position.
 - b. The operator handle shall have an up-down motion with the down position as off. The ON-OFF condition of the disconnecting means shall be permanently marked on the handle operator.
 - c. It shall be possible to lock the handle in the "OFF" position with up to three (3) 3/8-inch diameter shackle padlocks and in the "ON" position with one (1) 3/8-inch diameter shackle padlock.
 - d. The operator handle shall be mechanically interlocked such that the disconnecting means cannot be closed with the enclosure door open, nor can the enclosure door be opened when the disconnecting means is closed. A defeater mechanism shall be provided so that qualified personnel can bypass these interlocks for maintenance and testing purposes. The defeater mechanism shall allow the enclosure door to be opened without interrupting the operation of the motor controller.

H. Control Devices

1. Furnish and install control devices as required and/or shown on the Drawings. The following control devices shall be provided as specified in Section 26 09 16 – Electric Controls and Relays:
 - a. Pilot devices (switches, indicating lights, etc.)
 - b. Relays and timers
 - c. Control terminal blocks
- I. All control wiring shall be No. 14 AWG (minimum) labeled at each end in accordance with the wiring numbers shown on the accepted shop drawings. Power wiring shall be sized to suit the maximum horsepower rating of unit; No. 12 AWG (minimum). Wiring

shall be type MTW rated for 105°C. Wire color coding shall be as specified in Section 26 05 19 – Low Voltage Conductors and Cables.

- J. Each motor starter coil shall be equipped with a surge-suppression device, where applicable, for protection of solid-state equipment (e.g., programmable logic controller) wired as part of the control circuit.
- K. Individual magnetic motor starters shall be as manufactured by Eaton using NEMA rated Freedom Series starters and contactors, GE by ABB equivalent, the Square D Company equivalent, Rockwell Automation (Allen-Bradley) equivalent, or Siemens Energy & Automation, Inc. equivalent.

2.03 INDIVIDUAL MANUAL MOTOR STARTERS

- A. Individual manual motor starters in enclosures as specified above shall be furnished and installed for outdoor and indoor exposed work. Furnish and install manual motor starters in outlet boxes with flush wall plates as required for concealed work.
- B. Furnish and install manual motor starters with pilot lights and overload heater elements of correct rating based on motor nameplate data.
- C. Manual motor starters shall be equipped with either a push button or toggle operator with reset device or mechanism accessible without opening the enclosure.
- D. Individual manual motor starters for motors one (1) horsepower and less shall be manufactured by ABB, the Square D Company, Rockwell Automation (Allen-Bradley), or Siemens Energy & Automation, Inc.
- E. Individual manual motor starters for integral horsepower motors shall be manufactured by the Square D Company, Rockwell Automation (Allen-Bradley), or Siemens Energy and Automation, Inc.

PART 3 – EXECUTION

3.01 INSTALLATION

- A. All individual motor starters shall be installed in accordance with the manufacturer's installation instructions and as indicated on the Drawings.
- B. Individual motor starters shall be provided in the enclosure type and material of construction required for the area in which it is installed. Reference the requirements in Part 2 herein, and the area designations indicated on the Drawings.

3.02 TESTING

- A. All tests shall be performed in accordance with the requirements of the General Conditions and Division 01. The following tests are required:

1. Witnessed Shop Tests
 - a. None required.
2. Field Tests
 - a. Field testing shall be done in accordance with the requirements specified in the General Conditions, Division 01, and NETA Acceptance Testing Specifications, latest edition.

3.03 FIELD ADJUSTMENTS

- A. The settings of the motor circuit protectors and overload relays shall be developed and set by the entity responsible for protective device setting and testing as specified in Section 26 05 00 – Basic Electrical Requirements. The settings shall be in accordance with NEC requirements based on the motor nameplate data of the motors installed.

END OF SECTION

SECTION 26 29 23
LOW VOLTAGE VARIABLE FREQUENCY MOTOR CONTROLLERS

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. The Contractor shall furnish, install, connect, test and place in satisfactory operating condition all variable frequency drives (VFDs) as specified herein and indicated on the Drawings.
- B. Reference the following Specification Sections:
 - 1. Section 26 05 00 – Basic Electrical Requirements
 - 2. Section 26 05 53 – Identification for Electrical Systems
 - 3. Section 26 43 13 – Surge Protective Devices
 - 4. Section 26 29 13.13 – Low-Voltage Enclosed Motor Controllers-Full Voltage
 - 5. Section 26 29 13.16 – Low-Voltage Enclosed Motor Controllers-Reduced Voltage
 - 6. Section 26 09 16 – Electric Controls and Relays
- C. The Contractor is responsible for coordinating with the driven equipment manufacturer and the VFD manufacturer to ensure that the VFD is sized properly to meet all of the requirements herein. This includes, but is not limited to, accounting for motor RPM and variable or constant torque applications. The Contractor is responsible for including any costs related to equipment upsizing, conduit and wire upsizing, etc. that results from selecting equipment with a higher full load amp rating than was specified or used as the basis for design.
- D. The variable frequency drives shall be assembled using NEMA rated components. Components designed and built to International Electrotechnical Commission (IEC) standards are not recognized. Equipment designed, manufactured, and labeled in compliance with IEC standards is not acceptable.

1.02 CODES AND STANDARDS

- A. VFDs shall be designed, manufactured, and/or listed to the following standards as applicable:
 - 1. NEMA 250 – Enclosure for Electrical Equipment
 - 2. IEEE 519 – Recommended Practice and Requirements for Harmonic Control in Electric Power Systems

3. NEMA ICS 7 – Adjustable-Speed Drives
4. NEMA ICS 61800-2 – Rating Specifications for Low Voltage Adjustable Frequency AC Power Drive Systems
5. UL 489 – Molded Case Circuit Breakers, Molded Case Switches, and Circuit Breaker Enclosures
6. UL 508A – Standard for Industrial Control Panels
7. UL 508C – Standard for Power Conversion Equipment

1.03 DEFINITIONS

- A. The following definitions are provided for clarity with regard to the language used in this Specification:
 1. Variable Frequency Drive (VFD) – The complete custom-engineered VFD as packaged within an overall enclosure, including the VFD unit and all other components within that enclosure as specified herein.
 2. VFD Unit – The solid-state power electronic device or devices within the VFD.

1.04 SUBMITTALS

- A. In accordance with the procedures and requirements set forth in General Conditions and Section 01 30 00 – Submittal Procedures, the Contractor shall obtain from the equipment manufacturer and submit the following:
 1. Shop Drawings
 2. Operation and Maintenance Manuals
 3. Spare Parts List
 4. Reports of Certified Shop and Field Tests
 5. Manufacturer's Field Start-up Report
 6. Manufacturer's Representative's Installation Certification

1.05 SHOP DRAWINGS

- A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.
- B. Partial, incomplete, or illegible submittals will be returned to the Contractor without review for resubmittal.

C. Shop drawings **for each VFD** shall include but not be limited to:

1. A Compliance, Deviations, and Exceptions (CD&E) letter. If the shop drawings are submitted without this CD&E letter, the submittal will be rejected. The letter shall include all comments, deviations and exceptions taken to the Drawings and Specifications by the Contractor AND Equipment Manufacturer/Supplier. This letter shall include a copy of this Specification Section. In the left margin beside each and every paragraph/item, a letter "C", "D", or "E" shall be typed or written in. The letter "C" shall be for full compliance with the requirement. The letter "D" shall be for a deviation from the requirement. The letter "E" shall be for taking exception to a requirement. Any requirements with the letter "D" or "E" beside them shall be provided with a full typewritten explanation of the deviation/exception. Handwritten explanation of the deviations/exceptions is not acceptable. The CD&E letter shall also address deviations, and exceptions taken to each Drawing related to this Specification Section.
2. Complete bill of material and catalog data sheets for all equipment and devices comprising the VFD.
3. Heat loss data for each VFD.
4. Manufacturer's warranty information.
5. Product data sheets for **all** system components, including but not limited to:
 - a. VFD units
 - b. RVSS units and motor overloads
 - c. Harmonic correction devices and/or equipment, e.g. line reactors, passive filters, and 18-pulse phase-shifting transformers
 - d. Output reactors and/or output filters
 - e. Pilot lights and pilot devices
 - f. Control and timing relays
 - g. Enclosure fans
 - h. Contactors
 - i. Power supplies
 - j. Control power transformers
 - k. Current transformers

- l. Potential transformers
 - m. Circuit breakers and/or motor circuit protectors
 - n. Fuses
 - o. Terminal blocks (power, control, and shorting)
 - p. Surge protective devices
6. Layout drawings of the VFD that include:
- a. All cabinet or enclosure dimensions, access details, and weights.
 - b. Required clearances around the enclosure, e.g. ventilation.
 - c. Conduit entry areas and/or stub-up locations.
 - d. Nameplate sizes, colors, and locations.
 - e. Physical arrangement of door mounted devices located on the variable frequency drive enclosure.
 - f. Physical arrangement of **all** interior components, including DIN-rail-mounted devices.

General "catalog data sheet" layout drawings which are not specific to the systems specified herein are not acceptable.

7. Custom schematic and interconnection wiring diagrams of all electrical work, including but not limited to, circuit breakers, motor circuit protectors, contactors, instrument transformers, meters, relays, timers, control devices, terminal blocks and identification numbers, wire numbers, and other equipment comprising the complete system.
- a. These drawings shall be circuit specific for each motor-load combination (e.g. GAC Feed Pump, Backwash Pump) Specific equipment names consistent with the Drawings shall appear on each respective diagram.
 - b. Indicate all devices, regardless of their physical location, on the schematic diagrams.
 - c. Electrical ratings of all equipment and devices shall be clearly indicated on the schematic diagrams.

Standard schematics and wiring diagrams that are not custom created by the manufacturer for the variable frequency drives for this project are not acceptable.

8. Confirmation of spare parts requirements as specified herein.
 9. Table listing all motor loads connected to the VFD. Table shall include the full load amps of the APPROVED motors. Final approval of VFD shop drawings cannot be given until all motor loads for each VFD have been reviewed, approved, and shown in this table.
- D. The shop drawing information shall be complete and organized in such a way that the Engineer can determine if the requirements of these Specifications are being met. Copies of technical bulletins, technical data sheets from catalogs, and similar information which is "highlighted" or somehow identifies the specific equipment items the Contractor intends to provide are acceptable and shall be submitted.

1.06 FOPERATION AND MAINTENANCE MANUALS

- A. The Contractor shall submit operation and maintenance manuals in accordance with the procedures and requirements set forth in the General Conditions, Section 01 30 00 – Submittal Procedures and Section 46 00 00 – Equipment General Provisions.
- B. Prior to completion and final acceptance of the project, the Contractor shall furnish and install "as-built" wiring diagrams for each VFD. These final drawings shall be included in the O&M manuals and an additional copy that is plastic laminated shall be securely placed inside each VFD.
- C. The O&M manual shall include the "as-commissioned" parameters of each VFD in both print and digital formats.
- D. If the VFDs require computer software or configuration, the O&M manual shall include copies of all programming guides/manuals.

1.07 SPARE PARTS

- A. The VFDs and accessories shall be furnished with all spare parts as recommended by the equipment manufacturer. In addition to the manufacturer recommended spare parts, the Contractor shall furnish the following spare parts:
 1. Two (2) sets of fuses for each size and type of fuse provided.
 2. One (1) HMI per type of HMI provided.
 3. One (1) set of enclosure air filters for each VFD.
 4. For each VFD unit **without** field-replaceable internals, furnish one (1) spare VFD unit per size provided.
 5. For each VFD unit **with** field-replaceable internals, furnish one (1) fully functional main control circuit board per VFD unit size provided.

- B. The spare parts shall be packed in containers suitable for long term storage, bearing labels clearly designating the contents and the pieces of equipment for which they are intended.
- C. Spare parts shall be delivered at the same time as the equipment to which they pertain. The Contractor shall properly store and safeguard such spare parts until completion of the Work, at which time they shall be delivered to the Owner.
- D. Spare parts lists included with the shop drawing submittal shall indicate specific sizes, quantities, and part numbers of the items to be furnished. Terms such as "1 lot of packing material" are not acceptable.
- E. Parts shall be completely identified with a numerical system to facilitate parts inventory control and stocking. Each part shall be properly identified by a separate number. Those parts which are identical for more than one size, shall have the same parts number.

1.08 WARRANTY

- A. Contractor shall warrant that the material and workmanship of all components and the operation of the VFDs and auxiliary equipment is in accordance with the latest design practices and meets the requirements of this Specification.
- B. Warranty shall include, but not be limited to the following:
 - 1. Replace components found to be faulty and make changes in equipment arrangement or make adjustments necessary to meet the equipment or functional requirements or this Specification.
 - 2. System rewiring and component substitution/rebuild.
 - 3. All accessories and appurtenances provided by the VFD manufacturer.
- C. Warranty shall be in effect for a period of 24 months following final acceptance of each VFD.

PART 2 – PRODUCTS

2.01 MANUFACTURERS

- A. The equipment covered by this Specification is intended to be equipment of proven performance. Equipment shall be designed, constructed, and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as shown on the Drawings.
- B. The Contractor shall obtain the VFDs from one manufacturer who shall also manufacture and assemble the enclosure and major equipment components including, but not limited to the VFD unit and bypass starters. The manufacturer shall have five years minimum of

experience in the manufacture of similar units and shall have a general distribution to the electrical trade. **Subcontracting of wiring and/or third-party assembly is not acceptable.**

- C. The VFDs shall be manufactured by Eaton, the Square D Company, Rockwell Automation (Allen-Bradley), ABB, or Toshiba.
- D. The Contractor shall be responsible for the successful application and operation of the entire drive and control system serving the motor and driven equipment. This includes the responsibility for obtaining all load, torque, speed and performance requirements from the appropriate sources and integrating these into a VFD that fulfills the requirements of this Specification.

2.02 VFD SYSTEMS

A. Operating Conditions

- 1. The following operating conditions are applicable for all equipment of this Specification.
 - a. Humidity: 0-95%.
 - b. Ambient Temperature: 0 degrees Celsius to plus 40 degrees Celsius.
 - c. Altitude: up to 3,300 feet

B. Basic Design and Performance

- 1. Each VFD shall be a complete alternating current electric drive system including all hardware and software necessary to accomplish variable speed operation of a motor and load combination. VFDs shall be provided in accordance with the requirements indicated on the Drawings and as described in these Specifications.
- 2. Each VFD shall be suitable for operation as part of a 480 VAC, 3-phase, 60 Hertz power distribution system. The complete VFD system shall have a minimum short circuit current rating of 65,000 amperes symmetrical at rated voltage.
- 3. **The Contractor** is fully responsible for the review of the full Contract Documents to determine specified motor speed, horsepower and full load ampere requirements for each motor-driven load. In addition, the Contractor shall size and select the VFD and components as follows:
 - a. Each VFD shall provide, continuously, motor load current equal to 100% of the direct on-line motor nameplate full load current.
 - b. Each VFD shall be selected for Variable Torque (Normal Duty) or Constant Torque (Heavy Duty) based on its respective load type served as shown in

the Load Type tables below.

Variable Torque (Normal Duty) Load Types	Constant Torque (Heavy Duty) Load Types
Vertical Turbine Pumps	[Not Included Under this Contract]

- c. The Load Type tables above are intended to exhaustively cover all possible equipment controlled by VFDs to be provided under Division 26 for this Contract. If a piece of equipment is found that is not explicitly listed in these tables, this discrepancy shall be brought to the attention of the Engineer (in writing) immediately for resolution **prior to submitting the Bid for this Contract.**
4. Each VFD shall be suitable to operate, at times, on a limited power source engine-generator set. The VFD shall be provided with equipment and devices to prevent waveform distortion as specified herein.
5. Each VFD shall be provided with control and sequence logic as specified herein and indicated on the Drawings. Control and sequence logic shall be designed such that the motor-load combination can be operated in the manual mode upon control and sequence logic failure, including all necessary personnel and equipment safety interlocks. Each VFD shall be designed such that specific control and protection functions can be attained through simple programming by either factory engineers or Owner's trained operating personnel. In addition, refer to Section 40 61 96 – Process Control Descriptions, for a description of the operation of each VFD.
6. Unless otherwise accepted in writing by the Engineer, VFDs shall be provided with output reactors or filters to prevent elevated voltage levels at the motor terminals that exceed the ratings of the inverter duty rated motor winding insulation.
 - a. **The Contractor** is responsible for providing the VFD manufacturer with estimated and field-verified cable lengths between each VFD and its respective motor. The VFD manufacturer shall select and size the output reactors or filters based on the cable lengths provided by the Contractor. Any change in output filter or reactor selection and/or size from the Bid shall be immediately brought to the attention of the Engineer in writing for resolution.
 - b. The output filters or reactors shall be as manufactured by TCI, MTE Corporation, Mirus International, or engineer approved equal.
7. Motor control circuits shall be wired in accordance with the requirements specified herein and/or indicated on the Drawings.

C. Components

1. Each VFD shall contain the number of VFD units as shown on the Drawings and required for the applications.
2. Each VFD shall contain the number of auxiliary contacts, control power transformer(s), pilot devices and indicating lights, control relays, elapsed time meters, and other devices as specified herein, shown on the Drawings and required for the applications. The following components shall meet the requirements of Section 26 09 16 – Electrical Controls and Relays:
 - a. Pilot devices (switches, indicating lights, etc.)
 - b. Relays and timers
 - c. Terminal blocks
3. Each VFD shall be provided with full-capacity-rated isolation contactors as shown on the Drawings. Contactors shall be electrically and mechanically interlocked as shown on the Drawings. All isolation contactors shall have a continuous current rating of no less than 115% of the associated motor nameplate full load amperes. Contactors used for isolation of VFDs that have bypass starters shown shall additionally have a short-time rating suitable for at least 8 times the associated motor nameplate full load amperes.
4. Power terminal blocks for VFD output to the motor shall be fixed-mounted to a backplane or the enclosure. Mounting the terminal blocks on DIN rails is not acceptable.
5. Electrical bus, including ground bus, shall be tin-plated copper. Power and control wiring shall be copper, color coded and identified in accordance with these Specifications.
6. Each VFD shall be of modular construction allowing normal maintenance and repair to be done with ordinary hand tools. Design and install power electronic component assemblies so that, where practicable, components can be individually removed and replaced.
7. Auxiliaries, including fans, that are required for rated load operation at maximum ambient temperature, shall be 100% redundant. New and unused spare replacement fan(s) or air conditioning unit(s), shipped in original carton, may be provided in lieu of 100% redundant auxiliaries if accepted in writing by the Engineer.
8. Circuit boards and electrical components shall meet the corrosion protection requirements specified in these Specifications. Varnished or epoxy encapsulated

circuit boards and tropicalized contactors suitable for corrosive environments shall be furnished.

9. Motor Circuit Protectors

- a. Each VFD shall be protected by a motor circuit protector (MCP) that is UL 489 recognized.
- b. Motor circuit protectors shall be completely enclosed molded case devices with a current sensing coil in each of the 3 poles and have a magnetic trip adjustment located on the front. The motor circuit protector shall be manually operable. The protector shall be designed to meet the NEC requirement concerning motor full load and locked-rotor current. Ampere ratings shall be clearly visible. Contacts shall be of non-welding silver alloy. Arc extinction must be accomplished by means of arc chutes, consisting of metal grids mounted in an insulating support.
- c. The motor circuit protector shall be operated by a toggle type handle and shall have a quick make, quick break overcenter switching mechanism that is mechanically trip free from the handle, so that the contacts cannot be held closed against short circuits and abnormal currents. Tripping shall be clearly indicated by the handle automatically assuming a position midway between the manual ON and OFF positions. All latch surfaces shall be ground and polished. All poles shall be so constructed that they open, close, and trip simultaneously.
- d. Each pole of these motor circuit protectors shall provide instantaneous short circuit protection by means of an adjustable magnetic only element.
- e. Motor circuit protector ratings, modifications, etc., shall be as specified herein and as required for the VFD and motor load combination. MCP ratings shall be determined by the VFD manufacturer.

10. A minimum 50kA surge suppressor shall be provided for each VFD unless larger is indicated on the Drawings, VFDs shall be provided with surge protective devices that meet the requirements of Section 26 43 13 – Surge Protection Devices.
11. Motor Protection Relays
 - a. Where indicated on the Drawings, VFDs shall be furnished with motor management and protection relays as specified elsewhere in this Specification.

D. Controls

1. Each VFD shall be provided with automatic and manual controls as shown on the Drawings and as required to comply with all Specifications. Controls and indicators to accomplish operation and maintenance shall be located on the variable frequency drive equipment assembly as specified herein and indicated on the Drawings.
2. The Elementary Control Schematics shown on the Drawings are **representative of design intent only**. The manufacturer shall be responsible for providing all additional components, controls, and internal wiring necessary to meet the design intent.
3. VFD circuitry shall be designed such that the enclosure cooling fans only run when the VFD unit is producing output power. Designs that allow the enclosure cooling fans to run continuously when the VFD unit is energized but not producing output power are not acceptable. Fans that are used exclusively to provide cooling for the VFD unit (and not the overall enclosure) are permitted to run continuously if required by the VFD manufacturer's design standards/practices.

E. Enclosures

1. Equipment within the VFD enclosure shall be arranged so that it does not interfere with the entry of conduits and cables into the enclosure.
2. All pilot devices (selector switches, pushbuttons, indicating lights, etc.) and the human machine interface (HMI, specified elsewhere herein) shall be door mounted on the exterior of each VFD enclosure. Manipulation of the pilot devices or HMI, viewing of the information on the HMI, or viewing that status of pilot devices shall not require the VFD enclosure door to be opened.
3. Unless otherwise indicated on the Drawings, VFDs in non-hazardous locations, shall be furnished with the following enclosure type and material of construction, dependent upon the designation of the area in which they are to be installed. Area designations are indicated on the Drawings.

Area Designation	Enclosure Type and Material
Indoor Wet Process Area	NEMA 4X, Type 304 Stainless Steel
Indoor Dry Process Area	NEMA 12, Painted Steel
Indoor Dry Non-Process Area	NEMA 1, Painted Steel
All Outdoor Areas	NEMA 4X, Type 304 Stainless Steel

4. VFDs shall not be installed in hazardous locations.
5. NEMA 1 and NEMA 12 VFD enclosures shall be force ventilated with front accessibility and the following:
 - a. Enclosures shall be provided with washable enclosure air intake filters that can be replaced while the enclosure door remains closed.
 - b. Enclosures shall be designed for bottom or top entry of conduits and cables as required.
 - c. Enclosures shall be finished in manufacturer's standard gray enamel or in a color to match the complete line-up of equipment as indicated on the Drawings and accepted by the Engineer.
6. Each VFD shall be designed such that rear access to the enclosure is not required for operations, maintenance, or repair tasks.
7. The Contractor shall reference the Drawings for maximum dimensions of the VFDs. No exceptions to the dimensions indicated on the Drawings will be permitted.
8. Integrating VFDs into a motor control center assembly is not permitted unless specifically shown as integrated on the Drawings.
9. Enclosure doors shall have full length piano type hinges and shall be braced to prevent sag when fully open.
10. Each VFD enclosure shall be supplied with an industrial, heavy-duty flange-mount handle mechanism for the operation of the VFDs disconnecting means as follows:
 - a. The mechanism shall be engaged with the disconnect device at all times as an integral part of the unit regardless of the unit door position.
 - b. The operator handle shall have an up-down motion with the down position as off. The ON-OFF condition of the disconnecting means shall be permanently marked on the handle operator.

- c. It shall be possible to lock the handle in the "OFF" position with up to three (3) 3/8-inch diameter shackle padlocks and in the "ON" position with one (1) 3/8-inch diameter shackle padlock.
- d. The operator handle shall be mechanically interlocked such that the disconnecting means cannot be closed with the enclosure door open, nor can the enclosure door be opened when the disconnecting means is closed. A defeater mechanism shall be provided so that qualified personnel can bypass these interlocks for maintenance and testing purposes. The defeater mechanism shall allow the enclosure door to be opened without interrupting the operation of the VFD.

F. Nameplates and Legend Plates

- 1. Provide engraved plastic nameplates and legend plates to identify each VFD and associated door mounted devices and internal components. Nameplates shall be as specified in Section 26 05 53 – Identification for Electrical Systems.
- 2. Equipment names and/or numbers and device identification text shown on the Drawings shall be used as the basis to engrave the nameplates and legend plates. Where the equipment identification text would exceed the capacity of the VFD manufacturer's standard nameplate/legend plate size, the manufacturer shall provide larger nameplates and/or additional nameplates as necessary. Abbreviating equipment names/numbers and device identification text is not acceptable.
- 3. Control components mounted as part of the assembly, such as fuse blocks, control relays, pushbuttons, switches, and similar devices, shall be suitably marked with identification corresponding to appropriate designations on the manufacturer's wiring diagrams.

2.03 VFD UNITS

- A. The VFD unit shall be the Eaton PowerXL DG1 series, Square D Altivar 600 series, Rockwell Automation (Allen-Bradley) PowerFlex 750 series, ABB ACQ 580 series, or Toshiba AS3/W7 series.
- B. Basic Design and Performance
 - 1. Each VFD unit shall be of adjustable frequency, adjustable voltage, pulse width modulated (PWM) design. The units shall be microprocessor controlled, fully digitally programmable, and capable of precise and repeatable speed regulation of three phase 480 VAC NEMA Design A or B induction motors. Units for other than NEMA Design A or B induction motors (e.g., NEMA Design C) shall be coordinated with the requirements of that respective load.

2. Each VFD unit shall consist of a semiconductor rectifier system, direct current link, and pulse width modulated inverter. The inverter shall invert the direct current voltage into an alternating current voltage at a frequency which shall be proportional to the desired speed. This alternating current voltage and frequency shall both vary simultaneously at a constant "Volts-Per-Hertz" ratio to operate the motor at the desired speed.
3. Each VFD unit shall operate the motor and produce full rated nameplate horsepower at the motor output shaft without exceeding motor nameplate full load current and with the motor not exceeding rated total temperature not including the additional temperature increment that constitutes the motor service factor. Motor shall retain its service factor when operated by the variable frequency drive.
4. The overall efficiency of each VFD unit shall be a minimum of 95% when operating the specified motor-load combination at rated voltage, frequency, and current.
5. Each VFD unit shall provide smooth, stepless changes in motor speed and acceleration over the entire operating speed range from minimum to maximum speed. The VFD unit shall be provided with adjustable maximum and minimum frequency limits.
6. Each VFD unit shall maintain a desired output frequency (setpoint) with a steady state accuracy of 0.5% of rated frequency of 60 Hertz for a 24-hour period and a repeatability of 0.1% of rated frequency of 60 Hertz.
7. Each VFD unit shall be capable of operating the specified load continuously at any speed within the operating speed range of 10% to 100% of rated speed. The minimum and maximum continuous operating speeds shall each be adjustable within this speed range. The variable frequency drive shall provide for field adjustment of these setpoints.
8. Each VFD unit shall be capable of controlled linear acceleration and deceleration. Each VFD unit shall be capable of ramping the speed of the motor-load combination from the minimum selected operating speed to the maximum selected operating speed in a minimum of 30 seconds. Each VFD unit shall have two (2) field-adjustable speed setpoints for the variable frequency drive to skip equipment resonant frequencies. The acceleration and deceleration time limits shall be field adjustable to values up to 120 seconds.
9. Voltage or current unbalance between phases of the VFD unit output voltage shall not exceed 3% of the instantaneous values. The VFD unit shall continuously monitor the output voltages and generate an alarm condition when the unbalance exceeds 3%. The system shall detect and generate a separate alarm for loss of any output phase voltage (single phasing). Phase unbalance shall be as defined by NEMA Standard MG-1.

10. Each VFD unit shall operate continuously without interruption of service or damage to equipment during transient input voltage variations of plus or minus 10% for a duration of 15 cycles. VFD unit output voltage regulation shall be plus or minus 2%.

C. Features and Characteristics

1. Each VFD unit shall be furnished with a Human Machine Interface (HMI) to provide controls and indication to accomplish maintenance and operational functions as specified herein and shown on the Drawings. The HMI shall be password protected after startup to prevent unauthorized personnel from making changes. The HMI shall at minimum provide indication of the following:
 - a. Input Voltage
 - b. Output Voltage
 - c. Output Current
 - d. Output Frequency
 - e. Output Speed from 0-100%
 - f. Alarm Read-out
2. Each VFD unit shall provide a 4-20 mADC output signal that is proportional to the drive output frequency for use as speed feedback/speed indication to external equipment.
3. Each VFD unit shall accept a 4-20 mADC speed input command signal to control the output frequency in the automatic and/or manual control modes as specified herein or indicated on the Drawings. The system shall accept the input increase/decrease command with a resolution that permits incremental changes in speed equal to or less than 0.1% of rated speed.
 - a. Where shown on the Drawings, VFD units shall also accept a 0-10VDC input from a speed potentiometer for manual speed control. Each VFD unit shall be capable of automatically switching between the input speed command signals as shown on the Drawings.
4. Input Voltage Loss Handling
 - a. The VFD unit shall shut down upon a loss of one or more input phases, a 3-phase complete input power loss, or a sustained input undervoltage event. A sustained input undervoltage event is defined as voltage that is less 75% of nominal, for more than 0.5 seconds.

- b. Upon restoration of 3-phase power that is at an acceptable voltage level, the VFD unit shall automatically reset (after an adjustable time delay, 0-2 minutes) and be capable of being restarted and ramping up to speed when remotely commanded through the control system or locally commanded at any local controls. Personnel shall not be required to reset the VFD unit manually after a shutdown caused by any input voltage loss event.
 - c. Automatic reset of the VFD unit shall be achieved through programming/parameter setpoints, time delay relays, or a combination of both.
- 5. Each VFD unit shall have a multiple attempt restart feature.
- 6. Each VFD unit shall have an automatic current limit feature to control motor currents during startup and provide a "soft start" torque profile for the motor-load combination. The VFD unit shall also limit current due to motor winding or motor lead phase-to-phase short circuit or phase-to-ground short circuit. The current limit protection setting shall be field adjustable.
- 7. Each VFD unit shall be furnished with programmable electronic overload and torque limits.
- 8. Each VFD unit shall have an automatic trip feature which will remove the drive output from the motor and allow it to decelerate safely. This automatic system shall lock-out the VFD unit and indicate the fault only upon the following conditions:
 - a. Output voltage unbalance (trip threshold field set).
 - b. Loss of phase on output.
 - c. Motor overload.
 - d. Motor stator winding fault (phase-to-ground, phase-to-phase).
 - e. Unacceptable voltage variation.
 - f. High variable frequency drive equipment temperature.
 - g. VFD failure as determined by the manufacturer.
 - h. Component failure.
 - i. Overcurrent.
- 9. Provide each VFD unit with transmitted and received radio interference protection. In addition, provide protection against starting a rotating motor, both directions (coasting to zero speed and backspin). In the event that a motor automatic restart

feature (catch the motor "on-the-fly") is provided in the VFD unit, this feature shall be capable of being disabled.

10. Each VFD unit shall include on-line diagnostics, with an automatic self-check feature that will detect a variable frequency drive failure.
 - a. Diagnostics shall operate a visual alarm indicator on the HMI.
 - b. Diagnostics shall provide an easily readable output that can be used to isolate a failure.
 - c. Provide an event and diagnostic recorder to printout in narrative English of the specific fault(s) and the sequence in which the faults occurred. An indication of the "First Out" failure is a minimum for fault sequence detection.
 - d. Provide normally open and/or normally closed dry contacts as indicated on the Drawings for VFD failure conditions .
11. Each VFD unit shall communicate the following parameters to the control system via Ethernet/IP protocol. Provide any necessary hardware gateways to provide this communication capability. The following parameters, at a minimum, shall be communicated:
 - a. Motor current (all phases)
 - b. Motor voltage (all phases)
 - c. Motor KW
12. Where indicated on the Drawings, provide input cards that allow connection of speed encoders to the VFD unit.
13. Each VFD unit shall be provided with input/output (I/O) cards including expansion cards as necessary to facilitate connection of all I/O specified herein and shown on the Drawings.

2.04 HARMONIC CORRECTION

- A. Harmonic correction devices for each VFD shall be as specified herein and located as shown on the Drawings.
- B. Input Line Reactors
 1. 6-pulse VFD units shall be provided with input line reactor and/or integral DC link reactor. Total reactor impedance shall be a minimum of 3% and shall not exceed 5%.
- C. Passive Filters

1. Where indicated on the Drawings or where additional harmonic correction is required, 6-pulse VFD units shall be provided with a passive harmonic filter in addition to the integral DC link reactor specified above (if present.)
2. Passive harmonic filters shall be sized to attenuate harmonics resulting from operation of the VFD-driven motor load to no more than 5% THID when operating at full load, and no more than 8% THID when operating at 30% of full load. The filter shall be equipped with power contactors configured to remove the capacitors from the circuit when the VFD-driven loads are not in operation. The harmonic filters shall be as manufactured by TCI, MTE Corporation, Mirus International, or Engineer approved equal.
3. Passive filters shall be integrated into the VFD unless accepted in writing by the Engineer or shown as separately mounted from the VFD on the Drawings.

D. 18-Pulse and Active Front End (AFE) VFDs

1. Where indicated on the Drawings, VFDs shall consist of either:
 - a. an 18-pulse VFD unit with an 18-pulse phase-shifting transformer, or
 - b. a VFD unit with an IGBT-based active front end (AFE).
2. AFE VFDs may be provided in lieu of 18-pulse VFDs (or vice-versa) **if accepted in writing by the Engineer.**

2.05 MOTOR PROTECTION RELAYS

A. Protective Relays

1. Each VFD shall be provided with a microprocessor based, motor protector in each individual starter to protect, monitor, and control the motor.
2. The motor protector shall be capable of monitoring electrical current; receive commands from remote sources either by contact closures or digital data; give commands (e.g. fail, trip, etc.) to the motor controller and other devices under its control; and communicate by alphanumeric display with the operator and by digital signals with other equipment.
3. True rms current shall be constantly monitored, separated into positive and negative sequence components to determine the heating effects caused by both, and processed to provide maximum motor utilization. The motor protector shall be mounted on the low voltage compartment door. Current transformers shall be provided as indicated on the Drawings and as required.
4. Specific data entry to suit the actual motor application shall be accomplished by means of an operator panel. Entered data shall be stored in "non-volatile" memory so as not to require battery back-up.

5. A digital display of monitoring functions including, but not limited to, the following shall be provided:
 - a. Line current in each phase in rms amperes
 - b. Running time (cumulative in hours)
 - c. Remaining starts
 - d. Motor starts exceeded
 - e. Total energy consumption
 - f. Power factor
 - g. Power in kilowatts
 - h. Voltage reading
 - i. Alarm status
6. The following protection and control functions including, but not limited to, the following shall be provided:
 - a. Motor running time overcurrent: Device 49/51
 - b. Zero-sequence ground fault: Device 50G/51G
 - c. Adjustable instantaneous overcurrent: Device 50
 - d. Underload trip with start and run time delays: Device 37
 - e. Current unbalance: Device 46
 - f. Incomplete sequence delay: Device 48
 - g. Limitation on number of starts per time-period: Device 66
 - h. JAM trip with start and run time delays
 - i. Phase loss (voltage)
 - j. Phase unbalance (current)
 - k. Phase reversal (voltage)
 - l. Undervoltage

7. A metering and transducer module shall be included which will provide data to the unit as well as 4-20 maDC isolated analog outputs for current, KW, KVAR, and power factor for future connection to the plant control system. Motor protectors shall be Schweitzer SEL-710-5 or equal. The following options shall be included with the protector:
 - a. 5-inch color touchscreen
 - b. Ethernet 10/100BASE-T port, with communication on Ethernet/IP protocol.
 - c. Conformal Coating on internal components.
 - d. Adequate RTD input to satisfy all of the RTD connections shown on the elementary control schematic. If additional expansion modules are needed, they shall be located within the drive enclosure and not in the field.
 - e. An unmanaged 100BASE-T industrial ethernet switch to combine the ethernet communication of the drive and the relay so only one ethernet cable is needed to connect to the PLC from the drive enclosure.

PART 3 – EXECUTION

3.01 INSTALLATION

- A. The VFDs shall be installed as shown on the Drawings and in accordance with the manufacturer's installation instructions.
- B. Install VFDs to allow complete door swing required for component removal.

3.02 TESTING

- A. All tests shall be performed in accordance with the requirements of the General Conditions and Division 01. The following tests are required:
 1. Witnessed Shop Tests
 - a. None required.
 2. Certified Shop Tests and Reports
 - a. Submit description of proposed testing methods, procedures, and apparatus.
 - b. Factory test the complete VFD in accordance with IEEE and NEMA standards.

- c. Submit factory bench-test data to indicate that the manufacturer's proposed equipment has been tested in the specified arrangement and found to achieve specified accuracy.
- 3. Field Tests
 - a. Field testing shall be done in accordance with the requirements specified in the General Conditions, Division 01, and NETA acceptance testing specifications referenced in Section 26 05 00 – Basic Electrical Requirements.
 - b. The Contractor shall field measure actual harmonic distortion with tests performed by an independent testing agency acceptable to the Owner after satisfactory full-load operation. The Contractor shall provide the harmonic distortion reports with the O&M Manual.
 - c. Unless otherwise indicated on the Drawings, the harmonic distortion measurements shall be made at each load center where VFDs are present.
 - d. Harmonic distortion measurements shall be made after VFD installation. One set of measurements shall be made with the VFD loads inactive, and one set of measurements shall be made with the VFD loads running at design capacity.
- B. Acceptance of a shop test does not relieve Contractor from requirements to meet field installation tests under specified operating conditions, nor does the inspection relieve the Contractor of responsibilities.
- C. Certification on materials and records of shop tests necessary for the inspector to verify that the requirements of the Specifications are met, shall be made available to the inspector.
- D. Submit signed and dated certification that all of the factory inspection and testing procedures described herein have been successfully performed by the Contractor prior to shipment.

3.03 SERVICES OF A MANUFACTURER'S REPRESENTATIVE

- A. The Contractor shall provide the services of a qualified manufacturer's factory-trained technical representative who shall adequately supervise the installation and startup of all equipment furnished under this Contract. The manufacturer's representative shall certify in writing that the equipment has been installed in accordance with the manufacturer's recommendations. No further testing or equipment startup may take place until this certification is accepted by the Owner.
- B. The manufacturer's technical representative shall perform all startup and field acceptance testing as specified herein. For VFD units provided with encoder input cards, the VFD shall be commissioned to operate in induction flux vector mode so that the specified turn-down for the associated motor may be achieved.
- C. The Contractor shall provide training for the Owner's personnel. Training shall be conducted by the manufacturer's factory-trained representative who shall instruct Owner's personnel in operation and maintenance of all equipment provided under this Section. Training shall be provided for two (2) sessions of four (4) hours each. Training shall not take place until after the VFDs have been installed and tested. Training shall be conducted at times coordinated with the Owner.
- D. The services of the manufacturer's representative shall be provided for a period of not less than as follows:
 - 1. One (1) trip of one (1) working day during installation of the motor controllers.
 - 2. One (1) trip of one (1) working day to perform startup and field acceptance testing of the motor controllers.
 - 3. One (1) trip of one (1) working day to perform training as specified herein.
 - 4. One (1) trip of one (1) working day two (2) months before the expiration of the warranty to identify any issues to be corrected under warranty.
- E. Any additional time required to achieve successful installation and operation shall be at the expense of the Contractor.

3.04 PAINTING

- A. Prior to final completion of the work, all metal surfaces of the equipment shall be cleaned thoroughly, and all scratches and abrasions shall be retouched with the same coating as used for factory finishing coats.

END OF SECTION

SECTION 26 36 23
AUTOMATIC TRANSFER SWITCHES

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. The Contractor shall furnish, install, connect, test and place in satisfactory operation automatic transfer switches as specified herein and indicated in Drawings.
- B. All devices and components of the automatic transfer switch shall be NEMA rated. IEC rated devices are unacceptable and shall be cause for rejection of the submittals/equipment.

1.02 TESTING

- A. All tests shall be performed in accordance with the requirements of the General Conditions and Division 01. The following tests are required:
 - 1. Witnessed Shop Tests
 - a. Shall be made available at manufacturing facilities if requested.
 - 2. Certified Shop Tests and Reports
 - a. Automatic transfer switches shall be given routine factory tests. The factory tests shall demonstrate that the completed switches function correctly and that the required timing has been set. Certification of these settings shall be submitted to the Engineer upon request.
 - b. Test procedures shall be in accordance with UL-1008. During the 3-cycle withstand tests, there shall be no contact welding or damage.
 - c. The three cycle tests shall be performed without the use of current limiting fuses.
 - d. Oscillograph traces across the main contacts shall verify that contact separation has not occurred and there is contact continuity across all phases after completion of the test.
 - e. When conducting temperature rise tests in accordance with UL-1008, include post-endurance temperature rise tests to verify the ability of the transfer switch to carry full rated current after completing the overload and endurance tests.

- f. Manufacturer shall submit test reports upon request.
- 3. Field Tests
 - a. Field testing shall be done in accordance with the requirements specified in the General Conditions, Division 01, and Section 26 05 00 – Basic Electrical Requirements.
 - b. Prior to acceptance of the installation, load test the equipment with all available motor load, but do not exceed the generator's or automatic transfer switch's nameplate rating. Correct defects which become evident during this test.

1.03 SUBMITTALS

- A. In accordance with the procedures and requirements set forth in the General Conditions and Section 01 33 00 – Submittal Procedures, the Contractor shall obtain from the equipment manufacturer and submit the following:
 - 1. Shop Drawings
 - 2. Operation and Maintenance Manuals
 - 3. Spare Parts Lists
 - 4. Special Tools List
 - 5. Reports of certified shop tests shall be submitted which indicates a closing and withstand ampere rating as required based on short circuit study requirements. Rating shall be symmetrical, 3 cycles at 480 VAC.
 - 6. Guarantee/Warranty Program
- B. Each submittal shall be identified by the applicable Specification Section.

1.04 SHOP DRAWINGS

- A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.
- B. Partial, incomplete or illegible submittals will be returned to the Contractor for resubmittal without review.
- C. Shop drawings for each automatic transfer switch shall include but not be limited to:
 - 1. Product data sheets.

2. Complete assembly, layout, and installation drawings with clearly marked dimensions and conduit entrance locations.
 3. Example equipment nameplate data sheet.
 4. Complete internal schematic and interconnecting wiring diagrams.
 5. Nameplate schedule.
 6. Manufacturer's standard installation instructions.
 7. Manufacturer's standard warranty.
- D. The shop drawing information shall be complete and organized in such a way that the Engineer can determine if the requirements of these specifications are being met. Copies of technical bulletins, technical data sheets from "soft-cover" catalogs, and similar information which is "highlighted" or somehow identifies the specific equipment items the Contractor intends to provide are acceptable and shall be submitted.
- E. Prior to completion and final acceptance of the project, the Contractor shall furnish and install "as-built" wiring diagrams for each automatic transfer switch. These final drawings shall be plastic laminated and securely placed inside each transfer switch and included in the O&M manuals.

1.05 OPERATION AND MAINTENANCE MANUALS

- A. The Contractor shall submit operation and maintenance manuals in accordance with the procedures and requirements set forth in the General Conditions and Division 01.

1.06 TOOLS, SUPPLIES AND SPARE PARTS

- A. The automatic transfer switches shall be furnished with all special tools necessary to disassemble, service, repair and adjust the equipment. All spare parts as recommended by the equipment manufacturer shall be furnished to the Owner by the Contractor.
- B. The spare parts shall be packed in containers suitable for long term storage, bearing labels clearly designating the contents and the pieces of equipment for which they are intended.
- C. Spare parts shall be delivered at the same time as the equipment to which they pertain. The Contractor shall properly store and safeguard such spare parts until completion of the work, at which time they shall be delivered to the Owner.
- D. Spare parts lists, included with the shop drawing submittal, shall indicate specific sizes, quantities, and part numbers of the items to be furnished. Terms such as "1 lot of packing material" are not acceptable.

- E. Parts shall be completely identified with a numerical system to facilitate parts inventory control and stocking. Each part shall be properly identified by a separate number. Those parts which are identical for more than one size, shall have the same parts number.

1.07 SERVICES OF MANUFACTURER'S REPRESENTATIVE

- A. The Contractor shall provide the services of a qualified manufacturer's technical representative who shall adequately supervise the installation and testing of all equipment furnished under this Contract and instruct the Contractor's personnel and the Owner's operating personnel in its maintenance and operation as outlined elsewhere in Division 01 and Section 46 00 00 – Equipment General Provisions. The services of the manufacturer's representative shall be provided for a period of not less than as follows:
 - 1. One trip of one (1) working day during installation of the equipment for each automatic transfer switch.
 - 2. One trip of one (1) working day after acceptance of the equipment.
 - 3. One trip of one (1) working day during the warranty period.
- B. Any additional time required to achieve successful installation and operation shall be at the expense of the Contractor. The manufacturer's representative shall sign in and out at the office of the Engineer's Field Representative on each day they are at the project.
- C. The manufacturer shall have an established network of service centers capable of servicing the specified equipment. The manufacturer shall have a service center within 100 miles of the project site which shall stock parts necessary to service the switch. The manufacturer shall include an 800 telephone number for a field service contact affixed to each enclosure.
- D. Service center personnel shall be on call 24 hours a day, 365 days a year. Personnel shall be factory-trained and certified in the maintenance and repair of the specified equipment.
- E. After-warranty service contracts shall be made available to the Owner by the manufacturer, through the service centers, to provide periodic maintenance and/or repair of the specified equipment.

1.08 IDENTIFICATION

- A. Each automatic transfer switch shall be identified with the identification number indicated on the Drawings (e.g. ATS-1, ATS-2, etc.). A nameplate shall be securely affixed in a conspicuous place on each switch. Nameplates shall be as specified in Section 26 05 53, Identification for Electrical Systems.

1.09 TRAINING

- A. The Contractor shall provide training for Owner personnel. Training shall be conducted by the manufacturer's factory trained specialists who shall instruct Owner personnel in operation and maintenance of all equipment provided under this Section. Training shall be in accordance with the requirements of Section 46 00 00 – Equipment General Provisions.
- B. Provide the services of an experienced, factory trained technician or service engineer of the switch manufacturer at the jobsite for minimum of three (3) days for training of Owner personnel, beginning at a date mutually agreeable to the Contractor and the Owner. The technician shall be on duty at the site for at least 8 hours per day and shall be available 24 hours per day when required to advise concerning special problems with equipment and systems.

1.10 WARRANTY

- A. The manufacturer shall warrant each automatic transfer switch for a minimum of five (5) years from date of shipment. In addition, the manufacturer shall repair or replace equipment found faulty under the terms of the warranty. The manufacturer shall submit data outlining the guarantee/warranty program.

1.11 CONSTRUCTION SEQUENCING

- A. The Contractor shall reference 01 14 00 – Coordination with Owner's Operation, of these Specifications.

PART 2 – PRODUCTS

2.01 MANUFACTURERS

- A. The equipment covered by this Specification is intended to be standard equipment of proven performance as manufactured by reputable concerns. Equipment shall be designed, constructed and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as shown on the Drawings.
- B. The equipment described herein, as a minimum, shall meet all of the requirements specified in this Section and shall be a product of a manufacturer who has produced automatic transfer switches for a period of at least five (5) years. The equipment shall be compatible with the loads to be served. Assembly of the switches by a fabricator is not acceptable.
- C. The manufacturer of the automatic transfer switch shall verify that the switches are listed by Underwriters Laboratories, Inc., standard UL-1008, with 3-cycle withstand and close-

in values as indicated on the Drawings or specified herein.

- D. The automatic transfer switches shall be contactor design, as manufactured by ASCO/Square D, Siemens Energy and Automation Inc. equivalent, General Electric equivalent, or equal.

2.02 AUTOMATIC TRANSFER SWITCH

A. General

1. Switches shall have ampere ratings and number of poles as indicated on the Drawings and shall be suitable for 480 VAC, three-phase, 60 Hertz operation.
2. For three phase, four-wire systems where a neutral is required, a true four-pole contactor shall be supplied with all four electrically and mechanically identical poles mounted on a common shaft. The continuous current rating and the closing and withstand rating of the fourth pole shall be identical to the rating of the main poles.
3. The transfer switch shall be housed in a NEMA 1 (gasketed) free-standing enclosure fabricated from 12-gauge steel suitable for floor mounting. The enclosure shall exceed the UL-1008 minimum wire bending space requirements. The enclosure shall be equipped with an internal, welded steel, door-mounted print pocket.
4. The transfer switch shall have both top and bottom mounted cable access.
5. The switch shall be capable of switching all classes of load and rated for continuous duty when installed in a non-ventilated enclosure.
6. The three-cycle closing and withstand current rating of the switch shall be 65,000 amperes RMS (minimum). This rating shall not be restricted by the use of a specific manufacturer's circuit breaker.
7. This switch shall be complete with all accessories and listed by UL under Standard UL-1008 for use on emergency systems.
8. All bolted bus connections shall have Belleville compression type washers. Switches for four-wire systems shall be furnished with a fully rated solid neutral bus.
9. The switch shall be equipped with 90°C rated copper/aluminum solderless mechanical type lugs of the proper quantity and size to accommodate the termination of field wiring.

10. Switches shall be capable of normal operation during and after seismic loading. Seismic loading shall not cause false operation.

B. Design Requirements

1. Switches shall contain two drawout, mechanically interlocked, insulated case circuit breakers with ampere ratings and number of poles as indicated on the Drawings and shall be suitable for 480 VAC, three-phase, 60 Hertz operation. A center-off-position shall be provided as a neutral position during switching. Minimum transfer time shall 400 milliseconds. The switches shall be service entrance rated and shall bear the service entrance label as indicated on the Drawings.
2. Switches shall be capable of transferring successfully in either direction with 70 percent of rated voltage applied to the terminals.
3. The time delay between the opening of the closed contacts and the closing of the open contacts shall allow for voltage decay before transfer, allowing the motor and transformer loads to be re-energized after transfer with normal in-rush current. Switches using in-phase monitors are not acceptable.
4. Normal and standby contacts shall be positively interlocked mechanically and electrically to prevent simultaneous closing. Main contacts to be of silver-tungsten alloy, mechanically locked in position in both the normal and standby positions without the use of hooks, latches, or magnets. Provide separate arcing contacts, with magnetic blowouts on each pole. Interlocked molded case circuit breakers switches or contactors are not acceptable.
5. Equip the transfer switch with a permanently attached, safe, manual operator designed to prevent injury to personnel in the event the electrical operator should become energized during manual transfer. The manual operator shall provide the same contact-to-contact transfer speed as the electrical operator to prevent a flashover from slowly switching the main contacts.

C. Sequence of Operation

1. Should the voltage on any phase of the normal source drop below 80 percent or increase to 120 percent, or frequency drops below 90 percent, or increase to 110 percent, or 20 percent voltage differential between phases occur, after a programmable time delay period of 0-9999 seconds factory set at three (3) seconds to allow for momentary dips, the engine starting contact(s) shall close to connect the standby source.
2. Transfer to the standby power source shall occur when 90 percent of rated voltage and frequency has been reached by the standby power source.

3. After restoration of normal power on all phases to a preset value of 90 percent to 110 percent of rated voltage, at least 95 percent to 105 percent of rated frequency, and voltage differential is below 20 percent between phases, an adjustable time delay period of 0-9999 seconds factory set at 300 seconds shall delay the transfer to allow stabilization of the normal source. Should the standby source fail during this time delay period, the switch shall automatically retransfer to the normal source.
4. After retransfer to the normal power source, the standby plant shall operate at no load for a programmable period of 0-9999 seconds factory set at 300 seconds. Should the normal power source fail during this time delay period, the transfer switch shall automatically return to the standby source.

D. Controls

1. The transfer switch shall be equipped with a microprocessor-based control system to provide all the operational functions of the automatic transfer switch. The controller shall have two asynchronous serial ports. The controller shall have a real time clock with Nicad battery back-up.
2. The CPU shall be equipped with self-diagnostics which perform periodic checks of the memory, I/O, and communication circuits with a watchdog power fail circuit.
3. The controller shall use industry standard open architecture communication protocol for high speed serial communications via multidrop connection to other controllers and to a master terminal with up to 4000 ft of cable, or further with the addition of a communication repeater. The serial communication port shall be RS422/485 compatible.
4. The serial communication port shall allow interface to either the manufacturer's or the Owner's furnished remote supervisory control system.
5. The controller shall have password protection to limit access to authorized personnel.
6. The controller shall include a 20 character LCD display with a keypad, which allows access to the system.
7. The controller shall include three-phase over/under voltage, over/under frequency, phase sequence detection, and phase differential monitoring on both normal and standby sources.
8. The controller shall be capable of storing the following records in memory for access either locally or remotely:

- a. Number of hours the transfer switch is in the standby position (total since record reset).
 - b. Number of hours standby power source is available (total since record reset).
 - c. Total transfer in either direction (total since record reset).
 - d. Date, time, and description of the last four source failures.
 - e. Date of the last exercise period.
 - f. Date of record reset.
9. Light emitting diodes shall be mounted on the controller to indicate:
- a. Switch is in normal position
 - b. Switch is in standby position.
 - c. Controller is running.
10. A three-phase digital LCD voltage readout, with 1% accuracy shall display all three separate phase-to-phase voltages simultaneously for both the normal and standby source.
11. A digital LCD frequency readout with 1% accuracy shall display frequency for both the normal and standby source.
12. An LCD readout shall display both normal source and standby source availability.
13. The microprocessor controller shall meet the following requirements:

Storage conditions:	25°C to 85°C
Operation conditions:	20°C to 70°C ambient
Humidity:	0 to 99% relative humidity, non-condensing
Capable of withstanding infinite power interruptions	
Surge withstand per ANSI/IEEE C-37.90A-1978	

14. All control wiring shall be 18 gauge (minimum), 600 VAC, SIS switchboard type. All control wiring shall be identified at each termination (both ends) using tubular, sleeve-type wire markers.

15. The automatic transfer switch controller shall be a Model ATC-900 IQ transfer device as manufactured by Cutler-Hammer, or equal. The controller shall be programmed by the manufacturer at the factory.

E. Accessories

1. Programmable three phase sensing of the normal source set to pickup at 90% and dropout at 80% of rated voltage and overvoltage to pickup at 120% and dropout out at 110% of rated voltage. Programmable frequency pickup at 95% and dropout at 90% and over frequency to pickup at 110% and dropout at 105% of rated frequency. Programmable voltage differential between phases, set at 20%, and phase sequence monitoring.
2. Programmable three phase sensing of the standby source set to pickup at 90% and dropout at 80% of rated voltage and overvoltage to pickup at 120% and dropout out at 110% of rated voltage. Programmable frequency pickup at 95% and dropout at 90% and over frequency to pickup at 110% and dropout at 105% of rated frequency. Programmable voltage differential between phases, set at 20%, and phase sequence monitoring.
3. Time delay for override of momentary normal source power outages (delays engine start signal and transfer switch operation). Programmable 0-9999 seconds. Factory set at 3 seconds.
4. Time delay on retransfer to normal, programmable 0-9999 seconds, factory set at 300 seconds, with overrun to provide programmable 0-9999 second time delay, factory set at 300 seconds, unloaded engine operation after retransfer to normal.
5. Time delay on transfer to standby, programmable 0-9999 seconds, factory set at 3 seconds.
6. A maintained type load test switch shall be included to simulate a normal power failure, keypad initiated.
7. A time delay bypass on retransfer to normal shall be included. Keypad initiated.
8. Contact, rated 10 A at 30VDC, to close on failure of normal source to initiate engine starting.
9. A plant exerciser shall be provided with (10) 7 day events, programmable for any day of the week and (24) calendar events, programmable for any month/day, to automatically exercise the standby plant programmable in one minute increments. Also include a control switch for selection of either "no load" (switch will not transfer) or "load" (switch will transfer) during the exercise period. Keypad initiated.
10. Relay contacts which close when normal source fails wired to a terminal strip.

11. Relay contacts which open when normal source fails wired to a terminal strip.
12. Two auxiliary contacts rated 15 A at 120 VAC on main shaft, closed on normal and wired to a terminal strip.
13. Two auxiliary contacts rated 15 A at 120 VAC on main shaft, closed on standby and wired to a terminal strip.
14. Provide a preferred source selector switch to permit the selection of either source as the "preferred" source which the ATS will always seek if that source is available. The two-position selector switch shall have a legend plate which reads "Source A/Source B."

2.03 PAINTING

- A. Painting shall conform with the requirements of Section 09 90 00 – Painting. Finish coat shall be ANSI #61 or ANSI #49.
- B. Prior to final completion of the work, all metal surfaces of the equipment shall be cleaned thoroughly, and all scratches and abrasions shall be retouched with the same coating as used for factory finishing coats.

PART 3 – EXECUTION

3.01 INSTALLATION

- A. Each automatic transfer switch shall be installed as shown on the Drawings and in accordance with the manufacturer's installation instructions.
- B. The automatic transfer switch shall be provided with adequate lifting means for installation of wall or floor mounted enclosures.
- C. The Contractor shall tighten all assembled bolted connections to the manufacturer's torque recommendations prior to energizing.
- D. Install each switch to allow complete door swing required for component removal. This is specifically required where a switch is set next to a wall to the left of the switch enclosure.

3.02 RUBBER MATS

- A. A three foot wide rubber mat shall be furnished and installed on the floor and in front of each automatic transfer switch. The mat shall be long enough to cover the full length of each enclosure. The mat shall be 1/4 inch thick with beveled edges, canvas back, solid type with corrugations running the entire length of the mat. The mat shall be guaranteed extra quality, free from cracks, blow holes or other defects detrimental to their

mechanical or electrical strength. The mat shall meet OSHA requirements and the requirements of ANSI/ASTM D-178 J6-7 for Type 2, Class 2 insulating matting.

END OF SECTION

SECTION 26 41 00
FACILITY LIGHTNING PROTECTION

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. The Contractor shall furnish, install, test, and place in satisfactory operation a complete lightning protection system as specified herein. This is a performance specification. The Drawings do not show a complete lightning protection system design. The Contractor shall retain the services of a firm specializing in the design, installation, and testing of lightning protection systems.

1.02 CODES AND STANDARDS

- A. All equipment shall be Listed by and shall bear the Label of Underwriter's Laboratories, Incorporated (UL).
- B. The system shall comply with the following codes and standards:
 - 1. Underwriters Laboratories (UL):
 - a. UL 96 – Lightning Protection Components.
 - b. UL 96A – Installation Requirements for Lightning Protection Systems.
 - c. UL 467 – Safety Grounding and Bonding Equipment.
 - 2. National Fire Protection Association (NFPA):
 - a. NFPA 70 – National Electrical Code (NEC).
 - b. NFPA 780 – Standard for the Installation of Lightning Protection Systems.
 - 3. Lightning Protection Institute (LPI):
 - a. LPI-175 – Standard for the Design – Installation – Inspection of Lightning Protection Systems.

1.03 SUBMITTALS

- A. In accordance with the procedures and requirements set forth in the General Conditions and Section 01 33 00 – Submittal Procedures, the Contractor shall obtain from the equipment manufacturer and submit the following:

1. Shop Drawings
2. Operation and Maintenance Manuals
3. Spare Parts List
4. Test Reports
5. UL Master Label Certification

1.04 SHOP DRAWINGS

- A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.
- B. Partial, incomplete, or illegible submittals will be returned to the Contractor without review for resubmittal.
- C. Shop drawings for each lightning protection system shall include, but not be limited to:
 1. Product data sheets.
 2. Complete U.L. approved, full size layout and installation drawings/details with clearly marked dimensions. Drawings shall indicate the exact location of all system components. Drawings shall be signed by a full-time employee of the lightning protection system manufacturer who is in responsible charge of this project and has been engaged in the business for at least ten (10) years.
 3. Weights of all major components.
 4. Bill of material list for each lightning protection system.
 5. Manufacturer's installation instructions.
 6. Manufacturer's and installer's warranty information.
 7. Evidence of the designer/installers UL listing.
- D. The shop drawing information shall be complete and organized in such a way that the Engineer can determine if the requirements of these specifications are being met. Copies of technical bulletins, technical data sheets from "soft-cover" catalogs, and similar information which is "highlighted" or somehow identifies the specific equipment items the Contractor intends to provide are acceptable and shall be submitted.

1.05 OPERATIONS AND MAINTENANCE MANUALS

- A. The Contractor shall submit operation and maintenance manuals in accordance with the procedures and requirements set forth in the General Conditions and Division 01. The manuals shall include:
1. Instruction books and/or leaflets.
 2. Recommended spare parts list.
 3. Final as-built construction drawings included in the shop drawings incorporating all changes made during the installation.
 4. All other information that was included in the shop drawing submittal.

1.06 SPARE PARTS

- A. The lightning protection system shall be furnished with all spare parts as recommended by the equipment manufacturer. In addition to the manufacturer recommended spare parts, the Contractor shall furnish the following minimum spare parts for each structure provided with a lightning protection system under this Contract:

Number Required	Descriptions
2	Air Terminals
2	Point Tip Protectors

- B. Reference Section 26 05 00 – Basic Electrical Requirements for spare parts delivery and handling requirements.

PART 2 – PRODUCTS

2.01 MANUFACTURERS

- A. The lightning protection systems covered by this Specification shall be furnished using standard components of proven performance as manufactured by reputable concerns. The systems shall be designed, constructed, and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed.
- B. System designer/supplier/installer qualifications shall be as follows:
1. System components shall be manufactured by a company specializing in lightning protection equipment with a minimum of 5 years documented experience. Company shall be Listed in the section entitled "Lightning Conductor, Air Terminals

and Fittings" of the U.L. "Electrical Construction Materials Directory" for at least 5 years prior to this Contract's bid opening date.

2. The system designer/installer shall be an authorized installer of manufacturer with a minimum of 5 years of documented experience. Designer/Installer shall be Listed in the section entitled "Lightning Protection Installation" of the U.L. "Electrical Construction Materials Directory" for at least 5 years prior to this Contract's bid opening date.

2.02 LIGHTNING PROTECTION SYSTEMS

A. General

1. All components and parts of the lightning protection system shall be as specified herein. The materials used shall meet or exceed the material specification requirements of the Underwriters Laboratories, Inc. All materials shall be marked with a UL label or stamp.
2. The complete lightning protection system for both new structures and existing structures modified under this Contract shall be inspected and included in the Master Label certification.

B. Conductors

1. Conductors shall be aluminum cable, consisting of a minimum of 24 strands of No. 14 AWG aluminum wire. Copper conductors shall be furnished and installed only where required and when in contact with the earth. Where termination of copper conductors is required to aluminum parts, suitable bi-metallic connectors approved for the purpose shall be furnished and installed.

C. Fittings

1. Fittings shall be the bolted type with stainless steel bolts, nuts, and washers. Fittings shall be of cast metal construction specifically designed for the application. Crimp-type fittings are not acceptable. Bi-metallic type fittings shall be furnished where required.

D. Fasteners

1. Fasteners shall be manufactured from non-corrosive material of ample strength and rigidity for the application.

E. Bases

1. Bases shall be bolted style provided with the model to suit the application (i.e., parapet, standing seam, etc.). Bolts, nuts, and washers shall be made of stainless

steel. Bases shall be of aluminum or bronze construction, compatible with the material of the surface to which it is attached. Crimp-type bases are not acceptable.

F. Ground Rods

1. Ground rods shall be 3/4-inch by 10-foot 0-inch sectional type copper-clad steel rods; as specified in Section 26 05 26 – Grounding and Bonding for Electrical Systems; quantity as required. Ground rods and all associated hardware shall be UL 467 Listed.

G. Air Terminals

1. Air terminals shall be solid aluminum. Air terminals shall be tapered or blunt tip type to suit the application and furnished with air terminal bases and safety tips (ball or bullet type) for impalement protection.

H. Thru-Roof Hardware

1. Thru-roof penetrations shall have stainless steel nuts, bolts, and washers. Sealing washers and sealing boots shall be provided as required and shall be compatible with the roofing material. Conductor connections to this roof hardware shall be by bolted connection. Crimp type connections are not acceptable.

PART 3 – EXECUTION

3.01 INSTALLATION

- A. The lightning protection system shall be furnished and installed in accordance with the manufacturer's installation instructions. One (1) copy of these instructions shall be included with the system components at time of shipment. The system components shall be suitably protected until accepted by the Owner.
- B. The equipment shall be installed in accordance with the manufacturer's recommendations. Additional requirements shall include the following:
 1. Course all main down conductors to maintain a downward or horizontal run free of pockets or sags. Maintain an eight-inch (8") minimum radius and make no bend greater than 90 degrees. Follow the most direct route with inductance bonding conductors maintaining the horizontal or downward course of the main conductor. Interconnect roof conductors to provide at least two paths to ground from each terminal and to form closed loops. Follow the most direct path possible with down conductors between roof conductors and ground terminals. All down conductors for new occupiable buildings shall be placed in a concealed manner. Down

conductors for existing occupiable structures, tanks, basins, and other non-occupiable structures may be installed exposed.

2. Install ground connections at no less than 60-foot intervals and at each down conductor on perimeter. If the structure has a ground grid, the ground rods from that grid may be used for connection to the down conductors. At each ground connection, determine the extent of the grounding arrangement according to the volume and type of soil encountered and the lowest expected moisture content. Have the Owner's representative observe each ground connection. Bond together all electrical service, telephone service, and lightning protection grounds to all underground metallic piping systems as required by Article 250 of the NEC.
3. The structural steel frame (where provided) may substitute for main down conductors provided the frame is electrically continuous and of adequate cross-section. Where the steel frame is utilized, connect the roof conductor to steel at least as often and at the same column as the ground connections. Make connections to steel with exothermic welds wherever possible. Provide bonding as required to make the entire metal frame continuous.
4. Bond all sizable metal objects within 6-feet of down, roof, or grounding conductors to the system. Use only approved fittings and conductors.
5. Wherever possible problems with corrosion are encountered, use substitute approved materials and/or provide corrosion protection. Use bimetallic or other specially designed and approved connectors where dissimilar metals are to be joined.
6. Install air terminals within 2-feet of the edge of structure and at intervals not greater than 20-feet along perimeter and peak. Provide additional terminals to limit spacing across roof to 50-feet maximum. Bond any exposed metallic object or surface to the roof conductor.
7. Air terminals shall not be installed for the following:
 - a. On handrails or guardrails.
 - b. On the stems or stem covers of gates or valves.
8. Handrails and/or guardrails that are at least 3/16 inch thick may be used as lightning strike devices. Bond handrail and guardrail sections as required to achieve the necessary electrical continuity for the installation.
9. All penetrations of conductors through the roof shall be made with thru-roof hardware as specified herein. Flash all thru-roof penetrations to conform to the roof manufacturer and installer's requirements.

10. Every effort shall be made to avoid creating tripping hazards by not routing conductors across walkways on structures including but not limited to tanks, basins, clarifiers, etc. If a conductor must be routed across a walkway, it shall be done in one of the following ways, creating a tripping hazard is not acceptable:
 - a. Concrete walkways
 - 1) Use a flat tinned-copper strip across the walkway that is anchored down at no less than 6-inch intervals along the length of the strip.
 - 2) Embed a copper conductor in the walkway that is covered in no less than 2 inches of concrete embedment.
 - 3) Install an aluminum conductor within a PVC Schedule 40 conduit, with the conduit embedded across the walkway covered in no less than 3-1/2 inches of concrete embedment.
 - b. Metallic walkways
 - 1) Install the conductor under the metal walkway support structure, with the conductor material being compatible with the metal it will be fastened to. Drilling holes in the metal support structure is not acceptable.
11. Record each ground connection location and mark up a reproducible copy of the approved shop drawings with their location. Also, indicate any substantial field modifications on these drawings. These drawings shall be included in the O&M manual.
12. Log all continuity tests of metal framing, ground grid connections, bonding, and similar connections. Indicate the location of tests or plans. Include test results in the O&M manual.
13. Retain U.L. to inspect the completed installation and issue a Master Label Certification. Furnish a copy of the Certification to the Owner upon receipt.

3.02 TESTING

- A. All tests shall be performed in accordance with the requirements of the General Conditions and Division 01. The following tests are required:
 1. Certified Shop Tests and Reports
 - a. None Required.
 2. Field Tests

- a. After installation, the lightning protection system shall be tested for continuity to the ground grid. The tests shall be made by the lightning protection system installer. Test shall be as follows:
 - 1) Record the resistance between each down conductor and the ground grid to ensure a suitable low-resistance connection. All resistance values shall be 1 ohm or less. Test shall be made after the ground grid has been installed and tested per the requirements of Section 26 05 26 – Grounding and Bonding for Electrical Systems.

END OF SECTION

SECTION 26 43 13
SURGE PROTECTIVE DEVICES

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. The Contractor shall furnish, install, and place in satisfactory operation the surge protective devices (SPD) as specified herein and indicated on the Drawings.
- B. Reference the following Specification Sections:
 - 1. Section 26 05 19 – Low-Voltage Conductors and Cables
 - 2. Section 26 05 53 – Identification for Electrical Systems.

1.02 CODES AND STANDARDS

- A. All equipment shall be Listed by and shall bear the Label of Underwriter's Laboratories, Incorporated (UL).
- B. The equipment shall be designed, manufactured, and/or Listed to the following standards as applicable:
 - 1. American National Standards Institute (ANSI)/Institute of Electrical & Electronic Engineers (IEEE):
 - a. C62.41.1 – IEEE Guide on the Surge Environment in Low-Voltage (1000 V and less) AC Power Circuits.
 - b. C62.41.2 – IEEE Recommended Practice on Characterization of Surges in Low -Voltage (1000 V and less) AC Power Circuits.
 - c. C62.45 – IEEE Recommended Practice on Surge Testing for Equipment Connected to Low-Voltage (1000 V and less) AC Power Circuits.
 - d. C62.62 – IEEE Standard Test Specifications for Surge -Protective Devices (SPDs) for Use on the Load Side of the Service Equipment in Low Voltage (1000 V and less) AC Power Circuits.
 - 2. National Fire Protection Association (NFPA):
 - a. NFPA 70 – National Electrical Code (NEC).
 - 3. Underwriters Laboratories (UL):

- a. UL 1283, latest edition – Electromagnetic Interference Filters.
- b. UL 1449, latest edition – Surge Protective Devices.

1.03 SUBMITTALS

- A. In accordance with the procedures and requirements set forth in General Conditions and Section 01 33 00 – Submittal Procedures, the Contractor shall obtain from the equipment manufacturer and submit the following:
 - 1. Shop Drawings
 - 2. Operation and Maintenance Manuals
 - 3. Spare Parts List

1.04 SHOP DRAWINGS

- A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.
- B. Partial, incomplete, or illegible submittals will be returned to the Contractor without review for re-submittal.
- C. Drawings submitted by the manufacturer shall be complete and documented to provide the Owner with operations and maintenance capabilities.
- D. Shop drawings for each SPD shall include but not be limited to:
 - 1. Product Data Sheets.
 - 2. Detailed drawings showing weights and dimensions.
 - 3. Wiring diagrams showing field connections.
 - 4. Manufacturer's Warranty Information
- E. The shop drawing information shall be complete and organized in such a way that the Engineer can determine if the requirements of these Specifications are being met. Copies of technical bulletins, technical data sheets from "Soft Cover" catalogs, and similar information which is "highlighted" or somehow identifies the specific equipment items the Contractor intends to provide are to provide are acceptable and shall be submitted.

1.05 OPERATION AND MAINTENANCE MANUALS

- A. The Contractor shall submit operation and maintenance manuals in accordance with the procedures and requirements set forth in the General Conditions and Division 01.

1.06 SPARE PARTS

- A. All spare parts as recommended by the equipment manufacturer shall be furnished by the Contractor to the Owner.
- B. The Contractor shall furnish one (1) spare field replacement module of each type and rating provided under this Contract if modules are field replaceable.
- C. Reference Section 26 05 00 – Basic Electrical Requirements for spare parts delivery and handling requirements.

1.07 IDENTIFICATION

- A. Each SPD shall be identified by the circuit number and equipment name as indicated on the Drawings. A nameplate shall be securely affixed in a conspicuous place on each SPD. Nameplates shall be as specified in Section 26 05 53 – Identification for Electrical Systems.

1.08 WARRANTY

- A. All SPDs, associated hardware, and supporting components shall be warranted to be free from defects in materials and workmanship, under normal use and in accordance with the instructions provided, for a period of ten (10) years after acceptance of the equipment by the Owner.
- B. Any component or subassembly contained within the surge protection system that shows evidence of failure or incorrect operation during the warranty period, shall be replaced by the manufacturer at no additional cost to the Owner.

PART 2 – PRODUCTS

2.01 GENERAL

- A. The SPD units shall be UL 1449 Listed. Units that are “manufactured in accordance with” UL 1449 or “component recognized” SPDs are not acceptable and will be rejected.
- B. Type II SPD units shall be UL 1283 Listed. Units that are “manufactured in accordance with” UL 1283 or “component recognized” SPDs are not acceptable and will be rejected.

2.02 PRODUCTS

- A. Type I surge protective devices (SPD) shall be furnished and installed when shown without upstream overcurrent protection on the Drawings. Type II SPDs shall be provided in all other locations. Type II SPDs shall not require the use of a specific upstream overcurrent device. SPDs shall be provided in the location and quantity as shown on the Drawings.
- B. Each SPD shall be rated for the voltage and configuration of the equipment to which it is connected.
- C. Each Type II SPD shall have UL 1283 EMI/RFI filtering with minimum attenuation of - 50dB at 100kHz.
- D. The short circuit current rating of each SPD shall match or exceed the rating of the equipment to which it is connected. The Contractor shall reference the Drawings for short circuit current rating of each piece of equipment.
- E. Each SPD system shall provide surge protection in all possible modes. Surge protection shall be as follows:

System Configuration	Modes of Protection	Number of Modes
3-Phase Wye	L-N, L-G, N-G	7
3-Phase Delta	L-L, L-G	6
3-Phase Impedance Grounded	L-L, L-G	6
Single-Phase	L-N, L-G, N-G	3

- F. Each SPD shall have a Maximum Continuous Operating Voltage (MCOV) of at least 115% of the nominal voltage of the equipment to which it is connected.
- G. The Nominal Discharge Current (In) of each SPD shall be 20kA. Peak surge current ratings shall not be used as a basis for applying the SPD to the system.
- H. The Voltage Protection Rating (VPR) of each SPD shall not exceed the following:

System Voltage	L-N	L-G	L-L	N-G
208Y/120	800V	800V	1200V	800V
480Y/277	1200V	1200V	1800V	1200V
480 DELTA	N/A	1800V	1800V	N/A

System Voltage	L-N	L-G	L-L	N-G
240 DELTA	N/A	1200V	1200V	N/A
120/240	800V	800V	1200V	800V

- I. The surge current rating for each SPD shall be as indicated on the Drawings. Surge current ratings are indicated on single line diagrams and in panel schedules. Surge current rating indicated is on a per phase basis.
- J. SPDs which are indicated to be installed externally mounted from the equipment that they protect shall be provided within a separate enclosure. The enclosure shall match or exceed the NEMA rating of the enclosure for the equipment that it is serving (e.g., NEMA1, NEMA 12, NEMA 4X, etc.).
- K. Each SPD shall be provided with the following accessories:
 - 1. Each individual module shall feature an LED indicating the individual module has all surge protection devices active. If any single component is taken off-line, the LED shall turn off and another LED shall illuminate, providing individual module as well as total system status indication.
 - 2. Surge counter and audible alarm with reset/silence switch.
 - 3. One set of Form C (SPDT) dry contacts rated for at least 5A at 120VAC.
- L. SPDs which are indicated to be installed integral to (within) the equipment that they protect shall be manufactured by the same manufacturer as the equipment. SPDs which are indicated to be installed externally/separately mounted from the equipment that they serve shall be manufactured by ASCO/Emerson Network Power, Current Technologies, GE by ABB, Siemens, or Square D.

PART 3 – EXECUTION

3.01 INSTALLATION

- A. The SPD units shall be furnished and installed as shown on the Drawings and in accordance with the manufacturer's installation instructions.
- B. SPDs which are indicated to be integral with the equipment that they protect shall be installed within the enclosure for that equipment.
- C. Externally mounted SPDs shall be installed as follows:

1. The SPD units shall be mounted such that the conductor lengths are as short as possible, but no greater than 36 inches. Any installation resulting in a conductor length of greater than 36 inches shall be reviewed with the Engineer as a special type of cable may need to be installed. For equipment such as panelboards, the Contractor shall relocate the circuit breaker that is to be connected to the SPD as needed to achieve the shortest conductor length possible.
 2. The Contractor shall use a close nipple to enclose the conductors between the SPD and the equipment served. However, if due to field conditions a 90-degree conduit bend is required to connect the SPD to the equipment that it serves, the bend shall have a minimum radius of 24 inches to eliminate any potential for sharp bends in the conductors.
 3. Conductors between the equipment served and the SPD shall be 600V power wire and cable as specified in Section 26 05 19 – Low-Voltage Conductors and Cables. The individual phase conductors shall be gently twisted and all conductors shall be sized as indicated on the Drawings.
- D. Prior to energizing, the following shall be performed for each SPD:
1. Verify that the SPD unit voltage and configuration is suitable for the system to which it is connected.
 2. Verify that any neutral-to-ground bonding jumpers are installed as required.

3.02 TESTING

- A. All tests shall be performed in accordance with the requirements of the General Conditions and Division 01. The following tests are required:
1. Shop Tests
 - a. Standard factory tests shall be performed on the equipment under this Section. All tests shall be in accordance with the latest version of NEMA, ANSI, and UL standards.
 - b. All surge protective devices, subassemblies, and components shall be 100% tested and certified by the manufacturer to meet their published performance parameters.
 2. Field Tests
 - a. None required.

END OF SECTION

SECTION 26 50 00

LIGHTING

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. The Contractor shall furnish and install all lighting fixtures, labor, and material, in accordance with the preceding Specifications, the requirements of this Section, and as shown on the Drawings.
- B. Reference the following Specification Sections:
 - 1. Section 26 05 00 – Basic Electrical Requirements
 - 2. Section 26 05 26 – Grounding and Bonding for Electrical Systems
 - 3. Section 26 09 16 – Electric Controls and Relays

1.02 CODES AND STANDARDS

- A. All equipment shall be Listed by and shall bear the Label of Underwriter's Laboratories, Incorporated (UL).
- B. The equipment shall be designed, manufactured, and/or Listed to the following standards as applicable.
 - 1. Institute of Electrical and Electronic Engineers (IEEE)
 - a. IEEE C62.41.3 – Guide for Surge Voltages in Low-Voltage AC Power Circuits
 - 2. Illuminating Engineering Society (IES)
 - 3. National Fire Protection Association (NFPA)
 - a. NFPA 70 – National Electric Code (NEC).
 - 4. Underwriters Laboratories (UL)
 - a. UL 924 – Emergency Lighting and Power Equipment
 - b. UL 844 – Luminaires for Use in Hazardous (Classified) Locations
 - c. UL 916 – Standard for Energy Management Equipment

- d. UL 1012 – Standard for Safety Power Units Other Than Class 2
- e. UL 1598 – Luminaires

1.03 SUBMITTALS

- A. In accordance with the procedures and requirements set forth in the General Conditions and Section 01 33 00 – Submittal Procedures, the Contractor shall obtain from the equipment manufacturer and submit the following:
 - 1. Shop Drawings
 - 2. Operation and Maintenance Manuals
 - 3. Spare Parts Lists
- B. Each submittal shall be identified by the applicable Specification Section.

1.04 SHOP DRAWINGS

- A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.
- B. Partial, incomplete, or illegible submittals will be returned to the Contractor for resubmittal without review.
- C. Shop drawings shall include but not be limited to:
 - 1. Product data sheets.
 - 2. Catalog cuts for each fixture type showing performance and construction details of standard fixtures, and complete working drawings showing all proposed construction details of special or modified standard fixtures.
 - 3. Photometric curves.
 - 4. LED data including efficiency (Efficacy lumens/watt) information.
 - 5. LED Driver information
 - 6. Catalog data including applicable coefficients of utilization tables, isolux chart of illumination on a horizontal plane, beam efficiency, horizontal and vertical beam spread, and beam lumens.
 - 7. Manufacturer's warranty information.

8. Custom wiring diagrams for each individual combination of lighting contactor and photocell used on this project. Standard wiring diagrams that are not custom created by the manufacturer for the individual lighting contactors for this project are not acceptable. One wiring diagram which is typical for all lighting contactors is not acceptable. Each wiring diagram shall include wire identification and terminal numbers. Indicate all devices, regardless of their physical location, on the diagrams. Identify on each respective wiring diagram specific equipment names and equipment numbers consistent with those indicated on the Drawings.
 9. System (entire fixture assembly) efficiency data.
 10. Pole and foundation calculations.
- D. Shop drawings shall be submitted to the Engineer for review and acceptance for all fixtures before fixtures and poles are manufactured. Substitutions will be permitted only if acceptable to the Engineer.
 - E. Manufacturer's model/series and description in the fixture schedule on the Contract Documents establishes a level of quality, style, finish, etc. The use of a model/series describing the various types of fixtures shall be used as a guide only and does not exclude all the required accessories or hardware that may be required for a complete installation.

1.05 OPERATION AND MAINTENANCE MANUALS

- A. The Contractor shall submit Operation and Maintenance Manuals in accordance with the procedures and requirements set forth in the General Conditions and Division 01.

1.06 SPARE PARTS

- A. All spare parts as recommended by the equipment manufacturer shall be furnished to the Owner by the Contractor. The following additional spare parts shall be furnished:
 1. A minimum of one (1) LED driver for every ten (10) drivers (of the same type) installed.
 2. A full set of contacts and coils for each lighting contactor included on this project.
- B. Reference Section 26 05 00 – Basic Electrical Requirements for spare parts delivery and handling requirements.

1.07 LIGHTING CONTROLS

- A. The lighting systems shall be controlled as specified herein and indicated on the Drawings.

1.08 WARRANTY

- A. The manufacturer's warranty shall in no event be for a period of less than five (5) years from date of delivery of fixtures to the project site and shall include repair labor, travel expense necessary for repairs at the jobsite, shipping costs, expendables used during the course of repair, or complete replacement of the failed lighting unit.
- B. Warranty shall be provided for the entire fixture and shall include all parts and accessories.. Submittals received without written warranties as specified shall be rejected in their entirety.

PART 2 – PRODUCTS

2.01 MANUFACTURERS

- A. The equipment covered by this Specification is intended to be standard equipment of proven performance as manufactured by reputable concerns. Equipment shall be designed, constructed, and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as shown on the Drawings.
- B. The fixture schedule indicates the basis-of-design manufacturer(s) for each fixture type. The Contractor shall submit photometric calculations for each space and/or area where the Contractor wishes to use an equivalent fixture in accordance with Section 26 05 00 – Basic Electrical Requirements. Fixtures will be approved or denied as equivalent on a per-fixture and/or per-space/area basis.

2.02 FIXTURES

- A. All lighting fixtures shall be furnished complete with all fittings and hardware necessary for a complete installation. Lighting fixtures shall have all accessories, characteristics, and functionality as specified.
- B. Fixture leads shall be as required by NEC. Fixtures shall be grounded by the equipment grounding conductor in the conduit.
- C. All glassware shall be high quality, homogeneous in texture, uniform in quality, free from defects, of uniform thickness throughout, and properly annealed. Edges shall be well rounded and free from chips or rough edges.
- D. Emergency and exit fixtures shall be UL 924 Listed and have a minimum 90 minutes battery back-up.
- E. Fixtures for use in hazardous locations shall be UL 844 Listed.
- F. Fixtures specified to be damp or wet locations rated shall be UL 1598 Listed.

- G. Fixtures shall be as specified in the fixture schedule on the Drawings

2.03 LED DRIVERS

- A. Drivers shall have a voltage range of 347-480V or 120-277 (as required) +/- 10% at a frequency 60Hz.
- B. All drivers shall be designed to a power factor >90% with a total harmonic distortion THD <20% at full load.
- C. Case temperature shall be rated for -40°C through +80°C.
- D. Drivers shall have overheat protection, self-limited short circuit protection and overload protected.
- E. Drivers shall be furnished with a fused primary.
- F. Drivers shall have an output current ripple <30%
- G. Drivers shall be manufactured by Philips, Advance, Universal or equal.
- H. Drivers shall be UL Listed for damp location, UL1012, ROHS.
- I. Drivers shall meet FCC 47 Sub Part 15.
- J. All drivers shall be provided with ANSI/IEEE C62.41 Category C (10kV/5kA) surge protection.

2.04 LEDS

- A. Luminaires provided with LED technology shall utilize high brightness LEDs with a group binning code of P and/or Q.
- B. Color Temperature: as specified in fixture schedule.
- C. Junction point shall be designed and manufactured to allow adequate heat dissipation.
- D. LEDs shall be rated for 50,000 hours of life, minimum (based on IESNA L70).

2.05 POLES AND FOUNDATIONS

- A. Poles shall be designed to withstand calculated wind force based on wind velocity in accordance with the provisions of the Building Code for the State or Commonwealth in which the project is located.

- B. Pole mounted fixtures shall be mounted on poles as designated in the fixture schedule or as indicated on the Drawings. Poles shall have adequate handholes. Furnish and install weatherproof receptacles where indicated. All anchor bolts and nuts shall be hot-dipped galvanized steel.
- C. The Contractor shall furnish and install a concrete foundation for freestanding pole mounted fixtures as indicated on the Drawings and as required (e.g., site/roadway lighting). The Contractor shall furnish and install structural anchorage/attachment, including mounting brackets where applicable, for pole mounted fixtures that are attached to a structure (e.g., clarifiers, aeration basins, etc.).
 - 1. Foundation shall be designed and approved by a Professional Structural Engineer (PE) currently licensed in the State or Commonwealth in which the project is located. The wind design shall be in accordance with ASCE 7 and the Building Code for the State or Commonwealth in which the project is located. Submit signed and sealed calculations for review.
- D. Poles shall be as specified in the pole schedule below and shall be furnished with fixture types where specified in the fixture schedule as specified on the fixture schedule.

2.06 LIGHTING CONTROLS

- A. Lighting Contactor and Photocell
 - 1. Furnish and install a lighting contactor and photocell combination to control lighting as indicated on the Drawings.
 - 2. Lighting contactors shall be as manufactured by the Square D Company, General Electric Company, or Siemens Energy and Automation, Inc. Lighting contactors shall be heavy duty industrial type with 30A minimum rating and shall have the number of contacts required. Contactor ampere rating shall be increased as required to suit the application. Contactor coil voltage shall be as indicated on the Drawings. Contactors shall be the electrically or mechanically held type as indicated on the Drawings. Contactors shall include fused integral control power transformers. Any auxiliary relays, or other devices required for proper operation shall be included. Contacts and coils shall be separately replaceable.
 - 3. Photocells shown on the Drawings that are not integral to a fixture shall be provided by the Contractor. Photocells shall be rated for 120 VAC, 1800W, and be provided with 1/2" or 3/4" threads for box mounting.
 - 4. Pilot devices and control relays in/on the lighting contactor shall meet the requirements of 26 09 16 – Electric Controls and Relays.
 - 5. In non-hazardous locations, lighting contactors shall be furnished with the following enclosure type and material of construction, dependent upon the designation of

the area in which they are to be installed. Area designations are indicated on the Drawings.

AREA DESIGNATION	ENCLOSURE TYPE AND MATERIAL
Indoor Wet Process Area	NEMA 4X, Type 304 Stainless Steel
Indoor Dry Process Area	NEMA 12, Painted Steel
Indoor Dry Non-process Area	NEMA 1, Painted Steel
Indoor Type 1 Chemical Storage/Transfer Area	NEMA 4X, Fiberglass
Indoor Type 2 Chemical Storage/Transfer Area	NEMA 4X, Type 304 Stainless Steel
All Outdoor Areas	NEMA 4X, Type 304 Stainless Steel

PART 3 – EXECUTION

3.01 INSTALLATION

- A. Lighting fixtures shall be located symmetrically with building lines as shown on the Drawings. The Contractor shall furnish and install the lighting fixtures to allow "convenient" access for maintenance. The Contractor shall install fixtures at mounting heights indicated on the Drawings or as instructed by the Engineer. In areas with exposed ducts and/or piping, installation of lighting fixtures shall be adapted to field conditions as determined by the Engineer. Where fixtures are shown in locations on the Drawings where maintenance would be difficult, the Contractor shall notify the Engineer for direction.
- B. The Contractor shall provide and install all inserts, conduit, structural supports as required, mounting, poles, wiring, and any other items required for a complete system. Contractor shall properly adjust and test, to the satisfaction of the Engineer, the entire lighting system. The Contractor shall provide pigtails and flexible conduit connected to an outlet box where necessary or required resulting in a neat and complete installation.
- C. The Contractor shall protect all fixtures at all times from damage, dirt, dust, and the like. Upon completion of work, and after the building area is broom clean, all fixtures shall be made clean and free of dust and all other foreign matter both on visible surfaces, and on surfaces that affect the lighting performance of the fixture including diffusers, lenses, louvers, reflectors, etc.
- D. The Contractor shall furnish and install all pendant trapezes and pendant stem hangers with durable swivel or equivalent trapeze hanger permitting normal fixture motion and self-alignment. Fixture pendants shall be Appleton Type UNJ ball type flexible hanger at the fixture and supports from an Appleton JBLX junction box with JBLX hub cover, or

equal. Pendant lengths shall be adequate and adjusted to provide uniformity of installation heights above the reference datum. Stems shall be one-piece, with matching canopies and fittings.

- E. All wiring/cables associated with lighting equipment shall be installed in conduits or other raceways as specified. Installing wiring/cables exposed is not acceptable, unless specifically shown otherwise on the Drawings.
- F. The Contractor shall furnish and install recessed fixtures with a separate junction box concealed and located as to be accessible when fixture is removed.
- G. The Contractor shall furnish and install all boxes for lighting fixtures such that the box is not the sole support of the fixture. The boxes shall be offset to allow maintenance such that access to wiring within the box can be attained without having to consider supporting (holding) the fixture.
- H. All lighting fixtures, when installed, shall be set true and be free of light leaks, warps, dents, and other irregularities. All hangers, cables, supports, channels, and brackets of all kinds for safely erecting this equipment in place, shall be furnished and erected in place by the Contractor.
- I. The Contractor shall support each fixture securely. The Contractor shall not secure fixtures to the work of other trades, unless specified or noted otherwise, and shall not support fixtures from plaster. The Contractor shall furnish and install all members and supports as required to fasten and suspend fixtures from the structure.
- J. In all mechanical equipment areas, the Contractor shall install lighting fixtures after all piping and equipment therein has been installed. Exact locations for such fixtures may be determined by the Engineer on the site during the course of the work.
- K. All fixtures that require physical adjustment shall be so adjusted in accordance with the directions of the Engineer. The Contractor shall also adjust angular direction of fixtures as directed.
- L. All optical control surfaces such as lenses and reflectors shall be safely and securely attached to fixtures and shall be easily and quickly removed and replaced for cleaning without the use of special tools.
- M. Lighting contactors shall be provided in the enclosure type and material of construction required for the area in which it is installed. Reference the requirements in Part 2 herein, and the area designations indicated on the Drawings.

3.02 TESTING

- A. All tests shall be performed in accordance with the requirements of the General Conditions and Division 01. The following tests are required:

1. Certified Shop Tests
 - a. The lighting fixtures shall be given routine factory tests in accordance with the requirement of ANSI, NEMA and Underwriters Laboratories standards.
2. Field Tests
 - a. Field testing shall be done in accordance with the requirements specified in the General Conditions, Division 01, and NETA Acceptance Testing Specifications, latest edition.

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SECTION 26 52 00
EMERGENCY LIGHTING INVERTERS

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. The Contractor shall furnish and install emergency lighting inverters to supply selected lighting fixtures as indicated on the Drawings.
- B. Reference the following Specification Sections:
 - 1. Section 26 05 00 – Basic Electrical Requirements
 - 2. Section 26 05 53 – Identification for Electrical Systems

1.02 CODES AND STANDARDS

- A. The equipment specified herein shall comply with the following codes and standards.
 - 1. Underwriter's Laboratories, Inc. (UL):
 - a. UL924 – Emergency Lighting and Power Equipment
 - b. UL924A – Auxiliary Lighting
 - 2. American National Standards Institute (ANSI)
 - a. ANSI C62.41 (IEEE 587)
 - b. ANSI C62.42.45 (Cat. A & B)
 - 3. National Electrical Code (NEC), latest edition.
 - 4. National Fire Protection Association (NFPA) – 101
 - 5. OSHA and Life Safety Code

1.03 SUBMITTALS

- A. In accordance with the procedures and requirements set forth in the General Conditions and Section 01 33 00, Submittal Procedures, the Contractor shall obtain from the equipment manufacturer and submit the following:
 - 1. Shop Drawings

2. Operation and Maintenance Manuals

3. Spare Parts Lists

B. Each submittal shall be identified by the applicable specification section.

1.04 SHOP DRAWINGS

A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.

B. Partial, incomplete, or illegible submittals will be returned to the Contractor for resubmittal without review.

C. Shop drawings shall include but not be limited to:

1. Product data sheets.

2. Catalog data sheets for the inverter showing performance and construction details of the inverter including physical dimensions and weights.

3. Product wiring/connection diagrams.

4. Manufacturer's installation instructions.

5. Manufacturer's written warranty statement.

D. The shop drawing information shall be complete and organized in such a way that the Engineer can determine if the requirements of these specifications are being met. Copies of technical bulletins, technical data sheets from "soft-cover" catalogs, and similar information which is "highlighted" or somehow identifies the specific equipment items the Contractor intends to provide are acceptable and shall be submitted.

1.05 OPERATION AND MAINTENANCE MANUALS

A. The Contractor shall submit Operation and Maintenance Manuals in accordance with the procedures and requirements set forth in the General Conditions and Division 01. The manuals shall include:

1. Instruction books and/or leaflets.

2. Spare parts list.

3. Final as-built construction drawings (updated from those included in the shop drawings) incorporating all changes made in the manufacturing and installation process.

4. All other drawings, product information, and other materials originally included in the shop drawings, updated as necessary to reflect as-built conditions.

1.06 SPARE PARTS

- A. The lighting inverter shall be furnished with all spare parts as recommended by the equipment manufacturer. In addition to the spare parts recommended by the manufacturer, the Contractor shall furnish the following minimum spare parts for each inverter:

Number Required	Description
1 set	Fuses of each size and type provided.

- B. Reference Section 26 05 00 – Basic Electrical Requirements for spare parts delivery and handling requirements.

1.07 IDENTIFICATION

- A. Each inverter shall be identified with the identification name and/or number indicated on the Drawings (e.g., INV-GAC). A nameplate shall be securely affixed in a conspicuous place on the exterior of the inverter.
- B. Nameplates shall be as specified in Section 26 05 53 – Identification for Electrical Systems.

1.08 WARRANTY

- A. Emergency Lighting Inverter Module
 1. The manufacturer shall warrant the electronics module against defects in materials and workmanship for 12 months after initial start-up or 18 months after ship date, whichever occurs first.
- B. Battery
 1. The battery manufacturer's warranty shall be passed through to the end user. Sealed Lead Calcium VRLA, 10-year life expectancy - two-year full replacement warranty plus an additional eight years pro-rata.

PART 2 – PRODUCTS A

2.01 MANUFACTURERS

- A. The equipment covered by this Specification is intended to be standard equipment of proven performance as manufactured by reputable concerns. Equipment shall be designed, constructed, and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as shown on the Drawings.
- B. The lighting inverter shall be manufactured by Holophane, Lithonia, Daybrite or Engineer approved equal.
- C. It is the intent of these specifications that the Emergency Lighting inverter package be produced by a single manufacturer who shall be responsible for matching all components and providing equipment which functions together as a system.

2.02 EMERGENCY LIGHTING INVERTER

- A. Voltage
 - 1. Input/Output voltage specifications of the inverter shall be:
 - a. Input: 208 volts, single-phase, 2-wire-plus –ground.
 - b. Output: 208 volts, single-phase, 2-wire-plus –ground.
 - c. Other voltages for input and output may be shown on Drawings, refer to Drawings for the voltages.
- B. Output Load Capacity:
 - 1. Specified output load capacity of the Emergency Lighting inverter shall be as indicated on the Drawings, at unity power factor and shall be able to supply the rated load from 0.5 lagging to 0.5 leading power factor.

2.03 MATCHING BATTERY CABINET

- A. Battery Cells: Sealed lead-acid, valve regulated.
- B. Reserve Time: 90 minutes at full load, 0.8 power factor, with ambient temperature between 20 and 30 degrees C.
- C. Recharge Time: The battery charger shall recharge the fully discharge batteries within a 24 hour period. The charger shall be an integrated 3 step, microprocessor controlled and temperature compensating.

2.04 MODES OF OPERATION

- A. The Emergency Lighting Inverter shall be designed to operate with less than a 2-millisecond (no break) transfer time:
1. Normal: The Emergency Lighting Inverter is normally in Standby mode and the commercial AC power continuously supplies the critical load. The input converter (bi-directional transformer) derives power from the commercial AC power source and supplies to the inverter while simultaneously providing floating charge to the batteries.
 2. Emergency: Upon failure of the commercial AC power the inverter instantaneously, with a maximum of a 2-millisecond break, switches its power supply from the input converter to the battery system. There shall be a no loss of power to the critical load upon failure or restoration of the utility source. The dedicated emergency output circuit will remain on during a power outage and continue to remain on after the utility power source has returned to acceptable conditions.
 3. Recharge: Upon restoration of commercial AC power after a power outage, the input converter shall automatically restart and start charging the batteries. The critical loads are powered by the commercial AC power again.

2.05 PERFORMANCE REQUIREMENTS

- A. AC Input to Emergency Lighting Inverter
1. Voltage Configuration for Standard Units: single-phase, 2-wire-plus-ground.
 2. Voltage Range: (+10%, -10%)
 3. Frequency: 60 Hz. (+/- 3Hz)
 4. Power Factor: 0.5 lagging /leading
 5. Inrush Current: 1.25 times nominal input current, 10 times 1 line cycle for incandescent loads
 6. Current Limit: 125% of nominal input current
 7. Current Distortion: 10% THD maximum from 50% to full load
 8. Surge Protection: Sustains input surges without damage per standards set in UL 924, ANSI C62.41 (IEEE 587) & ANSI C62.42.45 (Cat. A&B)
- B. AC Output, Emergency Lighting Inverter

1. Voltage Configuration for Standard Units: single-phase, 2-wire-plus-ground
2. Static Voltage Stability: Load current changes +/- 2%, battery discharge +/- 12.5%
3. Dynamic Voltage Stability: +/- 2% (25% step load), +/- 3% (50% step load)
4. Dynamic Recovery Time to within 1% of nominal: 3 cycles (0-100% load step)
5. Output Harmonic Distortion: < 3% (with linear load)
6. Frequency: 60 Hz (+/- .05Hz during emergency mode)
7. Load Power Factor Range: 0.5 lagging to 0.5 leading
8. Output Power Rating: VA =W
9. Overload Capability: to 100% continuous rating to 115% for 5 minutes to 150% for 16 line cycles
10. Crest Factor: <=2.8
11. Efficiency >= 98% on Utility

2.06 ENVIRONMENTAL CONDITIONS

- A. The Emergency Lighting Inverter shall be capable to operate within the specified design and performance criteria provided that the following environmental conditions are met:
 1. Storage/Transport Temperature:
 - a. -4 to 158 deg. F (-20 to 70 deg. C) without batteries 0 to 104 deg. F (-18 to 40 deg. C) with batteries. Maximum recommended storage temperature for batteries is 77 deg. C for up to six months. Storage at up to 40 deg. C is acceptable for a maximum of three months.
 2. Relative Humidity: 0 to 95% non-condensing
 3. Altitude: Operating: to 10,000 ft. (3,000 m) above sea level de-rated 5% per Km above 3 Km
 4. Storage/Transport: to 40,000 ft. (12.2 Km) above sea level
 5. Audible Noise: 45 dBA at 1 meter from surface of the Emergency Lighting Inverter

2.07 MATERIALS

- A. The maximum working voltage, current, and di/dt of all solid-state power components and electronic devices shall not exceed 75% of the ratings established by the inverter system supplier. The operating temperature of solid-state component sub-assembly shall not be greater than 75% of their ratings. Electrolytic capacitors shall be computer grade and be operated at no more than 95% of their voltage rating at the maximum rectifier charging voltage.
- B. Wiring practices, materials and coding shall be in accordance with the requirements of the National Electrical Code (NFPA 70). All bolted connections of bus bars, lugs, and cables shall be in accordance with requirements of the National Electrical Code and other applicable standards. All electrical power connections are to be torqued to the required value and marked with a visual indicator.
- C. Provision shall be made for power cables to enter or leave from the top or bottom of the inverter cabinet.

2.08 CONSTRUCTION AND MOUNTING

- A. The inverter unit, comprised of input autotransformer, rectifier/charger with input filter, inverter, static transfer switch, and maintenance bypass switch, shall be housed in a single free-standing NEMA type 1 enclosure. Cabinet doors/covers shall require a tool for gaining access. Casters and leveling feet shall be provided for ease of installation. Front access only shall be required for expedient servicing, adjustments, and installation. The inverter cabinet shall be structurally adequate and have provisions for hoisting, jacking, and forklift handling.
- B. The inverter cabinet shall be cleaned, primed, and painted with the manufacturer's standard color. The inverter shall be constructed of replaceable subassemblies. Printed circuit assemblies shall be plug-in. Like assemblies and like components shall be interchangeable.

2.09 COOLING

- A. Cooling of the inverter shall be by forced-air. Redundant fans shall be used. Low velocity fans shall be used to minimize audible noise output. Fan power shall be provided by the inverter output.
- B. The thermal design, along with all thermal and ambient sensors, shall be coordinated with the protective devices before excessive component or internal cabinet temperatures are exceeded.

2.10 GROUNDING

- A. The AC output neutral shall be electrically isolated from the inverter chassis. The inverter chassis shall have an equipment ground terminal. Provisions for local bonding shall be provided.

- B. All components of the drive shall be bonded via some external visible copper connection sized for the ampacity of the transformer secondary current.

2.11 COMPONENTS

A. Rectifier

1. General - The term rectifier/charger shall denote the solid-state equipment and controls necessary to convert incoming AC power to regulated DC power for input to the inverter and for battery charging. The rectifier/charger shall be a phase-controlled, solid-state SCR type with constant voltage/current limiting control circuitry.
2. AC Input Current Limiting: The rectifier/charger unit shall be provided with AC input current limiting whereby the maximum input current shall be limited to 125% of the full input current rating. The rectifier/charger shall operate at a reduced current limit mode whenever the critical load is powered from the inverter static bypass circuit such that the maximum inverter input current will not exceed 125% of full load input current. In addition, the rectifier/charger input current limit shall be automatically reduced to 25% of full load input current whenever the critical load is powered from the inverter internal maintenance bypass circuit. An optional second circuit shall limit input current to 100% of rated full load current when activated by a customer supplied contact closure to signal a customer function such as generator operation.
3. Fuse Failure Protection: Power semiconductors in the rectifier/charger shall be fused with fast-acting fuses, so that loss of any one power semiconductor shall not cause cascading failures.
4. DC Filter: The rectifier/charger shall have an output filter to minimize ripple voltage into the battery. Under no conditions shall ripple voltage into the battery exceed 2% RMS. The filter shall be adequate to ensure that the DC output of the rectifier/charger will meet the input requirements of the inverter. The inverter shall be able to operate from the rectifier/charger with the battery disconnected.
5. Automatic Restart: Upon restoration of utility AC power, after a utility AC power outage and prior to an inverter automatic end-of-discharge shutdown, the rectifier/charger shall automatically restart, walk-in, and gradually assume the inverter and battery recharge loads. Upon restoration of utility AC power, after a utility AC power outage and after a full inverter automatic end-of-discharge shutdown, the inverter will (customer selectable) automatically restart, performing the normal inverter start up walk-in.
6. Battery Recharge: In addition to supplying power for the inverter load, the rectifier/charger shall be capable of producing battery charging current sufficient to replace 95% of the battery discharge power within ten (10) times the discharge

time. After the battery is recharged, the rectifier/charger shall maintain the battery at full charge until the next emergency operation.

7. Overvoltage Protection: There shall be DC over-voltage protection so that if the DC voltage rises to the pre-set limit, the inverter is to shut down automatically and initiate an uninterrupted load transfer to the static bypass line.

B. Inverter

1. General: The term inverter shall denote the solid-state equipment and controls to convert DC power from the rectifier/charger or battery to regulated AC power for supporting the critical load. The inverter shall be a transistorized, phase-controlled, pulse width modulated (PWM) design capable of providing the specified AC output.
2. Overload Capability: The inverter shall be capable of supplying current and voltage for overloads exceeding 100% and up to 150% of full load current. A status indicator and audible alarm shall indicate overload operation. The inverter shall transfer the load to bypass when overload capacity is exceeded.
3. Fault Clearing and Current Limit: The inverter shall be capable of supplying an overload current of 150% of full load current for twelve cycles, 115% for 5 minutes and 110% for 10 minutes. For greater currents or longer time duration, the inverter shall have electronic current-limiting protection to prevent damage to components. The inverter shall be self-protecting against any magnitude of connected output overload. Inverter control logic shall sense and disconnect the inverter from the critical AC load without the requirement to clear protective fuses.
4. Output Power Transformer: A dry type power transformer shall be provided for the inverter AC output. It shall have copper wiring exclusively. The transformers hottest spot winding temperature shall not exceed the temperature limit of the transformer insulation class of material when operating at full load at maximum ambient temperature.
5. Fuse Failure Protection: Power semiconductors in the inverter unit shall be fused with fast-acting fuses, so that loss of any one power semiconductor will not cause cascading failures.
6. Inverter DC Protection: The inverter shall be protected by the following disconnect levels:
 - a. DC Overvoltage Shutdown
 - b. DC Undervoltage Warning (Low Battery Reserve), user adjustable from 1 to 99 minutes

c. DC Undervoltage Shutdown (End of Discharge)

7. Inverter Output Voltage Adjustment: The inverter shall use a manual control to adjust the output voltage from +/- 5% of the nominal value.
8. Output Frequency: The output frequency of the inverter shall be controlled by an oscillator. The oscillator shall be temperature compensated and hold the inverter output frequency to +/- 0.1% for steady state and transient conditions. Drift shall not exceed 0.1% during a 24-hour period. Total frequency deviation, including short time fluctuations and drift, shall not exceed 0.1% from the rated frequency.

C. Display and Controls

1. Monitoring and Control: The inverter shall be provided with a microprocessor based unit status display and controls section. A system power flow diagram shall be provided as part of the monitoring and controls sections which depicts a single-line diagram of the inverter. Illuminated visual indicators shall be of the long-life light-emitting diode (LED) type. All of the operator controls and monitors shall be located on the front of the inverter cabinet. The monitoring functions such as metering, status and alarms shall be displayed on an alphanumeric LCD display.
2. Metering: The inverter shall be capable of metering the electrical parameters for the AC input, AC output, battery and charger/rectifier sections of the inverter system.
 - a. Normal Operation
 - b. Utility input voltage
 - c. System output voltage
 - d. Battery voltage
 - e. Battery current
 - f. System output current
 - g. System output VA
 - h. Inverter wattage
 - i. System temperature
 - j. Date & time

3. Alarm Messages: The inverter shall be capable of alarming the electrical and mechanical parameters for the AC input, AC output, and charger/rectifier and battery sections of the inverter system, including (but not limited to):
 - a. High battery charger voltage
 - b. Low battery charger voltage
 - c. High AC input voltage
 - d. Low AC input voltage
 - e. Near low battery voltage
 - f. Low battery voltage
 - g. Load reduction fault
 - h. High Ambient temperature
 - i. Inverter fault
 - j. Output fault
 - k. Output overload
4. Status Lights: The Inverter shall use LEDs as follows to indicate operational status:
 - a. AC Present (Green)
 - b. System Ready (Green)
 - c. Battery Charging (Yellow)
 - d. Battery Power (Yellow)
 - e. Fault (Red)
5. Controls: Inverter start-up, shutdown, and maintenance bypass operations shall be accomplished through the integrated control panel and keypad. An advisory display and menu-driven user prompts shall be provided to guide the operator through system operation without the use of additional manuals. The control panel shall be password protected to ensure authorized use.

6. On-Line Battery Test: The inverter shall be capable of performing tests on the batteries to check for open cell, shorted cell, and deteriorated cell conditions. The unit shall also be capable of performing a continuous battery test.

D. Battery Power Pack

1. The battery power pack shall include sealed, lead-acid valve regulated battery cells housed in a separate cabinet that matches the inverter cabinet styling to form an integral system line-up. Battery cells shall be mounted on slide-out trays for ease of maintenance. A disconnect means shall be included for isolation of the battery pack from the inverter module. Casters and leveling feet shall also be provided with the battery power pack cabinet for ease of installation.

E. Remote Contact Board

1. Isolated Form C contacts (rated for 10 amps at 120 volts) shall be provided to indicate a change of status of each of the following alarm conditions, minimum:
 - a. Inverter on battery
 - b. Low battery reserve
 - c. Load on bypass

F. Diagnostic Interface

1. A diagnostic interface shall be provided for remote display of inverter status information at a computer terminal (by others). The interface shall monitor and acquire the alarm log, the event log, and the automatic test log.
2. The interface shall allow the use to perform battery tests and review all system parameters.
3. The manufacturer shall provide all software and drivers required to run the monitoring and control features.

G. Battery Circuit Breaker

1. A battery circuit breaker shall be provided to isolate the battery from the inverter. This breaker shall have an undervoltage release (UVR) and auxiliary contacts, and shall be in a separate wall mounted NEMA-1 enclosure. The battery breaker provides a manual disconnecting means, short circuit protection, and overcurrent protection for the battery system. When opened, there shall be no battery voltage in the inverter enclosure. The inverter shall be automatically disconnected from the battery by opening the breaker when the battery reaches the minimum discharge voltage level.

PART 3 – EXECUTION

3.01 INSTALLATION

- A. The inverter shall be furnished and installed as shown on the Drawings and in accordance with the manufacturer's installation instructions. One (1) copy of these instructions shall be included with the equipment at the time of shipment. The equipment shall be suitably protected from any moisture, excessive heat or cold per the environmental limits listed in this specification until accepted by the Owner.
- B. Furnish and install appropriate structural mounting in accordance with the manufacturer's recommendations.
- C. The following test and inspection procedures will be followed during start-up:
 - 1. Visual Inspection
 - a. Inspect equipment for signs of damage.
 - b. Verify installation per drawings.
 - c. Inspect cabinets for foreign objects.
 - d. Verify neutral and ground conductors are properly sized and configured.
 - e. Inspect battery cases.
 - f. Inspect battery for proper polarity.
 - g. Verify all printed circuit boards are configured properly.
 - h. Verify that proper versions of software have been furnished for diagnostics and external communications.
 - 2. Mechanical Inspection
 - a. Check all control wiring connections for tightness.
 - b. Check all power wiring connections for tightness.
 - c. Check all terminal screws, nuts, and/or spade lugs for tightness.
 - 3. Electrical Inspection
 - a. Check all fuses for continuity.
 - b. Confirm input voltage and phase rotation is correct.

- c. Verify control transformer connections are correct for voltages being used.
- d. Assure connection and voltage of the battery string(s).

3.02 TESTING

- A. All tests shall be performed in accordance with the requirements of the General Conditions and Division 01. The following tests are required:
 - 1. Witnessed Shop Tests
 - a. None Required
 - 2. Certified Shop Tests
 - a. The inverters shall be given routing factory tests in accordance with the requirements of ANSI, NEMA and Underwriters Laboratories standards.
 - 3. Field Tests
- B. Field testing shall be done in accordance with the requirements specified in the General Conditions, Division 01, and Section 26 05 00, Basic Electrical Requirements.

3.03 UNIT START-UP AND FIELD TESTING

- A. Field testing shall be provided by the manufacturer's field service personnel if requested. Field testing shall consist of a complete test of the inverter system and the associated accessories supplied by the manufacturer. A full load power test including a partial battery discharge test shall be provided as part of the standard start-up procedure. This shall be accomplished without disturbing user wiring and completed prior to operation of the site critical load from the inverter output. The test results shall be documented, signed, and dated for future reference.

3.04 SERVICES OF A MANUFACTURER'S REPRESENTATIVE

- A. The inverter manufacturer shall directly employ a nationwide service organization, consisting of factory trained field service personnel dedicated to the start-up, maintenance, and repair of the inverter and power equipment. The organization shall consist of regional and local offices.
- B. A qualified, factory trained manufacturer's representative shall certify in writing that the equipment has been installed, adjusted, and tested in accordance with the manufacturer's recommendations.

3.05 FIELD ADJUSTMENTS

- A. The inverter manufacturer will furnish a set of all software and hardware parameter setting to the Engineer prior to final acceptance.
- B. Where applicable, field service personnel shall delineate between those settings that and field adjustable versus those settings that are custom set based on load characteristics, the type of inverter, etc.

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SECTION 31 00 01

EARTHWORK

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. The Contractor shall furnish all labor, equipment, and materials required to complete all work associated with excavation (including off-site borrow excavation), fill and backfill placement and compaction, coordination and payment for testing of soil materials and compaction by an independent Materials Testing Consultant as specified in Specification Section 01 45 23 – Materials Testing Services Furnished by Contractor, constructing embankments, dewatering, construction of drainage layers, installing foundation and backfill aggregate, placing filter and separation fabrics, stockpiling topsoil and any excess suitable material, designing, installing, maintaining and removing excavation support systems, disposing of all excess and unsuitable materials, providing erosion and sedimentation control, encasing utility conduits, site grading, preparation of pavement and structure subgrades, and other related and incidental work as required to complete the work shown on the Drawings and as specified herein.
- B. All excavations shall be in conformity with the lines, grades, and cross sections shown on the Drawings or established by the Engineer.
- C. It is the intent of this Specification that the Contractor conduct the construction activities in such a manner that erosion of disturbed areas and off-site sedimentation be absolutely minimized.
- D. Earthwork performed under this Contract shall be done in conformance with these specifications. Items and activities not addressed herein shall be subject to the limitations of the latest editions of the North Carolina Department of Transportation Standard Specifications for Roads and Structures. If there is a conflict between this specification and the Standard Specifications for Roads and Structures, the more conservative of the two shall take precedent.
- E. Erosion and Sediment Control shall be performed in accordance with Section 31 25 00 Erosion and Sedimentation Control of these specifications and with the latest edition of the North Carolina Erosion and Sediment Control Planning and Design Manual (ESCPDM). If there is a conflict between this specification and the ESCPDM, the more conservative of the two shall take precedent.
- F. All fill materials (soil, aggregate, topsoil, etc.) imported to the site and onsite materials to be reused as fill, backfill, or embankment shall be subjected to the testing requirements contained in Part 3.0 of this Section. The Engineer shall retain a Materials Testing

Consultant who shall perform all testing. The test results shall be used to determine if a material meets the requirements included herein. The Contractor shall furnish all necessary samples for laboratory testing and shall provide assistance and cooperation during field tests. The Contractor shall plan their operations to allow adequate time for laboratory tests and to permit taking of field density tests during compaction.

1. Contractor shall provide Engineer a minimum of 48 hours' notice prior to the need for any materials testing onsite as defined in the Contract Documents.
- G. Any costs for re-testing required as a result of failure to meet compaction requirements shall be borne solely by the Contractor.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Requirements of related work are included in Divisions 01, 02, 31, and 32 of these Specifications.

1.03 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

- A. Without limiting the generality of the other requirements of the Specifications, all work herein shall conform to the applicable requirements of the following documents. All referenced Specifications, codes, and standards refer to the most current issue available at the time of Bid.
1. North Carolina Department of Transportation Standard Specifications for Roads and Structures, latest edition.
 2. North Carolina Department of Transportation Materials and Test Manual, latest edition.
 3. Occupational Safety and Health Administration (OSHA) 29 CFR 1926 Subpart P
 4. American Society for Testing and Materials (ASTM):
 - a. ASTM C127 – Standard Test Method for Relative Density (Specific Gravity) and Absorption of Coarse Aggregate.
 - b. ASTM C136 – Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
 - c. ASTM D698 – Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lb/ft³ (600 kN-m/m³))
 - d. ASTM D1140 – Standard Test Method for Determining the Amount of Material Finer than 75-µm (No. 200) Sieve in Soils by Washing

- e. ASTM D1556 – Standard Test Method for Density and Unit Weight of Soil in Place by Sand Cone Method.
- f. ASTM D1557 – Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lb/lb³ (2,700 kN-m/m³)).
- g. ASTM D1883 – Standard Test Method for California Bearing Ratio (CBR) of Laboratory-Compacted Soils.
- h. ASTM D2216 – Test for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass.
- i. ASTM D2487 – Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System).
- j. ASTM D4253 – Standard Test Method for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table.
- k. ASTM D4318 – Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.
- l. ASTM D5268-22 - Standard Specification for Topsoil Used for Landscaping and Construction Purposes
- m. ASTM D6913 - Standard Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis
- n. ASTM D6938 – Standard Test Method for In-Place Density and Water Content of Soil and Soil Aggregate by Nuclear Methods (Shallow Depth).

1.04 SUBSURFACE CONDITIONS

- A. Information on subsurface conditions is referenced under Division 01, General Requirements.
- B. Attention is directed to the possible location of water pipes, sanitary pipes, storm drains, and other utilities located in the area of proposed excavation. In the event excavation activities disrupt service, the Contractor shall perform all repairs at no additional cost to the Owner. The Contractor shall contact NC811.org or 1-800-632-4949 to request underground utility location mark-out at least three (3) working days, not including the day the request is called in, but no more than ten (10) working days prior to the beginning of excavation. The Contractor shall also contact and request utility location mark-out from buried utility owners with utilities on the project site that are not participants of NC811.org.

1.05 SUBMITTALS

- A. In accordance with the procedures and requirements set forth in Section 01 33 00 – Submittal Procedures, the Contractor shall submit the following:
1. Evidence the Contractor has a minimum of five (5) years of experience performing excavation and backfill on heavy construction projects similar in size to the work for this project.
 2. Name and location of all material suppliers.
 3. Certificate of compliance with the standards specified herein for each source of each material.
 4. List of disposal sites for waste and unsuitable materials and all required permits for use of those sites.
 5. Plans and cross sections of open cut excavations showing side slopes and limits of the excavation at grade.
 6. Procedures for dewatering proposed by the Contractor shall be submitted to the Engineer for review and approval prior to any earthwork operations.
 7. Samples of synthetic filter fabric and reinforced plastic membrane with manufacturer's certificates or catalog cuts stating the mechanical and physical properties. Samples shall be at least one (1) foot wide and four (4) feet long taken across the roll with the warp direction appropriately marked.
 8. Construction drawings and structural calculations for any types of excavation support required. Drawings and calculations shall be sealed by a currently registered Professional Engineer in North Carolina.
 9. Monitoring plan and pre-construction condition inspection and documentation of all adjacent structures, utilities, and roadways near proposed installation of excavation support systems and near areas where dewatering is required to facilitate construction.
 10. A representative sample of the on-site or off-site source of each class of fill material weighing approximately 50 lbs. The sample shall be delivered to a location designated by the Engineer.
 11. The Contractor shall be required to submit plans of open cut excavation for review by the Engineer before approval is given to proceed.
 12. Submit excavation support installer qualifications with installation history.

13. Drawings and calculations on proposed excavation support systems sealed by a Professional Engineer currently registered in North Carolina.
14. Contractor shall also submit a monitoring plan developed by the excavation support design engineer.
15. Earthwork contractor qualifications.
16. All required permits and a list of disposal sites for unsuitable materials within thirty (30) consecutive days after Notice to Proceed. If the disposal site is located on private property, the submittal shall also include written permission from the owner of record.
17. Except where borrow is to be obtained from a commercial source, a borrow source development, use, and reclamation plan jointly developed by the Contractor and the property owner prior to engaging in any land disturbing activity on the proposed source (other than material sampling that may be necessary). The Contractor's plan shall address the following
 - a. Drainage: The source shall be graded to drain such that no water will collect or stand and a functioning drainage system shall be provided. If drainage is not practical, and the source is to serve as a pond, the minimum average depth below the water table shall be 4 feet or the source graded so as to create wetlands as appropriate, or as agreed to with the property owner
 - b. Slopes: The source shall be dressed and shaped in a continuous manner to contours which are comparable to and blend in with the adjacent topography, but in no case will slopes steeper than 3:1 be permitted.
 - c. Erosion Control: Except where borrow is to be obtained from a commercial source, the Contractor and the property owner shall jointly submit a Borrow Source Development, Use, and Erosion Control Plan to the appropriate State or Local permitting authority for approval and provide evidence of such to the Engineer for their approval prior to engaging in any land disturbing activity on the proposed source other than material sampling that may be necessary.

1.06 PRODUCT HANDLING

- A. Soil and rock material shall be excavated, transported, placed, and stored in a manner so as to prevent contamination, segregation and excessive wetting. Materials which have become contaminated or segregated will not be permitted in the performance of the work and shall be removed from the site.

PART 2 – PRODUCTS

2.01 FILL MATERIALS

- A. The contractor shall be responsible for providing fill materials meeting the gradation requirements included herein.
- B. All fill materials shall be free of organic material, environmental contaminants, snow, ice, frozen soil, or other unsuitable material.
- C. Bedding material installed above and below the water table shall meet the requirements of the NCDOT Standard Specifications for Roads and Structures.
- D. Below-grade walls shall be backfilled with Select Fill.
- E. When the excavated material from required excavations meets the requirements of Select Fill or Common Fill, but is replaced with off-site borrow material for the Contractor's convenience, the costs associated with such work and material shall be borne by the Contractor.
- F. Where excavated material does not meet requirements for Select Fill or Common Fill, the Contractor shall furnish off-site borrow material meeting the specified requirements herein. Determination of whether the borrow material will be paid for as an extra cost will be made based on the contract documents.
- G. Contractor may stockpile excavated material to be used as Select Fill, Common Fill, Drainage Fill or Topsoil on site in areas designated in the Contract Documents. Soil materials may be stockpiled as necessary to sort, segregate, test, and transfer the materials. Excess material and materials considered unsuitable for reuse by the Engineer shall be removed from the site for off-site disposal. No stockpiling of excavated material is allowed in a manner or location that would permit erosion and its subsequent sedimentation in wetlands or other natural areas.

2.02

2.03 SELECT FILL

- A. Select fill shall be used where shown on the Contract Drawings.
- B. Select fill shall not include particles or lumps larger than 3 inches.
- C. Select fill used as backfill against walls shall not contain any rock larger than 1½ -inches.

- D. Select fill shall consist of non-plastic materials classifying as SM, SC, ML or CL. per ASTM D-2487. Cleaner SP/SW sands should be used where undercut extends below the water table. Select fill shall be free of organic material, environmental contaminants, snow, ice, frozen soil, or other unsuitable material.
- E. Open-graded and dense-graded NCDOT aggregates meeting the gradation requirements above may be used as Select Fill.
- F. Select Fill to be used as pavement subbase material shall be NCDOT Aggregate Base Course.
- G. Select Fill shall be placed in 8-inch-thick lifts, with the exception of NCDOT No. 57 aggregate, which may be placed in 12-inch-thick lifts.
- H. Select Fill shall be compacted to not less than 95 percent of the maximum dry density obtainable by ASTM D 698 and does not contain unsuitable material. The top foot of Select Fill beneath pavement shall be 98 percent of Standard Proctor maximum dry density.
- I. Select Fill shall be compacted at a moisture content within 20 percent of the optimum moisture content of the fill material in accordance with the ASTM D 698, Standard Proctor.
- J. All materials used as Select Fill are subject to approval by the Engineer.

2.04 DRAINAGE FILL

- A. Drainage Fill shall be used where shown on the Contract Drawings.
- B. Drainage Fill shall consist of NCDOT No. 57 aggregate.

2.05 COMMON FILL

- A. Common Fill shall be used where shown on the Contract Drawings.
- B. Common Fill shall consist of non-organic on-site soils classifying as SM, SC, ML or CL according to ASTM D 2487.
- C. Common Fill shall be placed in 8-inch-thick loose lifts.
- D. Common Fill shall be compacted to not less than 95 percent of the maximum dry density obtainable by ASTM D 698 and does not contain unsuitable material.
- E. Common Fill shall be compacted at a moisture content within 20 percent of the optimum moisture content of the fill material in accordance with the ASTM D 698, Standard Proctor.

- F. All material used as common fill is subject to approval by the Engineer. If there is insufficient suitable material onsite, import whatever additional material is required which conforms to the specifications, at no additional cost to the Owner.
- G. Select Fill may be used as Common Fill, subject to approval by the Engineer. Select fill may be used as Common Fill at no change in the Contract Price.

2.06 TOPSOIL

- A. Topsoil shall be friable and loamy (loam, sandy loam, silt loam, sandy clay loam, clay loam). It shall be free of debris, trash, stumps, rocks, roots, and noxious weeds, and shall give evidence of being able to support healthy vegetation. It shall contain no substance potentially toxic to plant growth.
- B. All topsoil shall be tested before use on site by a recognized laboratory for the following criteria according to local standards (or at a minimum according to ASTM D5268-22, Table 1): Organic matter content shall not be less than 3% by weight. pH range shall be from 5.5 -7.5. If pH is less than 5.5, lime shall be added in accordance with test results or in accordance with the recommendations of the vegetative establishment practice being used. Soluble salts shall not exceed 2.5 mmhos/cm ppm. If additional topsoil is needed, it must meet the standards stated above.
- C. Soils falling within the ranges of ASTM D5268-22, Table 1 shall form a suitable topsoil. Soils being used as a topsoil with organic content matter contents between 10% and 90% may need to be amended prior to use. If soils proposed for use as topsoil do not meet the criteria of Table 1, an engineered soil amendment may be added to meet the requirements. When using an engineered soil amendment, the organic matter values need to be greater than 75%.

2.07 GEOTEXTILES

- A. The Contractor shall provide geotextiles as indicated on the Contract Drawings and specified herein. The materials and placement shall be as indicated under Section 31 05 19 - Geotextiles.

PART 3 – EXECUTION

3.01 STRIPPING OF TOPSOIL

- A. In all areas to be excavated, filled, or paved, the topsoil shall be stripped to its full depth.
- B. Topsoil may be stockpiled for subsequent reuse on site at locations shown on the Contract Drawings or designated by the Owner or Engineer. Topsoil shall be kept separated from other excavated materials and shall be piled free of roots and other undesirable materials. Topsoil shall not be stored in areas where it will interfere with surface drainage or with the conservation of trees, shrubs, and other vegetation to remain. No stockpile shall be placed within 50-feet of a pond, stream, wetland, or stormwater inlet.

3.02 EXCAVATION

- A. All material excavated, regardless of its nature or composition, shall be classified as UNCLASSIFIED EXCAVATION. Excavation shall include the removal of all soil, rock, weathered rock, rocks of all types, boulders, conduits, pipe, all other obstacles encountered, and all other obstacles shown to be removed within the limits of excavation shown on the Contract Drawings or specified herein. The cost of excavation shall be included in the Lump Sum Bid Price and no additional payment will be made for the removal of obstacles encountered within the excavation limits shown on the Drawings and specified herein.
- B. All suitable material removed in the excavation shall be used as far as practicable in the formation of embankments, subgrades, and shoulders, and at such other places as may be indicated on the Drawings or indicated by the Engineer. No excavation shall be wasted except as may be permitted by the Engineer. Refer to the drawings for specific location and placement of suitable excavated materials in the formation of embankments, backfill, and structural and roadway foundations. THE ENGINEER AND/OR MATERIALS TESTING CONSULTANT WILL DESIGNATE MATERIALS THAT ARE UNSUITABLE. The Contractor shall furnish off-site disposal areas for the unsuitable material. Where suitable materials containing excessive moisture are encountered above grade in cuts, the Contractor shall construct above grade ditch drains prior to the excavation of the cut material when in the opinion of the Engineer and/or materials testing consultant such measures are necessary to provide proper construction.
- C. All excavations shall be made in the dry and in such a manner and to such widths as will give ample room for properly constructing and inspecting the structures and/or piping they are to contain and for such excavation support, pumping and drainage as may be required. Excavation shall be made in accordance with the grades and details shown on the Drawings and as specified herein.

- D. Excavation slopes shall be flat enough to avoid slides that will cause disturbance of the subgrade or damage of adjacent areas. Excavation requirements and slopes shall be as indicated in the Drawings.
- E. The Contractor shall intercept and collect surface runoff both at the top and bottom of cut slopes. The intersection of slopes with natural ground surfaces, including the beginning and ending of cut slopes, shall be uniformly rounded as shown on the Drawings or as may be indicated by the Engineer. Concurrent with the excavation of cuts the Contractor shall construct intercepting berm ditches or earth berms along and on top of the cut slopes at locations shown on the Drawings or designated by the Engineer. All slopes shall be finished to reasonably uniform surfaces acceptable for seeding and mulching operations. No rock or boulders shall be left in place which protrude more than 1 foot within the typical section cut slope lines, and all rock cuts shall be cleaned of loose and overhanging material. All protruding roots and other objectionable vegetation shall be removed from slopes.
- F. It is the intent of these Specifications that all structures shall bear on an aggregate base, crushed stone or screened gravel bedding placed to the thickness shown on the Drawings, specified in these Specifications, or not less than 6 inches. Bedding for process piping shall be as specified in Section 40 05 00 – Basic Mechanical Requirements, or as shown on the Drawings.
- G. The bottom of all excavations for structures and pipes shall be examined by the Engineer and/or materials testing consultant for bearing value and the presence of unsuitable material. If, in the opinion of the Engineer and/or materials testing consultant, additional excavation is required due to the low bearing value of the subgrade material, or if the in place soils are soft, yielding, pumping or wet, the Contractor shall remove such material to the required width and depth and replace it with thoroughly compacted select fill, and/or crushed stone or screened gravel as indicated by the Engineer. Payment for such additional work ordered by the Engineer shall be made as an extra by a Change Order in accordance with the General Conditions and Division 01, General Requirements. No payment will be made for subgrade disturbance caused by inadequate dewatering or improper construction methods.
- H. All cuts shall be brought to the grade and cross section shown on the Drawings, or established by the Engineer, prior to final inspection and acceptance by the Engineer.
- I. Slides and over-breaks which occur due to negligence, carelessness or improper construction techniques on the part of the Contractor shall be removed and disposed of by the Contractor as indicated by the Engineer at no additional cost to the Owner. If grading operations are suspended for any reason whatsoever, partially completed cut and fill slopes shall be brought to the required slope and the work of seeding and mulching or other required erosion and sedimentation control operations shall be performed.

- J. Where the excavation exposes sludge, sludge contaminated soil or other odorous materials, the Contractor shall cover such material at the end of each workday with a minimum of 6 inches and a maximum of 24-inches of Common fill. The work shall be an odor abatement measure and the material shall be placed to the depth deemed satisfactory by the Engineer for this purpose.

3.03 EXCAVATION SUPPORT

- A. The Contractor shall furnish, place, and maintain such excavation support which may be required to provide safe working conditions and support sides of excavation or to protect structures, pipes, and utilities from possible damage. The Contractor shall be exclusively responsible for maintaining safe working conditions and structure integrity without overstressing or damaging existing structures, pipes, and utilities resulting from the Contractor temporarily placing, moving, or removing loads on or adjacent to existing structures, pipes, and utilities. If the Engineer is of the opinion that at any point sufficient or proper supports have not been provided, the Engineer may order additional supports put in at the expense of the Contractor. The Contractor shall be responsible for the adequacy of all supports used and for all damage resulting from failure of support system or from placing, maintaining and removing the support system.
- B. The selection of and design of any proposed excavation support systems is exclusively the responsibility of the Contractor. Contractor shall submit drawings and calculations to the Engineer on the proposed systems sealed by a Professional Engineer currently registered in North Carolina.
- C. The excavation support system shall be installed by a specialized contractor with a minimum of five (5) years' experience installing the type of excavation support system proposed.
- D. The Contractor shall exercise caution in the installation and removal of supports to ensure no excessive or unusual loadings or vibrations are transmitted to any new or existing structure. The Contractor shall promptly repair at their expense any and all damage that can be reasonably attributed to installation or removal of excavation support system.
- E. Contractor shall monitor movement and vibration in the excavation support systems as well as movement and vibration at adjacent structures, utilities and roadways near excavation supports. Contractor shall submit a monitoring plan developed by the excavation support design engineer. All pre-construction condition assessment and documentation of adjacent structures on-site and off-site shall be performed by the Contractor. If any sign of distress such as cracking or movement occurs in any adjacent structure, utility or roadway during installation of supports, subsequent excavation, service period of supports, subsequent backfill and construction, or removal of supports, Engineer shall be notified immediately. The Contractor shall be exclusively responsible

for repair of any damage to any roadway, structure, utility, pipes, etc. both on-site and off-site, as a result of their operations.

- F. All excavation supports shall be removed upon completion of the work except as indicated herein. The Engineer may permit supports to be left in place at the request and expense of the Contractor. The Engineer may order certain supports left permanently in place in addition to that required by the Contract. The cost of the materials so ordered left in place, less a reasonable amount for the eliminated expense of the removal work omitted, will be paid as an extra by a Change Order in accordance with the General Conditions and Division 01, General Requirements. Vibrations of new and existing structures shall be considered when the Contractor decides whether to remove excavation supports or leave them in place. Any excavation supports left in place shall be cut off at least two (2) feet below the finished ground surface or as directed by the Engineer.

3.04 PROTECTION OF SUBGRADE

- A. To minimize the disturbance of bearing materials and provide a firm foundation, the Contractor shall comply with the following requirements:
 - 1. Use of heavy rubber tired construction equipment shall not be permitted on the final subgrade unless it can be demonstrated that drawdown of groundwater throughout the entire area of the structure is at least 3 feet below the bottom of the excavation (subgrade). Even then, the use of such equipment shall be prohibited should subgrade disturbance result from concentrated wheel loads.
 - 2. Subgrade soils disturbed through the operations of the Contractor shall be excavated and replaced with compacted select fill or crushed stone at the Contractor's expense as indicated by the Engineer.
 - 3. The Contractor shall provide positive protection against penetration of frost into materials below the bearing level during work in winter months. This protection can consist of a temporary blanket of straw or salt hay covered with a plastic membrane or other acceptable means.

3.05 PROOF-ROLLING

- A. The subgrade of all structures and all areas that will support pavements or select fill shall be proof-rolled. After stripping of topsoil, excavation to subgrade and prior to placement of fills, the exposed subgrade shall be carefully inspected by probing and testing as needed. Any topsoil or other organic material still in place, frozen, wet, soft, or loose soil, and other undesirable materials shall be removed. The exposed subgrade shall be proof-rolled with a heavily loaded tandem-wheeled dump truck to check for pockets of soft material hidden beneath a thin crust of better soil. Any unsuitable materials thus

exposed shall be removed and replaced with an approved compacted material, as directed by the Materials Consultant.

3.06 DEWATERING

- A. The Contractor shall do all dewatering as required for the completion of the work. Procedures for dewatering proposed by the Contractor shall be submitted to the Engineer for review prior to any earthwork operations.
- B. All water removed by dewatering operations shall be disposed of in accordance with the North Carolina Sedimentation Pollution Control Act.
- C. The dewatering system shall be of sufficient size and capacity as required to control groundwater or seepage to permit proper excavation operations, embankment construction and reconstruction, subgrade preparation, and to allow concrete to be placed in a dry condition. The system shall include a sump system or other equipment, appurtenances and other related earthwork necessary for the required control of water. The Contractor shall drawdown groundwater to at least 2 feet below the bottom of excavations (subgrade), over the entire tempo, at all times in order to maintain a dry and undisturbed condition.
- D. The Contractor shall control, by acceptable means, all water regardless of source. Water shall be controlled, and its disposal provided for at each berm, structure, etc. The entire periphery of the excavation areas shall be ditched and diked to prevent water from entering the excavation. The Contractor shall be fully responsible for disposal of the water and shall provide all necessary means at no additional expense to the Owner. The Contractor shall be solely responsible for proper design, installation, proper operation, maintenance, and any failure of any component of the system.
- E. The Contractor shall be responsible for and shall repair without cost to the Owner, any damage to work in place and the excavation, including damage to the bottom due to heave and including removal of material and pumping out of the excavated area. The Contractor shall be responsible for damages to any other area or structure caused by their failure to maintain and operate the dewatering system proposed and installed by the Contractor.
- F. The Contractor shall be responsible for and shall repair, without cost to the Owner, any damage to work in place and nearby structures, roadways, and utilities which can be reasonably attributed to dewatering operations. This includes settlement of structures, roadways, and utilities due to dewatering of soils supporting the structures, roadways, and utilities.
- G. The Contractor shall take all the steps that they consider necessary to familiarize himself with the surface and subsurface site conditions, and shall obtain the data that is required

to analyze the water and soil environment at the site and to assure that the materials used for the dewatering systems will not erode, deteriorate, or clog to the extent that the dewatering systems will not perform properly during the period of dewatering. Copies of logs of borings and laboratory test results are available to the Contractor. This data is furnished for information only, and it is expressly understood that the Owner and Engineer will not be held responsible for any interpretations or conclusions drawn therefrom by the Contractor.

- H. Prior to the execution of the work, the Contractor, Owner and Engineer shall jointly survey the condition of adjoining structures. Photographs and records shall be made of any prior settlement or cracking of structures, pavements, and the like, that may become the subject of possible damage claims.

3.07 FILL OR EMBANKMENTS

- A. Contractor shall perform the construction of fill or embankments in such a manner that cut and fill slopes will be completed to final slopes and grade in a continuous operation. The operation of removing excavation material from any cut and the placement of embankment in any fill shall be a continuous operation to completion unless otherwise permitted by the Engineer.
- B. Subgrades upon which fill or embankments are to be constructed shall be stripped of topsoil, organic material, rubbish and other extraneous materials. After stripping and prior to placing fill or embankment material, the Contractor shall compact the top 12inches of in place soil as specified under Paragraph 3.09, COMPACTION.
- C. Any soft or unsuitable materials revealed before or during placement fill or embankment placement shall be removed as indicated by the Engineer and/or materials testing consultant and replaced with select fill and compacted as required.
- D. Fill subgrades on which fill or embankment is to be placed, shall be scarified or stepped in a manner which will permit bonding of the embankment with the existing surface. The fill or embankment soils shall be as specified under Part 2 - Products, and shall be deposited and spread in successive, uniform, approximately horizontal layers. The loose thickness of each lift shall not exceed the thickness for each fill type noted in Paragraph 3.09, COMPACTION.
- E. Hauling shall be distributed over the full width of the embankment, and in no case will deep ruts be allowed to form during the construction of the embankment. Fill or embankment subgrades shall be properly drained at all times and kept free of flowing or ponding water, snow, ice and frozen soils. Saturated soils, snow, ice, or frozen soils shall be removed as recommended by the Engineer.
- F. Each layer of the embankment shall be thoroughly compacted to the density specified under Paragraph 3.09, COMPACTION.

- G. The embankment or fill material in the layers shall be of the proper moisture content before rolling to obtain the prescribed compaction. Moisture conditions and manipulation of the fill or embankment material, when necessary, shall be performed to maintain a uniform moisture content throughout the layer. Should the material be too wet or too dry to permit proper compaction, earthwork operations shall be delayed until the material is adequately moisture conditioned. Samples of all fill or embankment materials for testing, both before and after placement and compaction, will be taken at frequent intervals. From these tests, corrections, adjustments, and modifications of methods, materials, and moisture content will be made to construct the embankment.
- H. Where fill or embankments materials are to be placed and compacted on sloped subgrades steeper than 4:1 shall be benched. Benches shall be at least 6-feet wide.
- I. When rock and other embankment material are excavated at approximately the same time, the rock shall be incorporated into the outer portions of the embankments and the other material which meets the requirements for select fill shall be incorporated into the formation of the embankments. Stones or fragmentary rock larger than 4 inches in their greatest dimension will not be allowed within the top 6 inches of the final grade. Stones, fragmentary rock, or boulders larger than 12 inches in their greatest dimension will not be allowed in any portions of embankments and shall be disposed of by the Contractor as indicated by the Engineer. When rock fragments or stone are used in embankments, the material shall be brought up in layers as specified or directed and every effort shall be exerted to fill the voids with finer material to form a dense, compact mass which meets the densities specified for embankment compaction.

3.08 BACKFILLING

- A. All structures and pipes shall be backfilled with the type of materials shown on the Drawings and specified herein. Fill placed as structure or utility backfill shall be deposited in successive, uniform, approximately horizontal lifts. The thickness of each lift shall not exceed the requirements of Paragraph 3.09, COMPACTION.
- B. Each lift of fill placed backfill shall be thoroughly compacted to the density specified for each type of fill included in Paragraph 3.09, COMPACTION.
- C. Where excavation support is used, the Contractor shall take all reasonable measures to prevent loss of support beneath and adjacent to pipes and existing structures when supports are removed. If significant volumes of soil cannot be prevented from clinging to the extracted supports, the voids shall be continuously backfilled as rapidly as possible. The Contractor shall thereafter limit the depth below subgrade that supports will be installed in similar soil conditions or employ other appropriate means to prevent loss of support.

- D. Backfill against concrete or masonry structure shall not be performed until the Work has been reviewed and backfilling permitted. Backfill against walls shall also be deferred until the structural slab for floors above the top fill line have been placed and attained design strength or earlier at the discretion of the Engineer. Partial backfilling against adequately braced wall may be considered by the Engineer on an individual situation basis. Where walls are to be waterproofed, all Work shall be completed and membrane materials dried or cured according to the manufacturer's instructions before backfilling.
- E. Backfill against tanks and other structures which are to retain liquids shall not be performed until leakage tests are completed and accepted by the Engineer in accordance with the Section entitled "Watertightness Testing".

3.09 COMPACTION

- A. The Contractor shall compact embankments, backfill, crushed stone, aggregate base, and in place subgrade in accordance with the requirements of this Section. The densities specified herein refer to percentages of maximum density as determined by the noted test methods. Compaction of materials on the project shall be in accordance with the following schedule:

	Density % Standard Proctor (D 698)	Density % Mod. Proctor (D 1557)	Max. Lift Thickness as Compacted Inches
Embankments Beneath Structures, Roadways, and Sidewalks*	98	92	8
Common Fill Areas	95	90	8
Backfill Around Structures	95	90	8
Backfill in Pipe Trenches	95	90	8
Crushed Stone Beneath Structures	**	**	12
Select Sand	98	92	8
Aggregate Base Course (ABC) Beneath Structures, Roadways, and Sidewalks	**	**	8
Crushed Stone Backfill	**	**	12
Crushed Stone Pipe Bedding	**	**	12
In Place Subgrade Beneath Structures, Roadways, and Sidewalks	98	92	Top 12-inches

Density % Standard Proctor (D 698)	Density % Mod. Proctor (D 1557)	Max. Lift Thickness as Compacted Inches

* Embankments beneath structures shall be considered to include a zone 10 feet out from the foundation of the structure extending down to the natural ground on a 45° slope.

** The aggregate shall be compacted to a degree acceptable to the Engineer by use of a vibratory compactor and/or crawler tractor.

B. Compaction Near Existing Structures

1. Vibratory equipment shall not be used with 25 feet of any existing structure.
2. Within 25 feet of any existing structure, non-vibratory compaction equipment such as a drum roller with a maximum weight of 4 tons should be used. Within 5 feet of any existing structure, a walk behind vibratory sled or roller shall be used.

C. Field density tests will be made by the Materials Testing Consultant to determine if the specified densities have been achieved, and these tests shall be the basis for accepting or rejecting the compaction. In-place density tests will be performed in accordance with ASTM D 1556, ASTM D 1557, or ASTM D 6938. The Engineer, in conjunction with the Materials Testing Consultant, will be the judge as to which test method will be the most appropriate. Failure to achieve the specified densities shall require the Contractor to recompact the material or remove it as required. The Contractor shall, if necessary, increase the compactive effort by increasing the number of passes, using heavier or more suitable compaction equipment, or by reducing the thickness of the layers. The Contractor shall adjust the moisture contents of the soils to bring them within the optimum range by drying them or adding water as required.

D. Testing will be performed as frequently as deemed necessary by the Engineer and/or Materials Testing Consultant. As a minimum, one in place density test shall be performed for each 1000 cubic yards of embankment placed and 500 cubic yards of backfill placed or one test performed each day for either or as directed by the Engineer or recommended by Material Testing Consultant.

3.10 VIBRATION MONITORING

A. Vibration monitoring shall be performed at nearby structures when compaction work is ongoing. A single monitoring point using vibration monitoring equipment capable of detecting velocities of 0.1 inch/second or less and survey measurements shall be used for vibration monitoring at each of the nearest structures. An elevation measurement on nearby structures shall be taken before compaction work starts, and then at least twice a day during the work with one reading taken at the conclusion of the day's operations. Elevation measurements shall be recorded to an accuracy of 0.005 foot. If at any time the Contractor detects settlement or heave of 0.005-feet or more, or vibration levels of

1.0 inch/second or more, the vibratory compaction shall be stopped immediately, and the Engineer notified.

3.11 REMOVAL OF EXCESS AND UNSUITABLE MATERIALS

- A. The Contractor shall remove and dispose of off-site all excess and unsuitable materials. Within thirty (30) consecutive days after Notice to Proceed, the Contractor shall submit to the Engineer for review all required permits and a list of disposal sites for the unsuitable materials. If the disposal site is located on private property, the submittal shall also include written permission from the owner of record.
- B. All excess and unsuitable materials shall be disposed of in locations and under conditions that comply with federal, state/commonwealth and local laws and regulations.
- C. The Contractor shall obtain an off-site disposal area prior to beginning demolition or excavation operations.
- D. All excess and unsuitable materials shall be hauled in trucks of sufficient capacity and tight construction to prevent spillage. Trucks shall be covered to prevent the propagation of dust.
- E. When all excess and unsuitable material disposal operations are completed, the Contractor shall leave the disposal sites in a condition acceptable to the Owner and Owner(s) of the disposal site(s).

END OF SECTION

SECTION 31 05 16
AGGREGATE MATERIALS

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. The Contractor shall furnish all labor, equipment and materials required to complete all work associated with the installation of aggregate material beneath foundations, as backfill and as roadway subgrades and other related and incidental work as required to complete the work shown on the Drawings and specified herein.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 01 42 00 – References
- B. Section 31 00 01 – Earthwork
- C. Section 31 25 00 – Erosion and Sedimentation Control
- D. Section 32 10 00 – Paving and Surfacing
- E. Section 33 41 13 – Foundation Drainage Systems
- F. Section 32 90 00 – Final Grading and Landscaping

1.03 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

- A. Without limiting the generality of the other requirements of the Specifications, all work herein shall conform to the applicable requirements of the following documents. All referenced specifications, codes, and standards refer to the most current issue available at the time of Bid.
 - 1. North Carolina Department of Transportation (NCDOT) Standard Specifications for Roads and Structures; South Carolina State Highway Department Standard Specifications for Highway Construction.
 - 2. ASTM C 127 – Test for Specific Gravity and Absorption of Coarse Aggregate.
 - 3. ASTM C 136 – Test for Sieve Analysis of Fine and Coarse Aggregates.
 - 4. ASTM C 535 – Test for Resistance to Degradation of Large Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.

1.04 SUBMITTALS

- A. Submit the following in accordance with Section 01 33 00 – Submittal Procedures.
 - 1. Materials gradation and certification.
 - 2. ASTM C127, ASTM C136, and ASTM C535 test results

PART 2 – PRODUCTS

2.01 CRUSHED STONE, SCREENED GRAVEL AND AGGREGATE BASE COURSE (ABC)

- A. Crushed stone or screened gravel shall meet the requirements of Aggregate Standard Size No. 8, No. 57, or No. 67 as defined by NCDOT Standard Specifications.
- B. ABC shall meet the requirements of ABC as defined by NCDOT Standard Specifications.

2.02 SELECT SAND

- A. Select sand shall meet the requirements of Sections 1005 and 1014 of the NCDOT Standard Specifications for materials and gradation. The size used shall be Standard Size No. 2S or 2MS as listed and defined in Table 1005-2, "Aggregate Gradation", of the NCDOT Standard Specifications.

PART 3 – EXECUTION

3.01 CRUSHED STONE, SCREENED GRAVEL AND AGGREGATE BASE COURSE (ABC)

- A. Contractor shall install crushed stone, screened gravel and ABC in accordance with the NCDOT Standard Specifications and as shown on the Drawings and indicated in the Contract Documents.
 - 1. Unless otherwise stated herein or shown on the Drawings, all mat foundations (bottom slabs) for the proposed structures shall have a blanket of crushed stone or ABC 6-inches thick minimum placed directly beneath the proposed mat. The blanket shall extend a minimum of 12 inches beyond the extremities of the mat.
 - 2. For subgrade preparation at structures and structural fill, the foundation material shall be ABC where specifically specified on Drawings, otherwise, crushed stone or screened gravel shall be used.
 - 3. For ground under drains, pipe bedding, and drainage layers beneath structures the coarse aggregate shall meet the requirements of aggregate standard Size No. 57 or No. 67, as defined by NCDOT Standard Specifications.

3.02 SELECT SAND

- A. Contractor shall install select sand in accordance with the NCDOT Standard Specifications and as shown on the Drawings and indicated in the Contract Documents.

END OF SECTION

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SECTION 31 05 19

GEOTEXTILES

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. The Contractor shall furnish and install all Geotextiles, including all necessary and incidental items, as detailed or required for the Contractor to complete the installation in accordance with the Drawings and these Specifications.
- B. For the location of each type of Geotextile see the Drawings.

1.02 REFERENCES

- A. ASTM Standards
 - 1. ASTM D4533 - Standard Test Method for Trapezoid Tearing Strength of Geotextiles
 - 2. ASTM D4632 - Standard Test Method for Grab Breaking Load and Elongation of Geotextiles
 - 3. ASTM D5261 - Standard Test Method for Measuring Mass per Unit Area of Geotextiles
 - 4. ASTM D6241 - Standard Test Method for Static Puncture Strength of Geotextiles and Geotextile-Related Products Using a 50-mm Probe
- B. AASHTO Standards
 - 1. AASHTO M 288-06 (2011) Geotextile Specification for Highway Applications

1.03 SUBMITTALS

- A. Prior to shipping to the site, the Contractor shall submit to the Engineer two copies of a mill certificate or affidavit signed by a legally authorized official of the Manufacturer for each type of Geotextile. The Supplier shall also submit three Geotextile samples of each product, 1 yard square each, seamed and unseamed as appropriate, with the mill certificate for each Geotextile type supplied. The mill certificate or affidavit shall attest that the Geotextile meets the chemical, physical and manufacturing requirements stated in the specifications. The samples shall be labeled with the manufacturer's lot number, machine direction, date of sampling, project number, specifications, manufacturer and product name.

- B. The Engineer shall be furnished copies of the delivery tickets or other acceptable receipts as evidence for materials received that will be incorporated into construction.

PART 2 – MATERIALS

2.01 MATERIALS

- A. Filter Geotextile shall be a minimum 6-ounce per square yard (nominal) nonwoven needle punched synthetic fabric consisting of staple or continuous filament polyester or polypropylene manufactured in a manner accepted by the Engineer and the Owner. The Geotextiles shall be inert and unaffected by long-term exposure to chemicals or liquids with a pH range from 3 to 10. The Geotextiles shall have a minimum threshold water head of 0.25-inches in the "as received" condition.
 - 1. Filter Geotextile shall have a Survivability Class of Class 1 or 2 in accordance with AASHTO M288, unless otherwise specified herein.
- B. Type I Separator Geotextile shall be a minimum 8-ounce per square yard (nominal) nonwoven needle punched synthetic fabric consisting of staple or continuous filament polyester or polypropylene manufactured in a manner accepted by the Engineer and the Owner. The Geotextiles shall be inert and unaffected by long term exposure to chemicals or liquids with a pH range from 3 to 10.
 - 1. Type I Separator Geotextile shall have a Survivability Class of Class 1 or 2 in accordance with AASHTO M288, unless otherwise specified herein.
- C. Type II Separator Geotextile shall be a woven slit film or monofilament synthetic fabric consisting of polyester or polypropylene in a manner approved by the Engineer. Geotextile shall be treated to resist degradation due to exposure to ultraviolet light.
 - 1. Type II Separator Geotextile shall have a Survivability Class of Class 1 in accordance with AASHTO M288, unless otherwise specified herein.
- D. All Geotextiles shall conform to the properties listed using the test methods listed in Table 1. The Contractor shall be responsible for timely submittals of all confirmation test data for Geotextiles.

PART 3 – EXECUTION

3.01 SHIPPING, HANDLING AND STORAGE

- A. During all periods of shipment and storage, all Geotextiles shall be protected from direct sunlight, temperature greater than 140°F water, mud, dirt, dust, and debris.

- B. To the extent possible, the Geotextile shall be maintained wrapped in heavy-duty protective covering until use. Geotextile delivered to the project site without protective covering shall be rejected. After the protective covering has been removed, the Geotextile shall not be left uncovered for longer than fourteen (14) days, under any circumstances.
- C. The Owner shall approve the shipping and delivery schedule prior to shipment. The Owner shall designate the on-site storage area for the Geotextiles. Unloading and storage of Geotextiles shall be the responsibility of the Contractor.
- D. Geotextiles that are damaged during shipping or storage shall be rejected and replaced at Contractor expense.

3.02 QUALITY ASSURANCE CONFORMANCE TESTING

- A. At the option of the Engineer representative samples of Geotextiles shall be obtained and tested by the Engineer to assure that the material properties conform to these Specifications. Conformance testing shall be conducted by the Engineer and paid for by the Owner.
- B. Conformance testing shall be completed at a minimum frequency of one sample per 100,000 square feet of Geotextile delivered to the project site. Sampling and testing shall be as directed by the Engineer.
- C. Conformance testing of the Geotextiles shall include but not be limited to the following properties:
 - 1. Mass Per Unit Area (ASTM D5261)
 - 2. Grab Tensile Strength (ASTM D4632)
 - 3. Trapezoidal Tear (ASTM D4533)
 - 4. Puncture Resistance (ASTM D6241)
- D. The Engineer may add to, remove or revise the test methods used for determination of conformance properties to allow for use of improved methods.
- E. All Geotextile conformance test data shall meet or exceed requirements outlined in Table 1 of these Specifications for the particular category of Geotextile prior to installation. Any materials that do not conform to these requirements shall be retested or rejected at the direction of the Engineer.
- F. Each roll of Geotextile will be visually inspected by the Engineer or the Engineer's representative. The Engineer reserves the right to sample and test at any time and reject, if necessary, any material based on visual inspection or verification tests.

- G. A Geotextile that is rejected shall be removed from the project site and replaced at the Contractor's expense. Sampling and conformance testing of the Geotextile supplied as replacement for rejected material shall be performed by the Engineer at Contractor's expense.

3.03 INSTALLATION

- A. Geotextiles shall be placed to the lines and grades shown on the Drawings. At the time of installation, the Geotextile shall be rejected by the Engineer if it has defects, rips, holes, flaws, evidence of deterioration, or other damage.
- B. It is the intent of these Specifications that Geotextiles used to protect natural drainage media be placed the same day as the drainage media to prevent soil, sediment or windblown soils to make contact with the drainage media.
- C. The Geotextiles shall be placed smooth and free of excessive wrinkles. Geotextiles shall conform to and be in contact with the approved subgrade.
- D. When the Geotextiles are placed on slopes, the upslope fabric portion shall be lapped such that it is the upper or exposed Geotextile.
- E. Geotextiles shall be temporarily secured in a manner accepted by the Engineer prior to placement of overlying materials.
- F. In the absence of specific requirements shown on the Drawings, the following shall be used for overlaps of adjacent rolls of Geotextile:

Geotextile Type / Application	Overlap of Adjacent Rolls ⁽¹⁾ (Inches)	Transverse End Overlap (Inches)
Filter Geotextile	6 min	12 min
Separator - Roadway Applications	12 min	24 min
Separator - Slope Protection	18 min	24 min
Separator Geotextile	12 min	18 min

(1) Overlaps may be reduced if adjacent panels are sewn or heat bonded where approved by the Engineer.

- G. Any Geotextile that is torn or punctured shall be repaired or replaced as directed by the Engineer by the Contractor at no additional cost to the Owner. The repair shall consist of a patch of the same type of Geotextile placed over the failed areas and shall overlap the existing Geotextile a minimum of 12-inches from any point of the rupture.

- H. Any Geotextile that is subjected to excessive sediment buildup on its surface during construction shall be replaced by the Contractor prior to placement of overlying material.

Geotextile Property	Filter Geotextile	Type I Separator Geotextile	Type II Separator Geotextile
Geotextile Construction	Nonwoven Needle punched	Nonwoven Needle punched	Woven
Ultraviolet Resistance, (500 hrs.) ASTM D7238, Average % Strength Retention	70	70	70
Grab Tensile Strength (lbs.), ASTM D4632	120	160	315
Grab Tensile elongation (%) ASTM D4632	50	50	15
Trapezoid Tear Strength (lbs) ASTM D4533	50	60	120
Apparent Opening Size (AOS), (mm), ASTM D4751	0.212	0.212	0.425
Permittivity at 50 mm constant head (sec ⁻¹), ASTM D4491	0.5	1.5	0.1
CBR Puncture Strength, ASTM D6241 (lb)	340	410	900

END OF SECTION

SECTION 31 10 00
CLEARING, GRUBBING, AND SITE PREPARATION

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. Includes all labor, material, equipment and appliances required for the complete execution of any additions, modifications, or alterations to existing building(s) and new construction work as shown on the Drawings and specified herein.
- B. Principal items of work include:
 - 1. Notifying all authorities owning utility lines running to or on the property. Protecting and maintaining all utility lines to remain and capping those that are not required in accordance with instructions of the Utility Companies, and all other authorities having jurisdiction.
 - 2. Clearing the site within the Contract Limit Lines, including removal of grass, brush, shrubs, trees, loose debris and other encumbrances except for trees marked to remain.
 - 3. Boxing and protecting all trees, shrubs, lawns and the like within areas to be preserved. Relocating trees and shrubs, so indicated on the Drawings, to designated areas.
 - 4. Repairing all injury to trees, shrubs, and other plants caused by site preparation operations shall be repaired immediately. Work shall be done by qualified personnel in accordance with standard horticultural practice and as approved by the Engineer.
 - 5. Removing topsoil to its full depth from designated areas and stockpiling on site where directed by the Engineer for future use.
 - 6. Disposing from the site all debris resulting from work under this Section.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 31 00 01 – Earthwork
- B. Section 31 25 00 – Erosion and Sedimentation Control

1.03 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

- A. North Carolina Administrative Code, Title 15, Chapter 2.

1.04 STREET AND ROAD BLOCKAGE

- A. Closing of streets and roads during progress of the work shall be in compliance with the requirements of the Owner and other authorities having jurisdiction. Access shall be provided to all facilities remaining in operation.

1.05 PROTECTION OF PERSONS AND PROPERTY

- A. All work shall be performed in such a manner to protect all personnel, workmen, pedestrians and adjacent property and structures from possible injury and damage.
- B. All conduits, wires, cables and appurtenances above or below ground shall be protected from damage.
- C. Provide warning and barrier fence where shown on the Drawings and as specified herein.

PART 2 – EXECUTION

2.01 CLEARING OF SITE

- A. Before removal of topsoil, and start of excavation and grading operations, the areas within the clearing limits shall be cleared and grubbed.
- B. Clearing shall consist of cutting, removal, and satisfactory disposal of all trees, fallen timber, brush, bushes, rubbish, sanitary landfill material, fencing, and other perishable and objectionable material within the areas to be excavated or other designated areas. Prior to the start of construction, the Contractor shall survey the entire Contract site and shall prepare a plan which defines the areas to be cleared and grubbed, trees to be pruned, extent of tree pruning, and/or areas which are to be cleared but not grubbed. This plan shall be submitted to the Engineer for approval. Should it become necessary to remove a tree, bush, brush or other plants adjacent to the area to be excavated, the Contractor shall do so only after permission has been granted by the Engineer.
- C. Excavation resulting from the removal of trees, roots and the like shall be filled with suitable material, as approved by the Engineer, and thoroughly compacted per the requirements contained in Section 31 00 01 – Earthwork.
- D. Unless otherwise shown or specified, the Contractor shall clear and grub a strip at least 15-ft. wide along all permanent fence lines installed under this Contract.
- E. In temporary construction easement locations, only those trees and shrubs shall be removed which are in actual interference with excavation or grading work under this Contract, and removal shall be subject to approval by the Engineer. However, the Engineer reserves the right to order additional trees and shrubs removed at no additional

cost to the Owner, if such, in their opinion, are too close to the work to be maintained or have become damaged due to the Contractor's operations.

2.02 STRIPPING AND STOCKPILING EXISTING TOPSOIL

- A. Erosion and sedimentation control measures shall be installed as per the Federal, State or Locally approved Erosion and Sedimentation Control Plan for the project and Specification Section 31 25 00 – Erosion and Sedimentation Control before any stripping and stockpiling of topsoil can occur.
- B. Existing topsoil and sod on the site within areas designated on the Drawings shall be stripped to whatever depth it may occur and stored in locations directed by the Engineer.
- C. The topsoil shall be free of stones, roots, brush, rubbish, or other unsuitable materials before stockpiling the topsoil.
- D. Care shall be taken not to contaminate the stockpiled topsoil with any unsuitable materials.

2.03 GRUBBING

- A. Grubbing shall consist of the removal and disposal of all stumps, roots, logs, sticks and other perishable materials to a depth of at least 6-inches below ground surfaces.
- B. Large stumps located in areas to be excavated may be removed during grading operations, subject to the approval of the Engineer.

2.04 DISPOSAL OF MATERIAL

- A. All debris resulting from the clearing and grubbing work shall be disposed of by the Contractor as part of the work of this Contract. Material designated by the Engineer to be salvaged shall be stored on the construction site as directed by the Engineer for reuse in this Project or removal by others.
- B. Burning of any debris resulting from the clearing and grubbing work will not be permitted at the site.

2.05 WARNING AND BARRIER FENCE

- A. The fence shall be made of a visible, lightweight, flexible, high strength polyethylene material. The fence shall be Guardian Visual Barrier as manufactured by TEMAX, or equal.
- B. Physical Properties

Fence	
Color	International Orange
Roll Size	4' x 100'
Roll weight	9 lbs.
Mesh opening	1-3/4" x 1-3/4"
Posts	
ASTM Designation:	ASTM 702
Length:	6 feet long (T-Type)
Weight:	1.25 #/Foot (min)
Area of Anchor Plate:	14 Sq. In.

- C. Drive posts 18 inches into ground every 8'. Wrap fence material around first terminal post allowing overlap of one material opening. Use metal tie wire or plastic tie wrap to fasten material to itself at top, middle and bottom. At final post, cut with utility knife or scissors at a point halfway across an opening. Wrap around and tie at final post in the same way as the first post.
- D. Use tie wire or tie wrap at intermediate posts and splices as well. Thread ties around a vertical member of the fence material and the post and bind tightly against the post. For the most secure fastening, tie at top, middle and bottom. Overlap splices a minimum of four fence openings, tie as above, fastening both edges of the fence material splice overlap.

END OF SECTION

SECTION 31 23 24
FLOWABLE FILL

PART 1 – GENERAL

1.01 WORK INCLUDED

- A. The Contractor shall furnish all labor, equipment, materials and services, including pumping equipment and application, necessary for the manufacture, transportation and placement of all cementitious flowable fill as shown on the Contract Drawings or as ordered by the Engineer, except for the work specifically included under other items.

1.02 RELATED WORK

- A. Division 03 - Concrete

1.03 SUBMISSIONS

- A. In accordance with the procedures and requirements set forth in the General Conditions and Division 01, the Contractor shall submit the following:
 - 1. Shop Drawings
 - 2. Certifications of specification compliance for all sources of each material
 - 3. Manufacturer's data on all admixtures
 - 4. Mix design and trial mix test results
 - 5. Aggregate gradation

1.04 QUALITY CONTROL

- A. The Contractor shall engage the services of a testing laboratory, with the qualifications required by Section 03 30 00 – Cast-in-Place Concrete, and experienced in the design and testing of flowable fill materials and mixes, to perform material evaluation tests and to design mixes for flowable fill. A trial mix shall be performed to verify the flowable fill mix design. The trial mix shall also report slump, air content, yield, cement content, and dry unit weight per ASTM C143 and ASTM D6023.

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PART 2 – MATERIALS

2.01 CEMENTITIOUS FLOWABLE FILL

- A. Flowable fill (controlled low strength material) shall be a uniform mixture of sand, Type II Portland cement, fly ash, admixtures and water. The mix design shall produce a flowable material with little or no bleed water, which produces a minimum compressive strength of 50 psi and maximum compressive strength of 100 psi at 56 days. The cured material shall be excavatable and have a maximum dry weight of 100 pounds per cubic foot. Slump of mix at the point of application shall be 7-inches to 10-inches.
- B. Admixtures specifically designed for flowable fill shall be used to improve flowability, reduce unit weight, control strength development, reduce settlement and reduce bleed water. Admixtures shall be Mastercell 25 by BASF Construction Chemicals; Darafill by Grace Construction Products; or approved equal. Cement and all other materials shall be as specified in Section 03 30 00 - Cast-in-Place Concrete.
- C. Fine Aggregate (Sand) shall consist of natural or manufactured siliceous sand, clean and free from deleterious substances, and graded within the following limits:

Sieve Size	Percent Passing by Weight
3/8"	100
No. 4	95 to 100
No. 8	80 to 100
No. 16	50 to 85
No. 30	25 to 60
No. 50	10 to 30
No. 100*	2 to 10

*For manufactured sand, the percent passing the No. 100 Sieve may be increased up to 20%.

PART 3 – EXECUTION

3.01 PLACEMENT OF FLOWABLE FILL

- A. Flowable fill shall be batched and premixed by an approved producer, dispensed from ready-mix trucks, and placed by approved methods and equipment.

- B. Flowable fill shall be placed as needed to completely fill the space to receive it with no trapped air pockets or other voids. Positive means of allowing the air to escape shall be provided where necessary and after approval of the Engineer. Where placed against, around and inside existing structures, lift heights shall be limited so as not to overload the structure. The Engineer shall approve lift heights and procedures. Specific procedures and methods shall be included in the Contractor's shop drawing submittals.
- C. Where flowable fill is placed around piping and other elements subject to floating within the fill space, positive means shall be taken to provide temporary balancing loads to prevent uplift or fill lift heights shall be limited to prevent uplift.
- D. Application of loads or placement of other fill materials or concrete on top of flowable fill shall not occur until the flowable fill surface is determined to be suitable for loading per ASTM D6024 subject to the approval of the Engineer.

END OF SECTION

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SECTION 31 25 00
EROSION AND SEDIMENTATION CONTROL

PART 1 – GENERAL

1.01 THE REQUIREMENTS

- A. The Contractor is responsible for implementing Stormwater Control Measures (SCMs) to prevent and minimize erosion and resultant sedimentation in all cleared and grubbed areas during and after construction. This item covers the work necessary for the installation of structures and measures for the prevention of soil erosion and control of sedimentation. The Contractor shall furnish all material, labor and equipment necessary for the proper installation, maintenance, inspection, monitoring, reporting, and removal (where applicable) of erosion prevention and sediment control measures and, if applicable, to cause compliance with all local permits and the State of North Carolina Department of Environmental Quality Construction Stormwater Program General Permit – NCG 010000 to Discharge Stormwater under the National Pollution Discharge Elimination System for Construction Activities, for any land disturbance or construction activity of one (1) acre or more, under this Section 31 25 00 – Erosion and Sedimentation Control.
- B. Any land disturbance as the result of modifications to a site's drainage features or topography requires protection from erosion and sedimentation.
- C. All excavations shall be in conformity with the lines, grades, and cross sections shown on the Contract Drawings or established by the Engineer.
- D. It is the intent of this Specification that the Contractor conducts the construction activities in such a manner that erosion of disturbed areas and off-site sedimentation be absolutely minimized.
- E. All work under this Contract shall be done in conformance with and subject to the limitations of the North Carolina Rules and Regulations for Erosion and Sedimentation Control as adopted by the North Carolina Sedimentation Control Commission (15A NCAC, Chapter 4, latest edition).
- F. The following excerpts from the regulations are particularly important:
 - 1. Pursuant to North Carolina G.S. 113A-57(2), the angle of graded slopes and fills shall be no greater than the angle that can be retained by vegetative cover or other adequate erosion-control devices or structures.
 - 2. As per North Carolina DEQ Construction Stormwater Program General Permit NCG01, perimeter dikes, swales, ditches and slopes, disturbed areas within High

Quality Water (HWQ) Zones, and slopes steeper than 3H:1V following completion of any phase of grading, shall be planted or otherwise provided with temporary or permanent ground cover, devices, or structures sufficient to restrain erosion within 7 calendar days.

3. All other slopes of 3H: 1V or flatter, except those with slopes greater than 50 feet in length or within HWQ Zones, following completion of any phase of grading, shall be planted or otherwise provided with temporary or permanent ground cover, devices, or structures sufficient to restrain erosion within 14 calendar days.
- G. Due to the nature of the work required by this Contract, it is anticipated that the location and nature of the erosion and sediment control devices will be adjusted on several occasions to reflect the current phase of construction. The construction schedule adopted by the Contractor will impact the placement and need for specific devices required for the control of erosion. The Contractor shall develop and implement such additional techniques as may be required to minimize erosion and off-site sedimentation. The location and extent of erosion and sedimentation control devices shall be revised at each phase of construction that results in a change in either the quantity or direction of surface runoff from constructed areas. All deviations from the erosion and sedimentation control provisions shown on the Contract Drawings shall have the prior acceptance of the Engineer and shall be completed at no additional cost to the Owner.
- H. Erosion and sedimentation controls applicable to this project shall be as shown on the Contract Drawings, as specified herein, as indicated by the Engineer and as detailed in the North Carolina Erosion and Sediment Control Planning and Design Manual.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 01 33 00 – Submittal Procedures
- B. Section 31 10 00 – Clearing, Grubbing, and Site Preparation
- C. Section 31 00 10 – Earthwork
- D. Section 31 05 19 – Geotextiles
- E. Section 32 11 00 – Surface Restoration
- F. Section 32 90 00 – Final Grading and Landscaping

1.03 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

- A. Without limiting the generality of other requirements of these specifications, all work hereunder shall conform to the applicable requirements of the referenced portions of the following documents, to the extent that the requirements therein are not in conflict with the provisions of this Section.

1. 15A NCAC, Chapter 4
2. North Carolina Erosion and Sediment Control Planning and Design Manual, latest edition
3. North Carolina Department of Environmental Quality Construction Stormwater Program General Permit NCG 010000 to Discharge Stormwater under the National Pollution Discharge Elimination System for Construction Activities, for any land disturbance or construction activity of one (1) acre or more
4. North Carolina Department of Transportation Standard Specifications for Roads and Structures, latest edition
5. North Carolina Division of Environmental Quality Stormwater Design Manual, latest edition

B. See Specification Section 01 42 00 – References.

1.04 REGULATORY COMPLIANCE

- A. Land disturbance activities are not authorized to begin until after all required erosion and sediment control permits are obtained from the United States, the State of North Carolina and local authorities, as necessary. Contractor is the Co-Primary Permittee and Operator under the provisions of the NPDES Permit. As such, the Contractor will be required to sign certain certifications as described in the NPDES Permit. Contractor shall comply with requirements specified in the Contract Documents, on the approved Erosion Control Plan, and by the Engineer. Contractor shall also comply with all other laws, rules, regulations, ordinances and requirements concerning soil erosion and sediment control established in the United States, the State of North Carolina and local authorities as applicable. The following documents and the documents referenced therein define the regulatory requirements for this Section:
1. NPDES PERMIT: The North Carolina Department of Environmental Quality Construction Stormwater Program General Permit NCG 010000 to Discharge Stormwater under the National Pollution Discharge Elimination System for Construction Activities (NPDES permit) governs land disturbance or construction activities of one (1) acre or more. On applicable sites, Contractor is responsible for complying with terms and conditions of this permit.
 2. Manual for Erosion and Sediment Control: Contractor shall follow Practices and Standards of the North Carolina Erosion and Sediment Control Planning and Design Manual (NC ESCPDM), latest edition.
- B. During the period beginning on the effective date of the permit and lasting until expiration, the Permittee is authorized to discharge stormwater associated with construction activity including clearing, grading and excavation activities resulting in the

disturbance of land and related support activities. Such discharges shall be controlled, limited and monitored as specified below.

1. The Contractor, as Co-Primary Permittee and Operator under the provisions of the NPDES Permit, shall submit a plan for compliance with the Owner-provided approved erosion and sedimentation control plan to the Engineer for approval. Plans must include designation of where 7 and 14-day ground stabilization requirements and where basins which comply with surface-withdrawal requirements of the NPDES permit, if applicable, are located. Land disturbing activity shall not commence until the plan is approved by the Engineer. Maintain an up-to-date copy of the approved plan on the site.
2. Implement the approved plan. Deviation from the plan is allowed only to correct emergency situations of sediment discharge offsite or when minor modifications are made to improve performance of the measures and the approval authority has been notified. Note allowed deviations on the plan maintained on the site.
3. Manage onsite activities such that no adverse impacts to water quality occur from site activities or allowed discharges. The following activities, and others on a site-specific basis, require oversight throughout the construction and development process to assure that all water quality standards are protected.
 - a. Equipment Operation and Maintenance: Equipment utilized during the construction activity on a site must be operated and maintained in such a manner as to prevent the potential or actual pollution of the surface or ground waters of the State. Fuels, lubricants, coolants, and hydraulic fluids, or any other petroleum products, shall not be discharged onto the ground or into surface waters. Spent fluids shall be disposed of in a manner so as not to enter the waters, surface or ground, of the State and in accordance with applicable state and federal disposal regulations. Any spilled fluids shall be cleaned up to the extent practicable and disposed of in a manner so as not to allow their entry into the waters, surface or ground, of the State.
 - b. Material Handling: Herbicide, pesticide, and fertilizer usage during the construction activity shall be consistent with the Federal Insecticide, Fungicide, and Rodenticide Act and shall be in accordance with label restrictions.
 - c. Building Material Waste Handling: All wastes composed of building materials shall be disposed of in accordance with North Carolina General Statutes, Chapter 130A, Article 9 - Solid Waste Management, and rules governing the disposal of solid waste (North Carolina Administrative Code Section 15A NCAC 13B). In particular, the following guidelines shall be followed:
 - 1) No paint or liquid wastes in streams or storm drains.

- 2) Dedicated area for demolition, construction, and other wastes must be located a minimum of 50' from storm drains and streams unless no reasonable alternatives are available.
 - 3) Earthen-material stockpiles must be located a minimum of 50' from storm drains and streams unless no reasonable alternatives are available.
 - 4) Concrete materials onsite, including excess concrete, must be controlled to avoid contact with surface waters, wetlands, or buffers. (Note discharges from onsite concrete plants may require coverage under a separate NPDES permit – NCG140000).
- d. Litter and Sanitary Waste: The Permittee shall control the management and disposal of litter and sanitary waste from the site.

C. Violations and Fines

1. Contractor shall be responsible for reimbursing the Owner for any fines incurred as a result of violations to the NC Sedimentation Pollution Control Act, the NPDES General Permit for Stormwater Discharges on Construction Sites, and any applicable delegated local program's sediment control regulations until construction activities are complete and the project is accepted by the Owner. These include fines levied by the NCDEMLR Land Quality Section, NCDEQ Division of Water Quality and delegated local programs.
2. If violations result in the issuance of a Notice of Violation, the Contractor shall comply with the requirements of the Notice within the specified time period for compliance. Failure to comply could result in the assessment of a penalty for each day of the continuing violation, beginning with the date of the violation.
3. Violations may result in civil and/or criminal penalties which include fines and imprisonment.

1.05 SUBMITTALS

- A. Prior to the start of the work, the Contractor shall prepare and submit a plan for implementing the temporary and permanent erosion and sedimentation control measures as shown on the Erosion and Sediment Control Plan approved by the appropriate regulatory authority. Construction work shall not commence until the schedule of work and the methods of operations have been reviewed and approved.
- B. The Contractor shall perform inspections of erosion and sedimentation control measures and stormwater discharge outfalls and prepare inspection reports as described in Part 3.0 of this Section. Copies of the inspection reports shall be submitted to the Engineer on a monthly basis.

C. In accordance with the procedures and requirements set forth in the General Conditions Division 01 and Section 01 33 00 – Submittal Procedures, the Contractor shall submit the following:

1. Name and location of all material suppliers.
2. Certificate of compliance with the standards specified above for each source of each material.
3. List of disposal sites for waste and unsuitable materials and evidence of all required permits for use of those sites.

1.06 GUARANTEE

A. All restoration and re-vegetation work shall be subject to the one-year guarantee period of the Contract as specified in the General Conditions.

PART 2 – MATERIALS

2.01 MATERIALS

- A. Materials for use in erosion and sedimentation control devices shall be in accordance with the NC ESCPDM.
- B. All erosion and sediment control bid prices shall include all excavation, grading, maintenance, legal sediment disposal, permits and all other work and appurtenances necessary to design, install and maintain the sediment and erosion control measures as detailed herein and in accordance with the NC ESCPDM.

2.02 SILT FENCE

- A. Silt (or sediment) fence shall be constructed as shown on the Contract Drawings, at other locations indicated by the Engineer, as specified herein, and as detailed in Section 6.62 of the NC ESCPDM. Silt fences shall be installed below small disturbed areas that are less than $\frac{1}{4}$ acre disturbed per 100-feet of fence when slopes are less than 2%. Contractor shall refer to Table 6.62a in the NC ESCPDM for criteria. Silt fence shall not be installed across streams, ditches, or waterways or other areas of concentrated flows.
- B. Silt fence shall be designed, installed and maintained in accordance with Part 3.0 of this Section and Section 6.62 of the NC ESCPDM. Silt fence shall be a woven geotextile filter fabric made specifically for sediment control. Filter fabric shall not rot when buried and shall resist attack from soil chemicals, alkalines and acids in the pH range from 2 to 13, and shall resist damage due to prolonged ultraviolet exposure. Filter fabric shall be C-50NW as manufactured by Contech Earth Stabilization Solutions, GT 142 as manufactured by SKAPS Industries, Soiltex ST 120N as manufactured by Geo-

Synthetics, Inc., or approved equal. The cost of silt fence shall include the materials, excavation, backfill, aggregate, periodic sediment removal, etc. and all maintenance and restoration activities required.

- C. Silt fence shall be stable for the 10-year peak storm runoff. Fabric shall meet the following specifications:

Temporary Silt Fence Material Property Requirements

	Test Material	Units	Supported ¹ Silt Fence	Un-Supported ¹ Silt Fence	Type of Value
Grab Strength	ASTM D 4632	N (lbs)			
Machine Direction			400	550	MARV
			(90)	(90)	
x-Machine Direction			400	450	MARV
			(90)	(90)	
Permittivity ²	ASTM D 4491	sec-1	0.05	0.05	MARV
Apparent Opening Size 2	ASTM D 4751	mm	0.60	0.60	Max. ARV ³
		(US Sieve #)	(30)	(30)	
Ultraviolet Stability	ASTM D 4355	% Retained Strength	70% after 500 hours exposure	70% after 500 hours exposure	Typical

Notes:

- 1 Silt Fence support shall consist of 14 gage steel wire with a mesh spacing of 150 mm (6 inches), or prefabricated polymer mesh of equivalent strength.
- 2 These default values are based on empirical evidence with a variety of sediment. For environmentally sensitive areas, a review of previous experience and/or site or regionally specific geotextile tests in accordance with Test Method D 5141 should be performed by the agency to confirm suitability of these requirements.
- 3 As measured in accordance with Test Method D 4632.

- D. The synthetic filter fabric shall consist of at least 95% by weight of polyolefins or polyester, certified by the manufacturer, and as specified by Section 6.62 of the NC ESCPDM.
- E. The posts for silt fences shall be 1.33 lb/linear feet steel with a minimum length of 5 feet; posts shall have projections to facilitate fastening of the fabric.
- F. For reinforcement of standard strength filter fabric use wire fence with a minimum 14 gauge and a maximum mesh spacing of 6 inches.

2.03 STONE FOR EROSION CONTROL

- A. The Contractor shall place stone for erosion control as shown on the Contract Drawings, as specified herein, as specified in Section 1610 of the NCDOT Standard Specifications, and as detailed in Section 6.15 of the NC ESCPDM. The stone for erosion control shall consist of field stone or rough un-hewn quarry stone. The stone shall be sound, tough, dense, and resistant to the action of air and water. The stone for erosion control shall be Class (A) or Class (B) as specified in the NCDOT Standard Specifications, Section 1610, and underlain by a Type II Separator Geotextile, as specified in Section 31 05 19 – Geotextiles, unless otherwise noted on the Contract Drawings.
- B. Stone for erosion control shall be designed, installed and maintained in accordance with Part 3.0 of this Section, Section 1610 of the NCDOT Standard Specifications, and Section 6.15 of the NC ESCPDM. The cost for stone for erosion control shall include furnishing, weighing, stockpiling, re-handling, placing and maintaining stone; disposal of any stone not incorporated into the project if directed by the Engineer; and any other incidentals necessary to complete the work.

2.04 RIP RAP

- A. The Contractor shall place rip rap as shown on the Contract Drawings, as specified in Section 1042 of the NCDOT Standard specifications for plain rip rap, and as detailed in Section 6.15 of the NC ESCPDM. The stone for rip rap shall consist of field stone or rough un-hewn quarry stone. The rip rap shall be sound, tough, dense, and resistant to the action of air and water. Neither the width nor thickness of individual stones shall be less than one third their length. The rip rap shall be Class 1 or Class 2 as specified in the NCDOT Standard Specifications, Section 1042, and underlain by a Type II Separator Geotextile, as specified in Section 31 05 19 – Geotextiles, unless otherwise noted on the Contract Drawings.
- B. Rip rap shall be designed, installed, and maintained in accordance with Part 3.0 of this Section, Section 1042 of the NCDOT Standard Specifications, and Section 6.15 of the NC ESCPDM. The cost for rip rap shall include furnishing, weighing, stockpiling, rehandling, placing, and maintaining rip rap; disposal of any rip rap not incorporated into the project if directed by the Engineer; geotextile material and installation, and all other incidentals necessary to complete the work.

2.05 ROLLED EROSION CONTROL (RECM) AND TURF REINFORCEMENT MAT (TRM)

- A. The purpose of rolled erosion control products (also known as recp's or ecp's, trm's, mats, etc.) is to prevent the movement of topsoil and sediment and to assist vegetation establishment. some erosion control methods which use plastic netting, while protecting the soil, can cause damage to wildlife and the environment. materials which are 100% biodegradable, made from natural fibers, and use a loose weave (often called leno weave) Rolled Erosion Control Mat (RECM), and Turf Reinforcement Mat (TRM), shall

be installed as shown on the Contract Drawings, at other locations indicated by the Engineer, as specified herein, and as detailed in Section 6.17 of the NC ESCPDM. RECMs should be utilized to aid stabilization of slopes greater than 2:1 and with more than 10 feet of vertical relief. RECMs should also be used when mulch cannot be adequately tacked and where immediate ground cover is required to prevent erosion damage. Examples of RECMs are blankets, nets and matting.

- B. RECM's utilizing plastic netting of any type – polypropylene, nylon, polyethylene, and polyester - shall not be used, including plastic netting designated as degradable, photodegradable, UV-degradable, oxo-degradable, or oxo-biodegradable. Use loose weave, non-welded, movable jointed netting (leno or gauze). Rectangle (elongated) mesh is preferred over square mesh.
- C. RECMs shall be designed, installed and maintained in accordance with Part 3.0 of this Section and Section 6.17 of the NC ESCPDM. The cost for RECMs shall include all excavation, grading, and materials, and all maintenance activities.
- D. RECMs shall be used to aid in stabilization of vegetated channels where runoff velocity will exceed 2.5 feet/second on bare earth during the 2-year rainfall event that produces peak runoff.
- E. RECMs shall be chosen based on the Design Criteria detailed in Section 6.17 of the NC ESCPDM. Typically, nets shall be used in conjunction with mulch; the use of mulch is typically not required with excelsior and coir blankets.
- F. The recommended anchoring devices are 12-inch minimum length wooden stakes, or rigid, 100% biodegradable stakes of a minimum of 6 inches in length. If Manufacturer's recommendations are more stringent, they shall supersede.
- G. The minimum tensile strength and bare soil shear stress values for specific RECMs are as follows:
 - 1. C1urled wood or coconut fiber RECM shall be American Excelsior Curlex II FibreNet, North American Green BioNet C125BN, East Coast Erosion Control ECC-2B, or equal matting with a minimum tensile strength of 140 lbs/ft and a minimum bare soil shear stress value of 1.75 lb/ft².
 - 2. Synthetic Turf Reinforcement Mat (TRM) shall be High Performance (HPTRM) woven products with continuous yarns woven into a tight, three-dimensional matrix with opening sizes less than 5 mm. HPTRM's shall be Propex Geosolutions Pyramat, North American Green TMax®, Nilex PP5-Xtreme, or equal matting with a minimum tensile strength of 3000 lbs/ft and a long-term vegetated shear stress value of 15.0 lb/ft².
- H. The cost of RECM and TRM shall include the mat and anchoring materials, installation, and all maintenance activities required.

2.06 TEMPORARY AND PERMANENT DIVERSIONS

- A. Temporary diversions shall be constructed as shown on the Contract Drawings, at other locations indicated by the Engineer, as specified herein, and as detailed in Sections 6.20 and 8.05 of the NC ESCPDM. Permanent diversions shall be constructed as shown on the Contract Drawings, at other locations indicated by the Engineer, as specified herein, and as detailed in Section 6.21 and 8.05 of the NC ESCPDM. Temporary diversions shall be constructed adjacent to disturbed areas to collect surface runoff from disturbed areas and direct the runoff to sediment basins or to divert non-sediment laden runoff away from undisturbed areas and/or sediment basins. All temporary diversions transporting sediment-laden runoff shall terminate in a sediment trapping device. Permanent diversions should be planned as a part of initial site development and should be coordinated with temporary diversions. All temporary and permanent diversions shall be stabilized with vegetation or other means within 7 days of installation. Permanent diversions shall be used to divert water to locations where it can be used or released without erosion or flood damage. Dimensions shall be as shown on the Contract Drawings.
- B. Temporary diversions shall be designed, installed and maintained in accordance with Part 3.0 of this Section and Sections 6.20 and 8.05 of the NC ESCPDM, to the satisfaction of the Engineer, until the site has been stabilized. Permanent diversions shall be designed, installed and maintained in accordance with Part 3.0 of this Section and Sections 6.21 and 8.05 of the NC ESCPDM. The cost of temporary and permanent diversions shall include the excavation, grading, materials, etc. and all maintenance and restoration activities required.

2.07 TEMPORARY SLOPE DRAINS

- A. Temporary slope drains shall be constructed as shown on the Contract Drawings, at other locations indicated by the Engineer, as specified herein, and as detailed in Section 6.32 of the NC ESCPDM. Temporary slope drains are used to convey concentrated runoff down the face of a slope without causing erosion and are generally used in conjunction with temporary diversions.
- B. The pipe diameter for temporary slope drains shall be selected according to Table 6.32a of the NC ESCPDM. The pipe shall be heavy-duty flexible material such as non-perforated, corrugated plastic pipe or specially designed flexible tubing.
- C. Temporary slope drains shall be designed, installed and maintained in accordance with Part 3.0 of this Section and Section 6.32 of the NC ESCPDM, to the satisfaction of the Engineer, until the site has been stabilized. The cost of the temporary slope drains shall include the piping, earthwork, stone for erosion control, and all maintenance activities required. Temporary slopes drains shall be removed from site and the materials disposed of in an approved manner once final stabilization has been achieved.

2.08 TEMPORARY GRAVEL CONSTRUCTION ENTRANCES/EXITS

- A. Temporary gravel construction entrances/exits shall be located at points where vehicles enter and leave a construction site, at other locations indicated by the Engineer, as specified herein, and as detailed in Section 6.06 of the NC ESCPDM.
- B. Temporary gravel construction entrances/exits shall be constructed with a minimum 6-inch layer of 2 – 3 inch washed stone placed over a stable foundation and shall be a minimum of 100 feet in length and 25 feet in width. Geotextile fabric shall be used under stone as shown on the Contract Drawings.
- C. Temporary gravel construction entrances/exits shall be designed, installed and maintained in accordance with Part 3.0 of this Section and Section 6.06 of the NC ESCPDM, to the satisfaction of the Engineer, until the site has been stabilized. The cost of temporary gravel construction entrances/exits shall include the materials, including the application of additional stone, tire washing, and other maintenance as may be necessary. Temporary gravel construction entrances/exits shall be removed from site and the materials disposed of in an approved manner once final stabilization has been achieved.

2.09 TEMPORARY AND PERMANENT STABILIZATION OF DISTURBED AREAS

- A. Temporary and permanent stabilization of disturbed areas will be provided at the locations shown on the Contract Drawings, at other locations indicated by the Engineer, as specified herein, and as detailed in Sections 6.10, 6.11, 6.12 and 6.14 of the NC ESCPDM. The Contractor shall provide ground cover adequate to restrain erosion on disturbed areas that will be left un-worked for periods exceeding 7 to 14 days, as noted in Paragraph 1.01. F. of this Specification.
- B. Soil amendments, including lime and fertilizer, shall be as detailed in Sections 6.10, 6.11 and 6.12 of the NC ESCPDM.
- C. Seed mixtures shall be selected based on site location and seasonal recommendations outlined in Sections 6.10 and 6.11 of the NC ESCPDM. Sod shall be selected based on site location and intended use as outlined in Section 6.12 of the NC ESCPDM.
- D. Mulch shall be as detailed in Section 6.14 of the NC ESCPDM. RECMs shall be as detailed in 2.05 herein and in Section 6.17 of the NC ESCPDM.
- E. Temporary soil stabilizer shall consist of an especially prepared highly concentrated powder which, when mixed with water, forms a thick liquid such as "Enviroseal 2001" by Enviroseal Corporation, "Terra Control" by Quattro Environmental, Inc., or "CHEM-CRETE ECO-110" by International CHEM-CRETE Corporation, and having no growth or germination inhibiting factors. The agent shall be used for hydroseeding grass seed in combination with other approved amendments resulting in a highly viscous slurry which, when sprayed directly on the soil, forms a gelatinous crust.

- F. Temporary and permanent stabilization of disturbed areas shall be achieved in accordance with Part 3.0 of this Section and Sections 6.10, 6.11, 6.12, 6.14 and 6.17 of the NC ESCPDM. The cost of temporary and permanent stabilization of disturbed areas shall include all grading, excavation, materials, and all reseeding and other maintenance activities required until stabilization is achieved.

2.10 CHECK DAMS AND CHECK DAMS WITH WEIRS

- A. Check dams shall be constructed at the locations shown on the Contract Drawings, at other locations indicated by the Engineer, as specified herein, and as detailed in Section 6.83 of the NC ESCPDM. Check dams with weirs shall be constructed at the locations shown on the Contract Drawings, at other locations indicated by the Engineer, as specified herein, and as detailed in Section 6.87 of the NC ESCPDM.
- B. Check dams and check dams with weirs shall not be constructed in an intermittent or perennial stream. The drainage area for any one check dam or check dam with weir shall be limited to ½ acre.
- C. Dimensions shall be as shown on the Contract Drawings. Check dams shall be constructed of stone or riprap with filter fabric, fiber filtration tubes, or sediment logs, as indicated on the Contract Drawings. Check dams with weirs shall be constructed of stone or riprap with filter fabric. Material specifications for stone, riprap, fiber filtration tubes, and sediment logs appear herein. If Manufacturer's recommendations are more stringent, they shall supersede. Filter fabric shall be Type II Separator Geotextile, as specified in Section 31 05 19 – Geotextiles.
- D. Check dams shall be designed, installed and maintained in accordance with Part 3.0 of this Section and Section 6.83 of the NC ESCPDM. Check dams with weirs shall be designed, installed and maintained in accordance with Part 3.0 of this Section and Section 6.87 of the NC ESCPDM. The cost of check dams and check dams with weirs shall include all excavation, grading, materials, and all maintenance activities required. Check dams shall be removed from site and the materials disposed of in an approved manner once final stabilization has been achieved.

2.11 INLET EROSION CONTROL MEASURES

- A. Yard, Curb and other Inlet Erosion Control Measures shall be constructed at the locations shown on the Contract Drawings, at other locations indicated by the Engineer, as specified herein, and as detailed in Sections 6.50 through 6.55 of the NC ESCPDM. Inlet erosion control measures shall be used to prevent or limit the introduction of sediment to storm drain systems and allow early use of the of the storm drainage system. Maximum drainage areas for inlet erosion control measures vary from 1 acre for excavated drop inlet protection, hardware & cloth gravel inlet protection, and block and gravel inlet protection to more than 5 acres for rock pipe inlet protection. In addition to the inlet protection measures described in the NC ESCPDM, other measures may be

specified by the Engineer. For measures not detailed in the NC ESCPDM, the materials will be as specified by the Engineer's and Manufacturer's instructions, with more stringent specifications superseding.

- B. Materials for Inlet Erosion Control Measures consist of silt fence, riprap, stone (gravel), hardware wire, sod, concrete blocks, and sediment logs. Riprap and stone for erosion control shall be as specified herein. Hardware wire shall be as specified in Section 6.51 of the NC ESCPDM. Sod shall conform to the specifications set forth in Section 6.12 of the NC ESCPDM. Concrete blocks shall be as specified in Section 6.52 of the NC ESCPDM. Material specifications for sediment logs appear within. If Manufacturer's recommendations are more stringent, they shall supersede.
- C. Inlet Erosion Control Measures shall be designed, installed, and maintained in accordance with Part 3.0 of this Section and **Sections** 6.50 through 6.55 of the NC ESCPDM. Measures not described in the NC ESCPDM shall be designed, installed, and maintained in accordance with the Engineer's and Manufacturer's instructions, with more stringent instructions superseding. The cost of inlet erosion control measures shall include all excavation, grading, materials, and all maintenance activities required. Inlet Control Measures shall be removed from site and the materials disposed of in an approved manner once final stabilization has been achieved.

2.12 FIBER FILTRATION TUBES (FFTS)

- A. FFTs shall be installed at the locations shown on the Contract Drawings, at other locations indicated by the Engineer, and as specified herein.
- B. FFTs shall consist of straw, wood, or coconut fibers, with or without performance-enhancing polymers, encased with cylindrical tubes composed of a heavy-duty, loose-weave, biodegradable natural-fiber netting made of burlap, jute, or coir. The netting shall be oriented in a diamond or hexagonal pattern and shall move freely at all fiber intersections (Leno weave, or equal).
- C. FFTs shall be designed, installed, and maintained as specified herein. If Manufacturer's recommendations are more stringent, they shall supersede. The cost of FFTs shall include all excavation, grading, materials, and all maintenance activities required. FFT's shall be removed from site and the materials disposed of in an approved manner once final stabilization has been achieved.

2.13 TEMPORARY AND PERMANENT CHANNELS

- A. Temporary and permanent channels shall be installed at the locations shown on the Contract Drawings, at other locations indicated by the Engineer, as specified herein, and as detailed in Sections 6.30, 6.31 and 8.05 of the NC ESCPDM. Temporary and permanent channels shall be used to convey concentrated runoff without damage from erosion, deposition or flooding.

- B. Temporary and permanent channels shall be designed, installed and maintained in accordance with Part 3.0 of this Section and Sections 6.30, 6.31 and 8.05 of the NC ESCPDM. The cost of all temporary and permanent channels shall include all excavation, grading, materials, and all maintenance activities required.

2.14 TEMPORARY SEDIMENT TRAPS, SEDIMENT BASINS, AND SKIMMER SEDIMENT BASINS

- A. Temporary sediment traps shall be constructed as shown on the Contract Drawings, at the termination of all temporary diversions diverting sediment laden runoff, at other locations indicated by the Engineer, as specified herein, and as detailed in Section 6.60 of the NC ESCPDM. These temporary measures shall not be constructed within an intermittent or perennial stream and shall be installed prior to any land disturbance activities within the drainage area. Temporary sediment traps shall be constructed by excavating the appropriate size rectangular basin and constructing a rock-fill dam on the discharge end. Where specific elevations are not indicated on the Contract Drawings, Contractor shall maintain basins at the depths shown below working grades.
- B. Sediment basins shall be installed at the locations shown on the Contract Drawings, at other locations indicated by the Engineer, as specified herein, and as detailed in Sections 6.61 and 8.07 of the NC ESCPDM. Skimmer sediment basins shall be installed at the locations shown on the Contract Drawings, at other locations indicated by the Engineer, as specified herein, and as detailed in Section 6.64 of the NC ESCPDM. Sediment basins and skimmer sediment basins shall be used where drainage areas are too large for temporary sediment traps. Outlet structures must withdraw from basin surface unless drainage area is less than 1 acre. They shall retain sediment on the site and prevent off site sediment in waterways, and they shall not be located in intermittent or perennial streams. Sediment basins and skimmer sediment basins shall be installed prior to any land disturbance activities within the drainage area.
- C. Porous baffles shall be installed in temporary sediment traps, sediment basins, and skimmer sediment basins as shown on the Contract Drawings, at other locations indicated by the Engineer, as specified herein, and as detailed in Section 6.65 of the NC ESCPDM. Porous baffles are used to reduce the velocity and turbulence of the water flowing through the structure and to facilitate the settling of sediment in the water before discharge. They effectively spread the flow across the entire width of a structure.
- D. Material used for porous baffles shall be as indicated on the Contract Drawings. Typical materials include silt fence, coir erosion blanket, coir mesh, and tree protection fence. Other materials may be used as noted on the Contract Drawings and indicated by the Engineer.
- E. The structure life for temporary sediment traps shall be limited to 2 years. Temporary sediment traps shall be spaced to limit the maximum tributary drainage area to 5 acres. The basin life of sediment basins and skimmer sediment basins shall be limited to 3

years unless they are designed as permanent structures. The drainage area for sediment basins and skimmer sediment basins shall be limited to 100 acres.

- F. The principal spillway for sediment basins shall consist of a riser and barrel. Ensure that the pipe is capable of withstanding the maximum expected load without yielding, buckling, or cracking. The basin should be provided with a skimmer or flashboard riser to dewater the basin from the water surface. The emergency spillway shall be constructed in undisturbed soil. The principal spillway outlet and emergency spillway shall be stabilized as shown on the Contract Drawings. Materials shall be as noted on the Contract Drawings.
- G. The principal spillway for skimmer sediment basins shall consist of a skimmer which dewater the basin from the top of the water surface at a controlled rate. A dewatering rate of 24 to 72 hours is required. The skimmer outlet pipe shall be capable of withstanding the maximum expected load without yielding, buckling, or cracking. The emergency spillway shall be constructed in undisturbed soil whenever possible and shall be lined with impermeable geotextile fabric in accordance with Section 31 05 19 – Geotextiles. The principal spillway outlet and emergency spillway shall be stabilized as shown on the Contract Drawings.
- H. Temporary sediment traps shall be designed, constructed and maintained in accordance with Part 3.0 of this Section and Section 6.60 of the NC ESCPDM, to the satisfaction of the Engineer, until the sediment producing areas have been permanently stabilized. The cost of the temporary sediment traps shall include the excavation, grading, fill, baffles, stone for erosion control, washed stone, geotextile, etc. and all maintenance activities required.
- I. Sediment basins shall be designed, installed and maintained in accordance with Part 3.0 of this Section and Sections 6.61 and 8.07 of the NC ESCPDM. Skimmer sediment basins shall be designed, installed and maintained in accordance with Part 3.0 of this Section and Section 6.64 of the NC ESCPDM. The cost of sediment basins and skimmer sediment basins shall include all excavation, grading, materials, and all maintenance activities required.
- J. Porous baffles shall be designed, installed and maintained in accordance with Part 3.0 of this Section and Section 6.65 of the NC ESCPDM. The cost of porous baffles shall include all excavation, grading, materials, and all maintenance activities required.

2.15 OUTLET STABILIZATION STRUCTURE

- A. Outlet stabilization structures shall be constructed at the locations shown on the Contract Drawings, at other locations indicated by the Engineer, as specified herein, and as detailed in Sections 6.41 and 8.06 of the NC ESCPDM. These structures shall be used where the discharge velocity of the upstream water conveyance structure exceeds the permissible velocity of the receiving channel or disposal area.

- B. Structures shall be sized for a capacity equivalent to a 10-year, peak runoff or design discharge of the water conveyance structure, whichever is greater. Riprap materials shall be as specified on the Contract Drawings. Filter fabric shall be Type II Separator Geotextile, as specified in Section 31 05 19 – Geotextiles.
- C. Outlet stabilization structures shall be designed, installed, and maintained in accordance with Part 3.0 of this Section and Sections 6.41 and 8.06 of the NC ESCPDM. The cost of outlet stabilization structures shall include all excavation, grading, materials, and all maintenance activities required.

2.16 TREE PROTECTION FENCE

- A. Tree protection fence shall be installed at the locations shown on the Contract Drawings, at other locations indicated by the Engineer, as specified herein, and as detailed in Section 6.05 of the NC ESCPDM.
- B. Tree protection fence shall be used to protect trees and their root zones during construction. Tree protection fence shall be brightly-colored, UV-resistant poly barricade fabric. Signs designating the area as protected shall be installed on all sides of the fence. Wording and spacing of the signage shall be as indicated on the Contract Drawings.
- C. Tree protection fence shall be installed and maintained in accordance with Part 3.0 of this Section and Section 6.05 of the NC ESCPDM. The cost of tree protection fence shall include all materials as well as all maintenance activities required.

2.17 FILTER BAGS

- A. Temporary filter bag sediment control bags for use in dewatering and retaining sediment pumped out of active 'dirty' project areas, such as stream restoration projects, where water is pumped from work area, sent through the bag and flow is then released from the bag to discharge on a stable flood plain or other secure area.
- B. The filter bag shall be a nonwoven bag which is sewn with a double needle matching using a high strength thread. The dewatering bag must be made of non-woven geotextile with a minimum surface area of 225 square feet per side. Each sack is required to have a fill spout large enough to accommodate a 4-inch discharge hose. Straps are to be attached such that the hose is secure, and the hose prevents pumped water from escaping without being filtered.
- C. The geotextile fabric shall be non-woven and shall meet the following properties:

Properties	Test Method	Units	Value
Weight	ASTM D-3776	Oz/yd	12

Properties	Test Method	Units	Value
Grab Tensile	ASTM D-4632	lbs	300
Puncture	ASTM D-4833	lbs	180
Flow Rate	ASTM D-4491	gal/min/ft ²	75
Permittivity	ASTM D-4491	sec ⁻¹	1.1
Mullen Burst	ASTM D-3786	psi	550
UV Resistant	ASTM D-4355	%	70
AOS% Retained	ASTM D-4751	%	100

2.18 DEWATERING SUMPS

- A. This section includes installation of temporary sump pits from which pumping is conducted to remove excess water while minimizing sedimentation. The sump pit filters water being pumped to reduce sedimentation. Further sedimentation may be reduced when flow is pumped to a filter bag (if required) as part of the Contract Drawings.
- B. Non-woven Geotextile: Per Section 31 05 19 – Geotextiles.
- C. Stone: Shall be #57 clean gravel stone (3/4 to 1.5-inch max diameter).
- D. Hardware Cloth: Shall be one-quarter (1/4) inch metal hardware cloth.
- E. Standpipe to be twelve (12) to thirty-six (36) inch diameter perforated high density polyethylene (HDPE), polyvinyl chloride (PVC), or corrugated metal pipe (CMP) as per the Construction Documents and site conditions, with ½ inch by six (6) inch slits or one (1) inch diameter holes, six (6) inches on center. Bottom of pipe to have a watertight cap or plate attached.

PART 3 – EXECUTION

3.01 INSTALLATION AND MAINTENANCE

- A. All installation and maintenance shall be conducted in accordance with this specification and the NC ESCPDM. In the event of a discrepancy between this specification, Manufacturer's recommendations and the NC ESCPDM, the more stringent requirements shall take precedence.
- B. If applicable, all requirements of the NPDES Permit shall be followed. In the event of a discrepancy between this specification and the NPDES Permit requirements, the more stringent requirements shall take precedence.

- C. If possible, erosion and sedimentation control devices shall be established prior to clearing operations in a given area. Where such practice is not feasible, the erosion and sedimentation control device(s) shall be established concurrent with the clearing operations or immediately following completion of the clearing operations.
- D. The Contractor shall furnish the labor, materials and equipment required for routine maintenance of all erosion and sedimentation control devices. At a minimum, maintenance shall be scheduled as required for a particular device to maintain the removal efficiency and intent of the device. Note that specific maintenance intervals for various measures and practices are specified within the NC ESCPDM. Of the maintenance requirements specified herein and in the NC ESCPDM, the more stringent shall take precedence for each and every sediment and erosion control measure utilized on the site. Maintenance shall include but not be limited to 1) the removal and satisfactory, legal disposal of accumulated sediment from traps or silt barriers and 2) replacement of filter fabrics used for silt fences and stone impaired by sediment in stone filters, gravel construction entrances, etc. Maintenance as noted in items 1) and 2) above shall be performed as required, and at least once every 3 months for the duration of construction activities. Sediment removed from erosion and sedimentation control devices shall be disposed of in locations that will not result in off-site sedimentation as acceptable to the Engineer, at no additional cost to the Owner. If no suitable on-site locations are available, all such sediment will be legally disposed of off site, at no additional cost to the Owner.

3.02 SILT FENCE

- A. Silt Fence shall be designed, installed and maintained in accordance with the requirements of Section 6.62 of the NC ESCPDM. Silt fence shall be erected at the locations shown on the Contract Drawings and at all other locations as may be directed by the Engineer. Silt fence shall be erected and maintained to the satisfaction of the Engineer until a vegetative ground cover has been established. Replacement of the filter fabric and its associated appurtenances, if required by the Engineer, will be at the Contractor's expense.
- B. Silt fence shall not be installed across streams, ditches, waterways or other areas of concentrated flow. Silt fence shall be placed at least 6 feet beyond the toe of slope of any embankment or stockpile area to allow space for ponding and maintenance access.
- C. Dig a trench approximately 8 inches deep and 4 inches wide and place the fabric in the bottom of the excavated ditch or use the slicing method to insert the fabric into a cut sliced in the ground with a disc. Ensure that the height of the sediment fence does not exceed 24 inches above the ground surface.
- D. Install posts 4 feet apart in critical areas and 6 feet apart on standard applications when extra strength filter fabric is used. When wire mesh support is used, posts shall be

installed a maximum of 8 feet apart. Install posts 2 feet deep on the downstream side of the silt fence, as close as possible to the fabric.

- E. Joints should be avoided along the fencing. When joints are necessary, securely fasten the filter cloth only at a support post with 4 feet minimum overlap to the next post.
- F. Compaction is vitally important for effective results. Compact the soil immediately next to the silt fence fabric with the front wheel of the tractor, skid steer or roller exerting at least 60 pounds per square inch. Compact the upstream side first and then each side twice for a total of 4 trips.
- G. Stabilized outlets for silt fence shall be provided at locations shown on the Contract Drawings. The outlet section shall have a maximum width of 4 feet. The height of silt fence at the outlet shall be a maximum of 1 foot. A 5 foot x 5 foot (minimum) apron of #57 washed stone shall be provided on the downstream side of the silt fence outlet.
- H. Silt fence shall be erected around all catch basins which are located downstream from any construction work unless other inlet protection is specified. Should any catch basins be indicated to be relocated or modified, silt fence shall be utilized until work is completed on the catch basins. Upon completion of the modification, the area shall be rough graded, as shown on the Contract Drawings, until the end of the project, at which time final grading shall occur.
- I. Inspect silt fence at least once a week and after each rainfall event. Make any required repairs immediately.
- J. Should the fabric of any silt fence collapse, tear, decompose or become ineffective, replace it promptly. All fabric shall be replaced after the first 6 months of construction activity and every 6 months thereafter until construction activities are complete, unless otherwise directed by the Engineer.
- K. Remove sediment deposits as necessary to provide adequate storage volume for the next rain and to reduce pressure on the fence. Take care to avoid undermining the fence during cleanout.
- L. Remove all fencing materials and unstable sediment deposits and bring the area to grade and stabilize it after the contributing drainage area has been properly stabilized. Removal of any silt fence shall be permitted only with the prior approval of the Engineer or the local governing agency.

3.03 STONE FOR EROSION CONTROL

- A. Stone for erosion control shall be designed, installed, and maintained in accordance with the requirements of Section 6.15 of the ESCPDM. Stone for erosion control shall be dumped and placed in such manner that the larger rock fragments are uniformly distributed throughout the rock mass and the smaller fragments fill the voids between the

larger fragments. Rearranging of individual stones by equipment or by hand shall only be required to the extent necessary to secure the results specified above, to protect structures from damage when rock material is placed against the structures, or to protect the underlying Separator Geotextile from damage during installation.

- B. Inspect at least weekly and within 24 hours after any storm event of greater than 1 inch of rain per 24-hour period. Remove accumulated sediment and replace stone impaired by sediment as necessary.

3.04 RIPRAP

- A. Riprap shall be designed, installed and maintained in accordance with the requirements of Section 6.15 of the NC ESCPDM. Riprap shall be graded so that the smaller stones are uniformly distributed through the mass. The Contractor may place the stone by mechanical methods, augmented by hand placing where necessary or ordered by the Engineer. The placed riprap shall form a properly graded, dense, neat layer of stone. The placed riprap shall have a minimum depth of 24 inches unless otherwise specified by the Engineer. Type II Separator Geotextile, as specified in Section 31 05 19 – Geotextiles, shall be used under all riprap unless otherwise noted.
- B. Inspect periodically for scour or dislodged stones. Control of weed and brush growth may be needed.

3.05 ROLLED EROSION CONTROL MATTING (RECM)

- A. RECMs shall be designed, installed and maintained in accordance with the requirements of Section 6.17 of the NC ESCPDM. The Engineer may direct the Contractor to place RECMs in permanent channels or on slopes at other locations in addition to those shown on the Contract Drawings. If Manufacturer's instructions are more stringent, they shall supersede.
- B. The Contractor shall place the RECMs where directed immediately after the channel or slope has been properly graded and, if applicable, prepared, fertilized, and seeded.
- C. Grade the surface of the installation area so that the ground is smooth and loose. When seeding prior to installation, follow the steps in Section 6.10 (Temporary Seeding) and 6.11 (Permanent Seeding) of the NC ESCPDM as applicable. Remove all large rocks, debris, etc. so as to ensure that good contact between the RECM and the ground is maintained so that no erosion occurs beneath the RECM. Terminal anchor trenches are required at RECM ends and intermittent trenches must be constructed across channels at 25-foot intervals. Terminal anchor trenches should be a minimum of 12 inches in depth and 6 inches in width, while intermittent trenches should be a minimum of 6 inches deep and 6 inches wide. Take care to maintain direct contact between the soil and the RECM.

- D. For slope installation, place RECM 2-3 feet over top of slope and into an approximately 12 inch deep by 6 inch wide excavated end trench. Using staples, stakes, or pins, anchor the RECM at 1 foot intervals along the bottom of the trench, backfill, and compact. Along the slope, pin the RECM in a 3 foot center-to-center pattern; provide a minimum 3 inch overlap for adjacent rolls.
- E. For channel installations, excavate 12 inch deep by 6 inch wide terminal trenches across the upper and lower end of the lined channel. Anchor the RECM at a minimum of 25 foot intervals utilizing either two rows of anchors or 6 inch by 6 inch cross trenches. Bury outside RECM edges in longitudinal trenches 6 inches deep and wide along the channel edges. Pin the RECM in at 1 foot intervals along the bottom of terminal trenches, backfill, and compact. Overlap adjacent rolls a minimum of 3 inches and pin at 1 foot intervals. Place the first RECM at the downstream end of the channel and unroll upstream. When starting installation of a new roll, begin in a trench or shingle-lap ends of rolls a minimum of 1 foot with upstream RECM on top to prevent uplifting.
- F. Staples, stakes, and pins shall be driven so that the top is flush with the ground.
- G. During the establishment period, check RECMs at least weekly and within 24 hours after any storm event of greater than 1 inch of rain per 24-hour period. Immediately make repairs. Good contact with the ground must be maintained. Monitor and repair the RECM as necessary until ground cover is established.

3.06 TEMPORARY AND PERMANENT DIVERSIONS

- A. Temporary diversions shall be designed, installed and maintained in accordance with the requirements of Sections 6.20 and 8.05 of the NC ESCPDM. Permanent diversions shall be designed, installed, and maintained in accordance with the requirements of Sections 6.21 and 8.05 of the NC ESCPDM. The Contractor shall provide temporary and permanent diversions at all locations noted on the Contract Drawings and at all other locations as may be directed by the Engineer.
- B. Remove and properly dispose of all trees, debris, etc. Fill and compact all ditches, swales, etc. that will be crossed to natural ground level or above.
- C. Excavate, shape and stabilize diversions as shown on the Contract Drawings and described herein. Unless otherwise noted, provide vegetative stabilization immediately after installation of permanent diversions. Temporary diversions that are to serve longer than 7 working days shall be seeded and mulched as soon as they are constructed to preserve dike height and reduce maintenance. Seed and mulch disturbed areas draining into the diversions within 14 calendar days of completing any phase of grading.
- D. For temporary diversions, ensure that the top of the dike is not lower at any point than the design elevation plus the specified settlement. Provide sufficient room around temporary diversions to permit machine re-grading and cleanout. Vegetate the ridge of

temporary diversions immediately after construction unless they will remain in place less than 7 working days.

- E. Provide outlet protection adequate to accept flow from diversion plus any other contributing runoff. Sediment-laden runoff shall be routed through a sediment-trapping device.
- F. Inspect temporary diversions once a week and after every rainfall event. Immediately remove sediment from the flow area and repair the diversion ridge. Carefully check outlets and make timely repairs as needed. When the area protected is permanently stabilized, remove the ridge and the channel to blend with the natural ground level and appropriately stabilize it. Inspect permanent diversions weekly and after every rainfall event during construction operations until permanent vegetation is established. After vegetation is established, inspect after major storms. Immediately remove any debris and make repairs as needed in a timely manner. Maintain healthy vegetation at all times.

3.07 TEMPORARY SLOPE DRAINS

- A. Temporary slope drains shall be designed, installed and maintained in accordance with the requirements of Section 6.32 of the NC ESCPDM. The Contractor shall provide temporary slope drains with inlet and outlet protection and associated diversion channels at all locations noted on the Contract Drawings, and at other locations as may be directed by the Engineer.
- B. Place slope drains on undisturbed soil or well compacted fill. Slightly slope the section of pipe under the dike toward its outlet. Hand-tamp the soil under and around the entrance section in lifts not to exceed 6 inches.
- C. Ensure that all slope drain connections are watertight. Ensure that all fill material is well-compacted. Securely fasten the exposed section of the drain with grommets or stakes spaced no more than 10 feet apart. Extend the drain beyond the toe of the slope and provide outlet protection.
- D. Immediately stabilize all disturbed areas following construction.
- E. Inspect the temporary slope drain, inlet and outlet protection, and supporting diversions weekly and after every rainfall event and promptly make any necessary repairs. When the protected area has been permanently stabilized, temporary measures may be removed, materials disposed of properly, and all disturbed areas stabilized appropriately.

3.08 TEMPORARY GRAVEL CONSTRUCTION ENTRANCES/EXITS

- A. Temporary gravel construction entrances/exits shall be designed, installed and maintained in accordance with the requirements of Section 6.06 of the NC ESCPDM. The Contractor shall provide temporary gravel construction entrances/exits at all

locations noted on the Contract Drawings and at all other locations as may be directed by the Engineer.

- B. Maintain the gravel pad as specified in Section 6.06 of the NC ESCPDM and in a condition to prevent mud or sediment from leaving the construction site. This may require periodic topdressing with 2 – 3 inch stone. Inspect each construction entrance at least weekly and after each rainfall event and replace stone impaired by sediment as necessary. Immediately remove all objectionable materials spilled, washed, or tracked onto public roadways.
- C. If, despite the use of a gravel construction entrance/exit, most of the mud and sediment are not removed from vehicle tires, tire washing may be necessary as detailed in Section 6.06 of the NC ESCPDM. If necessary, this shall be done at no additional cost to the Owner.

3.09 TEMPORARY AND PERMANENT STABILIZATION OF DISTURBED AREAS

- A. The Contractor shall temporarily stabilize disturbed areas that will not be brought to final grade within 14 calendar days unless as noted in Paragraph 1.01 F. of this Section. Temporary seeding shall be applied on areas that include diversions, dams, temporary sediment basins, temporary road banks and topsoil stockpiles. Areas to be stabilized with permanent vegetation must be seeded or planted within 14 working days after final grade is reached, unless temporary stabilization is applied. Temporary seeding provides protection for no more than 1 year, after which permanent stabilization should be initiated.
- B. Complete grading before preparing seedbeds and install all necessary erosion control measures. Minimize steep slopes. If soils become compacted during grading, loosen to a depth of 6-8 inches.
- C. Reseed and mulch temporary seeding areas where seedling emergence is poor, or where erosion occurs, as soon as possible. Do not mow. Protect from traffic as much as possible.
- D. Refer to Section 6.10 of the NC ESCPDM for additional information and specifications regarding seedbed requirements, plant selection, seeding and mulching for temporary seeding applications.
- E. The operation of equipment is restricted on slopes steeper than 3:1. Provisions for vegetation establishment can be made during final grading. Vegetation chosen for these sites must not require mowing or other intensive maintenance. Good mulching practices are critical for protecting against erosion on steep slopes.
- F. Generally, a stand of vegetation cannot be determined to be fully established until soil cover has been maintained for one full year from planting. Inspect seeded areas for failure and make necessary repairs and reseedings within the same season, if possible.

- G. Reseeding – If a stand has inadequate cover, re-evaluate choice of plant materials and quantities of lime and fertilizer. Re-establish the stand after seedbed preparation or overseed the stand. Consider seeding temporary, annual species if the time of year is not appropriate for permanent seeding.
- H. If vegetation fails to grow, soil must be tested to determine if acidity or nutrient imbalance is responsible.
- I. Fertilization - On the typical disturbed site, full establishment usually requires re-fertilization in the second growing season. Fine turf requires annual maintenance fertilization. Use soil tests if possible or follow the guidelines given for the specific seeding mixture.
- J. Refer to Section 6.11 of the NC ESCPDM for additional information and specifications regarding seedbed requirements, plant selection, seeding and mulching for permanent seeding applications.
- K. Refer to Section 6.12 of the NC ESCPDM for additional information and specifications regarding soil preparation, sod selection, installation, and maintenance for sodding.
- L. Inspect all seeded areas weekly and after heavy rains until permanent cover is established. Inspect within 6 weeks of planting to see if stands are adequate. Fertilize, reseed and mulch damaged and sparse areas immediately.

3.10 CHECK DAMS AND CHECK DAMS WITH WEIRS

- A. Check dams shall be designed, installed and maintained in accordance with the requirements of Section 6.83 of the NC ESCPDM. Check dams with weirs shall be designed, installed and maintained in accordance with the requirements of Section 6.87 of the NC ESCPDM. The Contractor shall provide check dams or check dams with weirs at all locations noted on the Contract Drawings and at all other locations as may be directed by the Engineer.
- B. Stone shall be placed on a filter fabric foundation. Center stone shall be at least 9 inches below natural ground level and stone shall extend 1.5 feet beyond ditch bank.
- C. For check dams with weirs, provide an apron with a length 3 times the height of the dam and a width a minimum of 4 feet. A 12-inch layer (minimum) of sediment control stone shall be placed on the upstream side of the dam. Excavate sediment storage area to the dimensions shown on the Contract Drawings.
- D. Fiber filtration tubes and sediment logs may be specified for use as check dams. These measures shall be installed according to instructions included herein. If Manufacturer's recommendations are more stringent, they shall supersede.

- E. Spacing shall be such that the elevation of the top of the lower dam is the same as the toe elevation of the upper dam.
- F. Check dams and check dams with weirs shall be inspected at least weekly and within 24 hours after any storm event of greater than 1 inch of rain per 24-hour period. Sediment, limbs and other debris shall be cleared from the channel. Repairs shall be made immediately.

3.11 INLET EROSION CONTROL MEASURES

- A. Inlet erosion control measures shall be designed, installed and maintained in accordance with the applicable requirements of Sections 6.50 through 6.55 of the NC ESCPDM. If inlet erosion control measures shown on the Contract Drawings are not included in the NC ESCPDM, Engineer's and Manufacturer's instructions for design, installation, and maintenance shall be followed, with more stringent instructions superseding. The Contractor shall provide inlet erosion control measures at all locations noted on the Contract Drawings, and at all other locations as may be directed by the Engineer.
- B. Excavated drop inlet protection shall be installed and maintained in accordance with Section 6.50 of the NC ESCPDM. Drainage area is limited to 1 acre. The minimum volume of excavated area around the drop inlet is 1800 ft³/acre disturbed. Minimum depth of the excavated area shall be 1 foot and maximum depth shall be 2 feet as measured from the crest of the inlet structure. Weep holes shall be protected by gravel. Inspect the excavated basin at least weekly and after every storm event until the contributing drainage area has been permanently stabilized. Remove sediment when the storage volume has been reduced by one-half.
- C. Block and gravel inlet protection shall be installed and maintained in accordance with Section 6.52 of the NC ESCPDM. Drainage area shall be limited to 1 acre unless site conditions allow for frequent removal of accumulated sediment. The height of the block barrier shall be no more than 12 inches and no less than 24 inches. On the bottom row, place some of the blocks on their side to allow for dewatering. Place wire mesh over all block openings to hold gravel in place. Lateral support may be provided by placement of 2 x 4 wood studs through block openings. Place gravel 2 inches below the top of the block barrier. The top elevation of the structure must be at least 6 inches below the ground elevation downslope from the inlet to ensure that all stormwater flows over the structure and enters the storm drain instead of bypassing the structure. Block and gravel inlet protection shall not be used near the edge of fill material and shall not divert water away from the storm drain. Inspect at least weekly and after every storm event until the contributing drainage area has been permanently stabilized. Remove sediment as necessary to provide adequate storage volume for subsequent rains. Replace stone as needed.

- D. Rock pipe inlet protection shall be installed and maintained in accordance with Section 6.55 of the NC ESCPDM. Rock pipe inlet protection may be used at pipes with a maximum diameter of 36 inches. It shall not be installed in intermittent or perennial streams. The minimum crest width of the riprap berm shall be 3 feet, with a minimum bottom width of 11 feet and minimum height of 2 feet. The top of the riprap shall be 1 foot lower than the shoulder of the embankment or diversions. The outside face of the riprap should be covered with a 12-inch thick layer of #5 or #57 washed stone. The sediment storage area should be excavated upstream of the rock pipe inlet protection, with a minimum depth of 18 inches below grade. The rock pipe inlet protection shall be inspected at least weekly and after any storm event of greater than 1 inch of rain per 24-hour period. Repairs shall be made immediately. Remove sediment when the volume of the sediment storage area has been decreased by one-half and replace the contaminated part of the gravel facing.

3.12 FIBER FILTRATION TUBES (FFTS) AND SEDIMENT LOGS

- A. FFTs and sediment logs shall be placed along slopes to function as slope breaks and to minimize sediment transport and in diversions/channels to serve as check dams. The Contractor shall provide FFTs and sediment logs at all locations noted on the Contract Drawings, and at all other locations as may be directed by the Engineer.
- B. FFTs and sediment logs shall be installed to maintain contact with the soil surface. Install prior to seeding. May be installed before or after installation of RECMs.
- C. Anchor the upstream/upslope side of the FFTs using wire staples or approved devices at 1-foot intervals. Drive wooden stakes through downstream/downslope side of the FFTs at 2-foot intervals. Take care not to compress the FFTs. Backfill and compact loose soil against the upstream/upslope side. Overlap adjacent FFT ends by a minimum of 1 foot.
- D. For channel installation, construct anchor trench 3 inches deep by FFT diameter and place loose soil against upstream side of FFT. For channel gradients of 2%, install trenches on 25-foot intervals. Decrease interval distance with steeper channel gradients or more highly erosive soils.
- E. Any sediment accumulation at the base of the FFT must be removed when it reaches one-third of the height of the tube. FFT may need to be removed if fully loaded with captured sediment for maximum product performance. FFTs are to be left in place or removed from the site as directed by the Engineer.
- F. Sediment logs do not require installation trenches. Wood stakes shall be placed at least every 2 feet along the length of the sediment log. Stakes shall only penetrate the netting around the log. They shall not be driven through the center of the log. Sediment logs are to be left in place or removed from the site as directed by the Engineer.

- G. The FFTs and sediment logs shall be inspected at least weekly and within 24 hours after any storm event of greater than 1 inch of rain per 24-hour period. Look for signs of flow undercutting the logs. Re-anchor and replace as necessary.

3.13 TEMPORARY AND PERMANENT CHANNELS

- A. Temporary and permanent channels shall be designed, installed and maintained in accordance with the requirements of Sections 6.30, 6.31 and 8.05 of the NC ESCPDM. The Contractor shall provide temporary and/or permanent channels at all locations noted on the Contract Drawings, and at all other locations as may be directed by the Engineer.
- B. Remove all trees, brush, stumps, etc. from the channel area and dispose of properly.
- C. Excavate the channel to the dimensions shown on the plans, over-excavating to allow for liner thickness. Remove and properly dispose of all excess soil so that surface water may enter the channel freely.
- D. Armor the channel as specified on the Contract Drawings. If the specified channel lining requires an establishment period, protect the channel with mulch or a temporary liner sufficient to withstand anticipated velocities during this period.
- E. During the establishment period, inspect channels weekly and after every rainfall. After lining has been fully established, inspect channels after any storm event of greater than 1 inch of rain per 24-hour period. Immediately make repairs.
- F. Perform all channel construction to keep erosion and water pollution to a minimum. Immediately upon completion of the channel, vegetate all disturbed areas or otherwise protect them against soil erosion. Where channel construction will take longer than 7 days, stabilize channels by reaches.
- G. Inspect the channel outlet and all road crossings for bank stability and evidence of piping or scour holes. Give special attention to outlets and points where concentrated flow enters the channel.
- H. Maintain all vegetation adjacent to and in the channel in a healthy, vigorous condition to protect the area from erosion.
- I. Remove all significant sediment accumulations to maintain the designed carrying capacity.

3.14 TEMPORARY SEDIMENT TRAPS, SEDIMENT BASINS, AND SKIMMER SEDIMENT BASINS

- A. Temporary sediment traps shall be designed, installed and maintained in accordance with the requirements of Section 6.60 of the NC ESCPDM. Sediment basins shall be designed, installed and maintained in accordance with the requirements of Section 6.61

of the NC ESCPDM. Skimmer sediment basins shall be designed, installed and maintained in accordance with the requirements of Section 6.64 of the NC ESCPDM. The Contractor shall provide these structures at all locations shown on the Contract Drawings and at all other locations as may be directed by the Engineer.

- B. Care shall be taken to ensure that proper site preparation operations are conducted prior to trap or basin construction. Clear, grub and strip embankment location.
- C. A cut-off trench shall be excavated along the center line of the earth fill embankment for sediment basins and skimmer sediment basins. Keep the trench dry during backfilling and compaction operations.
- D. Fill material shall be free of roots, woody vegetation, rocks, and other objectionable materials. Fill shall be placed in 6 to 8-inch layers and compacted. Construct the embankment to an elevation 10 percent (minimum of 6 inches) higher than the design height to allow for settling.
- E. Inlets to the sediment traps and basins shall be constructed so as to prevent erosion. Use diversions to divert sediment-laden water to the upper end of the basin.
- F. Shape the sediment trap or basin to the specified dimensions.
- G. Following construction of the embankment, clear the sediment trap or basin area below the crest elevation of the spillway to facilitate sediment cleanout. Provide access for cleanout of accumulated sediment.
- H. Spillway/outlet configuration shall be constructed as specified below.
- I. Temporary sediment trap
 - 1. Construct riprap outlet in embankment. Use filter fabric or a keyway cutoff trench between the riprap and the soil to protect it from piping. The outlet weir must be level and constructed to grade to assure design capacity. Ensure that the stone spillway outlet extends downstream past the toe of the embankment until the outlet velocity is acceptable for the receiving stream.
 - 2. Provide emergency bypass in natural, stable areas, located so that flow will not damage the embankment.
- J. Sediment basin
 - 1. Securely attach the riser to the barrel or barrel stub to make a watertight structural connection. Secure all barrel connections with approved watertight assemblies. Install anti-seep collar(s) as noted on the Contract Drawings. Ensure that the pipe stays in firm contact with its foundation when compacting fill around the pipe. Do not use pervious material as backfill around the pipe. Anchor the riser to prevent

floatation. Install trash guard to prevent the riser and barrel from becoming clogged.

2. Install basin dewatering mechanism as noted on the Contract Drawings.
3. Install outlet protection as specified at principal spillway outlet. Install the emergency spillway in undisturbed soil and provide stabilization as specified.

K. Skimmer sediment basin

1. Excavate a shallow pit under the skimmer or provide a low support of stone or timber under the skimmer to prevent the skimming device from settling into the mud.
2. Place the barrel on a firm, smooth foundation of impervious soil. Do not use pervious material to backfill around the pipe. Ensure that the barrel stays in firm contact with its foundation when compacting fill around the pipe.
3. Assemble the skimmer following the Manufacturer's instructions, or as designed.
4. Lay the assembled skimmer on the bottom of the basin with the flexible joint at the inlet of the barrel pipe. Attach the flexible joint to the barrel pipe and position the skimmer over the excavated pit or support. Attach a rope to the skimmer and anchor it to the side of the basin so that the skimmer may be pulled to the side for maintenance.
5. Install the spillway in undisturbed soil to the greatest extent possible and line with laminated plastic or impermeable geotextile fabric. Anchor the edges of the fabric in a trench with staples or pins. Install outlet protection as specified at the principal spillway outlet.

L. Install porous baffles in temporary sediment traps, sediment basins, and skimmer sediment basins as shown on the Contract Drawings and as specified herein. Porous baffles shall be designed, installed and maintained in accordance with the requirements of Section 6.65 of the NC ESCPDM. The Contractor shall provide porous baffles at all locations noted on the Contract Drawings, and at all other locations as may be directed by the Engineer.

1. Care shall be taken when installing porous baffles so they perform as designed. Baffle material shall be secured at the bottom and sides of sediment trap or basin. Fabric shall not be spliced but a continuous piece shall be used across the trap or basin.
2. Install at least three rows of baffles between the inlet and outlet discharge point. Sediment traps and basins less than 20 feet in length may use 2 baffles.

3. Posts or sawhorses shall be installed across the width of the sediment trap or basin unless an alternate baffle configuration is shown on the Contract Drawings. Steel posts shall be driven to a depth of 24 inches, spaced a maximum of 4 feet apart. Baffle weirs shall be installed at locations and according to details on the Contract Drawings. Except in locations of baffle weirs, the top of the fabric shall be 6 inches higher than the invert of the spillway and 2 inches lower than the top of the berms.
- M. Sediment traps and basins shall be constructed so that the area disturbed and resulting erosion is minimized. The emergency spillway, embankment, and all other disturbed areas above the crest of the principal spillway are to be stabilized immediately after construction.
- N. Sediment traps and basins may attract children and should be considered dangerous. Steep side slopes should be avoided and fences with warning signs may be necessary if trespassing is likely.
- O. Inspect temporary sediment traps, sediment basins, and skimmer sediment basins once a week and within 24 hours after any storm event of greater than ½ inch of rain per 24-hour period. Repairs shall be made immediately.
1. Sediment, limbs and other debris shall be cleared and the trap or basin shall be restored to its original dimensions when it accumulates to one-half the design depth or more frequently as directed by the Engineer. Sediment material removed from traps and basins shall be disposed of by the Contractor in locations that will not result in off-site sedimentation as acceptable to the Engineer, at no additional cost to the Owner. If no suitable on-site locations are available, all such sediment will be legally disposed of off site, at no additional cost to the Owner.
 2. The embankment, spillways and outlet shall be checked for erosion damage and the embankment shall be checked for piping and settlement. Immediately fill any settlement of the embankment to slightly above design grade. Any riprap displaced from the spillway must be replaced immediately. Replace contaminated gravel facing of riprap outlets as necessary. Inspect vegetation. Reseed and re-mulch as necessary.
 3. Baffles, fabric and skimmer shall be inspected for damage. Repairs shall be made immediately. Re-anchor baffles if water is flowing under or around them.
 4. Debris shall be removed from the skimmer to prevent clogging. Special precautions shall be taken in winter to prevent the skimmer from plugging with ice.

3.15 OUTLET STABILIZATION STRUCTURE

- A. Outlet stabilization structures shall be designed, installed and maintained in accordance with the requirements of Sections 6.41 and 8.06 of the NC ESCPDM.

- B. The Contractor shall ensure the subgrade, riprap and gravel filter conforms to the grading limits shown on the plans.
- C. Riprap shall be installed in accordance with the specifications contained herein, with filter fabric placed under the riprap.
- D. The apron shall be constructed on zero grade with no overfill. Ensure the apron is properly aligned with the receiving stream.
- E. All disturbed areas shall be stabilized with vegetation immediately after construction.
- F. Outlet stabilization structures shall be inspected at least weekly and within 24 hours after any storm event of greater than ½ inch of rain per 24-hour period to see if any erosion around or below the riprap has taken place or if stones have been dislodged. Repairs shall be made immediately.

3.16 TREE PROTECTION FENCE

- A. Tree protection fence shall be installed and maintained in accordance with the requirements of Section 6.05 of the NC ESCPDM. If Manufacturer's recommendations are more stringent, they shall supersede.
- B. Install tree protection fence around all designated tree protection areas prior to clearing, deliveries, and other construction activities onsite. Post signs designating area as protected on all sides of the fencing.
- C. Inspect tree protection fence weekly. Repair and replace as needed.

3.17 FILTER BAG

- A. Install filter bag on a slope so incoming water flows downhill through the filter bag without creating more erosion. Strap the neck of the filter bag tightly to the discharge hose. To increase the efficiency of filtration, place the bag on an aggregate or hay bale bed to maximize water flow through the surface area of the bag.
- B. The filter bag is full when it no longer can efficiently filter sediment or pass water at a reasonable rate. Flow rates will vary depending on the size of the filter bag, the type and amount of sediment discharged into the filter bag, the type of ground, rock or other substance under the bag and the degree of the slope on which the bag lies. Under most circumstances filter bags will accommodate flow rates of 1500 gallons per minute. Use of excessive flow rates or overfilling filter bag with sediment will cause ruptures of the bags or failure of the hose attachment straps. Damage and replacement costs for improper pumping shall be the responsibility of the Contractor.
- C. Full or partially full silt bags cannot be left in place and must be removed from site and legally disposed. If allowed, the filter bag may be cut open and the contents seeded after

removing visible fabric. Filter bag is strong enough to be lifted with added straps. Off-site disposal may be facilitated by placing the filter bag in the back of a dump truck or flatbed prior to use and allowing the water to drain from the bag in place, thereby dismissing the need to lift the filter bag.

- D. The payment for any filter bag used during construction is to be included in the bid of overall erosion and sediment control plan unless a unit price is specified in the Contract Documents.

3.18 DEWATERING SUMP

- A. Excavate for pit installation. Pit dimensions are variable, with the minimum diameter being three times the diameter of the standpipe.
- B. A base of filter material consisting of clean gravel or #57 stone (1.5 inch max diameter) is to be placed in the pit to a depth of six (6) inches.
- C. The standpipe shall be wrapped with hardware cloth and approved non-woven geotextile fabric and placed in pit on clean gravel.
- D. After installing the standpipe, the pit surrounding the standpipe should then be backfilled with #57 stone to an elevation that is six (6) inches minimum above the anticipated highwater level.
- E. The standpipe shall extend twelve (12) inches minimum above the anticipated standing water level.
- F. Insert pumping mechanism. Connect to separate filter bag if required by the Contract Drawings.

3.19 ADDITIONAL REQUIREMENTS

- A. All storm sewer piping shall be blocked at the end of every working day until the inlet is constructed above grade.
- B. All streets around the construction area shall be scraped as necessary to prevent accumulation of dirt and debris.
- C. The Contractor shall provide adequate means to prevent any sediment from entering any storm drains, curb inlets (curb inlet filter box), ditches, streams, or bodies of water downstream of any area disturbed by construction. Excavation materials shall be placed upstream of any trench or other excavation to prevent sedimentation of offsite areas. Silt fence will be provided, at no additional cost to the Owner, around excavation materials if deemed necessary by the Engineer. In areas where a natural buffer area exists between the work area and the closest stream or water course, this area shall not be disturbed.

- D. The Engineer may direct the Contractor to place any additional sediment and erosion control devices at other locations not shown on the Drawings.

3.20 INSPECTIONS AND MAINTENANCE

- A. The Contractor shall designate an Authorized Representative to perform inspections and maintenance as described herein. Contractor shall perform regular inspections and maintain records as follows:
 - 1. Inspections shall be performed, at a minimum, once every seven calendar days and within 24 hours after any storm event of greater than 1 inch of rain per 24-hour period.
 - 2. A rain gauge shall be maintained in good working order on the site and all rainfall amounts recorded throughout the duration of construction activities.
 - 3. Inspection reports must be available on-site during business hours unless a site-specific exemption is approved.
 - 4. Inspection records must be kept for 3 years following completion of construction and be available upon request.
 - 5. Electronically-available records may be substituted under certain conditions as approved by Land Quality and DWQ.
- B. During inspections, the following will be observed and appropriate maintenance activities shall be performed:
 - 1. The conformance to specifications and current condition of all erosion and sediment control structures.
 - 2. The effectiveness and operational success of all erosion and sediment control measures.
 - 3. The presence of sediments or other pollutants in storm water runoff at all runoff discharge points.
 - 4. The presence of sediments or other pollutants in receiving waters.
 - 5. Evidence of off-site tracking at all locations where vehicles enter or exit the site.
 - 6. Evidence of impacts to water quality due to site activities pertaining to equipment operation and maintenance, material handling, and material storage and construction laydown areas exposed to precipitation.
- C. Immediate action shall be taken to repair/maintain erosion and sediment control measures that are not performing as designed. The State/Commonwealth reserves the

right to stop all construction activities not related to these measures until such deficiencies are repaired.

- D. In areas that have undergone final stabilization, inspections and, if necessary, maintenance by Contractor will occur at least once per month for the duration of the contract or project, whichever is longer.

3.21 MONITORING AND REPORTING

- A. Monitoring: The Contractor shall be responsible for the implementation of the Inspections and Maintenance Procedures as included in the approved erosion and sediment control plan. The implementation must comply with guidelines as set forth in the NPDES General Permit NCG 010000 (Part I Section B: Minimum Monitoring and Reporting Requirements), as well as those of any local regulatory authorities. Minimum monitoring requirements are as follows:

1. A rain gauge shall be maintained in good working order on the site.
2. A written record of the daily rainfall amounts shall be retained. (Note: if no rainfall occurred the Contractor must record "zero").
3. The control measures shall be inspected to ensure that they are operating correctly. Inspection records must be maintained for each inspection event and for each measure. All erosion and sedimentation control measures must be inspected by the Contractor at least once every seven calendar days and within 24 hours after any storm event of greater than 1 inch of rain per 24-hour period unless otherwise noted herein. Some measures require inspection following each rainfall event.
4. Once land disturbance has begun on the site, stormwater runoff discharge outfalls shall be inspected by observation for erosion, sedimentation and other stormwater discharge characteristics such as clarity, floating solids, and oil sheens. Inspections of the outfalls shall be made at least once every seven calendar days and within 24 hours after any storm event of greater than 1 inch of rain per 24-hour period. Inspection records must be maintained for each inspection event and for each discharge location.
5. If any visible sedimentation is leaving the site or entering waters of the State/Commonwealth, corrective action shall be taken immediately to control the discharge of sediments. Where visible deposition of sediment has occurred in surface waters or wetlands, the Contractor must verbally contact the Engineer and the Division of Water Quality within 24 hours of becoming aware of the deposition. Written notification shall be made to the Engineer and the Division of Water Quality within 5 days of becoming aware of the deposition.

B. Reporting: The Contractor must keep a record of inspections onsite with a copy of the approved erosion and sediment control plan. Inspection records shall be made available to DWQ or its authorized agent upon request. Copies of inspection records shall be sent to the Engineer on a monthly basis. The records must provide the details of each inspection including observations and corrective actions taken as described below. The required rainfall and monitoring observations shall be recorded on an "Inspection Record for Activities Under Stormwater General Permit NCG010000" form provided by DEQ or a similar inspection form that is inclusive of all of the elements contained in the Division's form. A sample inspection form can be found at the end of this Section.

1. Control Measure Inspections: Inspection records must include at a minimum: 1) identification of the measures inspected, 2) date and time of the inspection, 3) name of the person performing the inspection, 4) indication of whether the measures were operating properly, 5) description of maintenance needs for the measure, 6) corrective actions taken and 7) date of actions taken.
2. Stormwater Discharge Inspections: Inspection records must include at a minimum: 1) identification of the discharge outfall inspected, 2) date and time of the inspection, 3) name of the person performing the inspection, 4) evidence of indicators of stormwater pollution such as oil sheen, floating or suspended solids or discoloration, 5) indication of visible sediment leaving the site, 6) actions taken to correct/prevent sedimentation and 7) date of actions taken.
3. Visible Sedimentation Found Outside the Site Limits: Inspection records must include 1) an explanation as to the actions taken to control future releases, 2) actions taken to clean up or stabilize the sediment that has left the site limits and 3) the date of actions taken.
4. Visible Sedimentation Found in Streams or Wetlands: All inspections should include evaluation of streams or wetlands onsite or offsite (where accessible) to determine if visible sedimentation has occurred.
5. Visible Stream Turbidity: If the discharge from a site results in visible stream turbidity, inspection records must record that evidence and actions taken to reduce sediment contributions.

C. The State/Commonwealth reserves the right to use its own resources to duplicate monitoring and verify the work required by the Contractor in this Section.

1. The Sedimentation Pollution Control Act requires persons responsible for land-disturbing activities to inspect a project after each phase of the project to make sure that the approved erosion and sedimentation control plan is being followed.
2. The self-inspection program is separate from the weekly self-monitoring program of the NPDES Stormwater Permit for Construction Activities. The focus of the self-inspection report is the installation and maintenance of erosion and sedimentation

control measures according to the approved plan. The inspections should be conducted after each phase of the project and continued until permanent ground cover is established.

3. The Self-Inspection Report form may be found at the end of this Section and is also available as an Excel spreadsheet from the NC DEMLR Land Quality Section web site, http://www.dlr.enr.state.nc.us/pages/sedimentation_new.html
- D. Sites discharging to streams named on the state's 303(d) list as impaired for sediment-related causes may be required to perform additional monitoring, inspections or application of more stringent management practices if it is determined that the additional requirements are needed to assure compliance with the federal or state/commonwealth impaired-waters conditions. Inspection records must be maintained for each inspection event and for each discharge location. If a discharge covered by this permit enters a stream segment that is listed on the Impaired Stream List for sediment-related causes, and a Total Maximum Daily Load (TMDL) has been prepared for those pollutants, the Permittee must implement measures to ensure that the discharge of pollutants from the site is consistent with the assumptions and meets the requirements of the approved TMDL. The DWQ 303(d) list can be found at: http://h2o.enr.state.nc.us/tmdl/General_303d.htm/.

3.22 REMOVAL OF TEMPORARY SEDIMENT CONTROL STRUCTURES

- A. At such time that temporary erosion and sediment control structures are no longer required under this item, the Contractor shall notify the Engineer of its intent and schedule for the removal of the temporary structures. The Contractor shall obtain the Engineer's approval in writing prior to removal. Once the Contractor has received such written approval from the Engineer, the Contractor shall remove, as approved, the temporary structures and all sediments accumulated at the removed structure shall be returned upgrade and stabilized so they do not re-erode. In areas where temporary control structures are removed, the site shall be left in a condition that will restore original drainage. Such areas shall be evenly graded and seeded as specified in Section 32 90 00 – Final Grading and Landscaping.

END OF SECTION

(The Inspection Record for Activities under North Carolina Stormwater General Permit NCG01000 and the Land Quality Self-Inspection Report Form follows this Section.)

**INSPECTION AND MONITORING RECORDS FOR ACTIVITIES UNDER STORMWATER GENERAL PERMIT NCG010000 AND SELF-INSPECTION
RECORDS FOR LAND DISTURBING ACTIVITIES PER G.S. 113A-54.1**

Project Name			Land Quality or Local Program Project/Permit #	
Approving Authority		Date of Plan Approval	Expiration Date, if applicable	
NCG010000 Certificate of Coverage Number			Date of COC Issuance	
Coverage under the NCG010000 permit must be renewed annually, if issued after April 1, 2019 until Notice of Termination is filed and approved.				

PART 1A: Rainfall Data

	Rain Amount (inches) Daily Rainfall Required. If no rain, indicate with a "zero"
M	
T	
W	
Th	
F	
Sat (Inspection Optional)	
Sun (Inspection Optional)	

PART 1B: Phase(s) of the Plan

Check ALL applicable box(es) that apply to completed & current phases	X
Initial installation of erosion and sediment control measures	
Clearing and grubbing of existing ground cover	
Completion of any grading that requires ground cover	
Completion of all land-disturbing activity, construction or	
Permanent ground cover sufficient to restrain erosion has been	

Are there any site or project conditions that limit completion of inspection? If yes, explain conditions and areas of site that were inaccessible.	

PART 2: STORMWATER PLANS AND CONTROLS: For each question below, mark the corresponding box as Yes, No or N/A. For all items marked "No", note in Part 3A the Reference letter and provide the Corrective Action and location of the deficiency, the original date noted, and the date it was noted as being corrected. NOTE: Reference letters may be used multiple times.

Reference	Part 2A: Storm Water Plans and Related Documents	Yes	No	N/A
A	Is the approval letter or certificate, COC and a copy of the NPDES Construction General Permit (CGP) on site? (Readily available electronic copy of CGP is acceptable)			
B	Is the approved plan on site and current?			
Reference	Part 2B: Stormwater Pollutant Controls	Yes	No	N/A
C	Are erosion and sediment controls that are shown on the approved plan installed and operating properly with no repairs needed?			
D	Are stormwater controls that are shown on the approved plan installed and operating properly with no repairs needed?			
E	Vehicle Tracking: Are construction entrances operating properly with no repairs needed?			
F	Soil Stabilization: Are areas of the site where construction activities have ceased been properly stabilized within the required timeframes?			
G	Are earthen stockpiles stabilized or otherwise protected from sediment loss, and located at least 50 feet away or downhill from drain inlets and surface waters?			
Reference	Part 2C: Non-Storm Water Pollutant Controls	Yes	No	N/A
H	Concrete, stucco, paint, etc. washouts: Are washouts installed, properly located, posted and operating with no repairs needed?			
I	Solid & hazardous wastes: Are trash, debris, and hazardous materials properly managed?			
J	Sanitary waste: Are portable toilets properly located and operating with no visible repairs needed?			
K	Equipment and stored fluids: Are fuels, lubricants, hydraulic fluids, etc. contained so as not to enter surface and ground waters?			
	Report oil spills and the release of hazardous substances to the appropriate DEQ Regional Office via phone call or email within 24 hours of discovery. https://deq.nc.gov/contact/regional-offices			

For any items listed in the section below, a full description of sedimentation is required in Part 3A. This includes, but may not be limited to: location, estimated amount of sediment that has left the site and/or entered waters, apparent causes of the sediment loss, and what corrective actions need to be taken to prevent this from recurring.

Reference	Part 2D: Sedimentation	Yes	No	N/A
L	Are sediment or other pollutants noted beyond the approved or permitted limits of disturbance?			
M	Are BMPs detected as releasing sediment or other pollutants into receiving waters?			

Report visible sedimentation into streams or wetlands to the appropriate DEQ Regional Office via phone call or email within 24 hours of discovery. <https://deq.nc.gov/contact/regional-offices>

PART 3A: EROSION AND SEDIMENTATION CONTROL MEASURES: Measures must be inspected at least ONCE PER 7 CALENDAR DAYS AND WITHIN 24 HOURS OF A RAINFALL EVENT EQUAL TO OR GREATER THAN 1.0 INCH PER 24 HOUR PERIOD. *Add rows as needed.*

Erosion and Sedimentation Control Measures Inspected			Inspection Date	Describe Actions Needed <u>Corrective actions should be performed as soon as possible and before the next storm event</u>	Date Previous Action(s) Observed as Corrected
Measure ID or Location and Description	Reference(s)	Operating Properly? (Y/N)			
Report unanticipated bypasses, or non-compliance conditions that may endanger health or the environment, to the appropriate DEQ Regional Office via phone call or email within 24 hours of discovery. https://deq.nc.gov/contact/regional-offices					

PART 3B: STORMWATER DISCHARGE OUTFALLS (SDOs): SDOs must be inspected at least ONCE PER 7 CALENDAR DAYS AND WITHIN 24 HOURS OF A RAINFALL EVENT EQUAL TO OR GREATER THAN 1.0 INCH PER 24 HOUR PERIOD. *Add rows as needed.*

Stormwater Discharge Outfalls Inspected					Inspection Date	Describe Actions Needed <u>Corrective actions should be performed as soon as possible and before the next storm event</u>	Date Previous Action(s) Observed as Corrected
Stormwater Discharge Outfall ID or Location	Any Visible Sedimentation in Streams, Wetlands or Outside Site Limits? (Y/N)	Any Increase in Stream Turbidity from Discharge? (Y/N)	Any Visible Erosion below SDO? (Y/N)	Any visible oil sheen, floating or suspended solids or discoloration? (Y/N)			

PART 3C: GROUND STABILIZATION: Must be recorded, at a minimum, after each phase. Add rows as needed.

Site area description and location where construction activities have temporarily or permanently ceased	Time Limit for Ground Cover (see table below)	Have stabilization measures been installed? (Y/N)	Temporary or Permanent Stabilization (T/P)	Is Ground Cover Sufficient to Restrain Erosion? (Y/N)	Original Inspection Date	Describe Actions Needed Corrective actions should be performed as soon as possible and before the next storm event	Date Previous Action(s) Observed as Corrected

GROUND STABILIZATION TIMEFRAMES

Site Area Description	Stabilization	Timeframe Variations
Perimeter dikes, swales and slopes	7 Days	None
High Quality Water (HQW) Zones	7 Days	None
Slopes Steeper than 3:1	7 Days	7 days for perimeter dikes, swales, slopes and HWQ zones 14 days for slopes 10 ft or less in length and not steeper than 2:1 10 days for Falls Lake Watershed
Slopes 3:1 to 4:1	14 Days	7 days for perimeter dikes, swales, slopes and HWQ zones 7 days for slopes greater than 50 ft in length 10 days for Falls Lake Watershed
All other areas with slopes flatter than 4:1	14 Days	7 days for perimeter dikes, swales, slopes and HWQ zones 10 days for Falls Lake Watershed

PART 3D: NEW OR REVISED MEASURES: Erosion and sedimentation control measures omitted or installed, at a minimum since the last inspection, shall be documented here or by initialing and dating each measure or practice shown on a copy of the approved erosion and sedimentation control plan. Alterations and relocations of measures shall also be documented if they significantly deviate from the approved plan. The removal of measures should also be documented.

List dimensions of measures such as Sediment Basins and Dissipator Pads. Add rows as needed. Corrective actions should be included in Part 3A.

Measure ID or Location and Description	Proposed Dimensions (ft.)	Actual Dimensions (ft.)	Significant Deviation* from Plan? (Y/N)	Date measure observed as installed, altered, relocated or removed	Installed (I) Altered (A) Relocated (R) Removed (X)

*Significant deviation means any omission, alteration or relocation of an erosion or sedimentation control measure that prevents it from performing as intended.

PART 4: Signature of Inspector

Financially Responsible Party (FRP) / Permittee				County	
INSPECTOR		Name	Employer		
Inspector Type (Mark)	X	Address			
FRP/Permittee					
Agent/Designee					
		Phone Number	Email Address		
By this signature, I certify in accordance with the NCG010000 permit & G.S. 113A-54.1 that this report is accurate and complete to the best of my knowledge.					
Financially Responsible Party / Permittee or Agent / Designee			Date & Time of Inspection		

SECTION 32 10 00
PAVING AND SURFACING

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. The Contractor shall furnish all labor, equipment and materials and perform all operations in connection with the construction of asphalt concrete pavement, asphalt concrete overlay, reinforced concrete pavement, gravel roads, concrete curb and gutter, repair and reconstruction of existing asphalt concrete pavement, repair of existing gravel roads, pavement markings, and all in-place testing complete as specified herein and as detailed on the Drawings.
- B. All new roads including the replacement of portions of the existing roads shall be to the limits, grades, thicknesses and types as shown on the Drawings. Patches for pipe crossings and areas damaged during the construction work shall be asphalt and/or gravel, depending upon the material encountered, unless otherwise indicated.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Requirements of related work are included in Division 01, Division 02 and Division 03 of these Specifications.

1.03 RELATED SECTIONS

- A. Section 31 00 01 – Earthwork
- B. Section 03 30 00 – Cast-in-Place Concrete

1.04 REFERENCES

- A. 2018 North Carolina Department of Transportation (NCDOT) Standard Specification for Road and Structures, or latest edition.

1.05 STANDARD SPECIFICATIONS

- A. Except as otherwise provided in the Specifications or on the plans, all work shall be in accordance with the North Carolina Department of Transportation Standard Specifications for Roads and Structures except that any reference to "NCDOT", "Department" or "Unit" shall mean the "Owner".

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B. Except with the approval of the Engineer, the placing of concrete or asphalt concrete surface paving shall be subject to the Seasonal and Weather Restrictions set forth in NCDOT Specifications.

PART 2 – MATERIALS

2.01 SELECT FILL

- A. The Contractor shall place select fill as necessary to complete the embankments, shoulders, subgrade foundation and replacement for removed unsuitable material in accordance with NCDOT Section 235, and Section 31 00 01 – Earthwork.

2.02 GRAVEL

- A. All work, including materials, associated with gravel shall be in accordance with NCDOT Section 545, Incidental Stone Base, except that Articles 545-6 and 545-7, shall be deleted.

2.03 AGGREGATE STABILIZATION

- A. All work, including materials, associated with Aggregate Stabilization shall be in accordance with NCDOT Section 510, Aggregate Stabilization, except that Articles 510-6 and 510-7, shall be deleted.

2.04 AGGREGATE BASE COURSE (ABC)

- A. All work, including materials, associated with Aggregate Base Course shall be in accordance with NCDOT Section 520, Aggregate Base Course, except that Articles 520-11 and 520-12 shall be deleted. Type "A" or "B" aggregate will be acceptable for this project.

2.05 ASPHALT BINDER FOR PLANT MIX

- A. All work, including materials, associated with asphalt binder shall be in accordance with Section 620, Asphalt Binder for Plant Mix, Grade PG 64-22, of the NCDOT Standard Specifications for Roads and Structures, except Articles 620-4 and 620-5 shall be deleted.

2.06 ASPHALT PAVEMENTS

- A. All work, including materials, associated with asphalt pavement shall be in accordance with Section 610, Asphalt Concrete Plant Mix Pavements, of the NCDOT Standard

Specifications for Roads and Structures, except Articles 610-15 and 610-16 shall be deleted. Surface Course shall be Superpave S-9.5B, Intermediate Course shall be Superpave I-19.0C, and Base Course shall be Superpave B-25.0C. Asphalt pavement mix designs shall be in accordance with TABLE 610-2 of the NCDOT.

- B. The job mix formulas shall be delivered to the Engineer at least two (2) weeks prior to beginning paving operations.

2.07 RIGID PORTLAND CEMENT CONCRETE PAVEMENT

- A. All work, including materials associated with rigid concrete pavement shall be in accordance with Section 03 30 00 – Cast-in-Place Concrete. Class A concrete shall be used. Placement shall be in accordance with Section 03 30 00 – Cast-in-Place Concrete and NCDOT Section 700, General Requirements for Portland Cement Concrete Pavement and Section 710, Concrete Pavement, except that Articles 700-2, 700-15, 710-3, 710-4, 710-8, 710-9, 710-10, and 710-11 shall be deleted.

2.08 RIGID CONCRETE PAVEMENT REINFORCING

- A. Reinforcing, if specified, shall be as shown on the Structural Drawings and as specified under Section 03 21 00 – Reinforcing Steel.

2.09 CONCRETE CURB AND GUTTERS

- A. Concrete shall be Class B in accordance with the requirements of Section 03 30 00 – Cast-in-Place Concrete, except that concrete shall be air-entrained to provide an air content of $6\% \pm 1.5\%$.
- B. Premolded expansion joint filler for expansion joints shall conform to ASTM D 1751 and shall be 1/2-inch thick, minimum.

2.10 ASPHALT TACK COAT

- A. All work, including materials, associated with asphalt tack coat shall be in accordance with Section 605, Asphalt Tack Coat, of the NCDOT Standard Specifications for Roads and Structures, except that Article 605-10 shall be deleted.

2.11 POLYCYCLIC AROMATIC HYDROCARBON (PAH)

- A. The EPA has classified seven PAHs as probable human carcinogens, and 16 PAHs as Priority Pollutants. Materials containing concentrations of Polycyclic aromatic hydrocarbon (PAH), such as Coal Tar Based Sealcoat, higher than allowed by OSHA limits shall not be allowed for use on the project.

PART 3 – EXECUTION

3.01 EMBANKMENT

- A. The embankment shall be constructed in accordance with Section 31 00 01 – Earthwork.

3.02 SUBGRADE

- A. The top 8 inches of subgrade shall be compacted in accordance with NCDOT Section 510-4. The subgrade shall be formed true to crown and grade and shall be compacted with a minimum of four (4) passes of a 15-ton vibratory roller to conform to the maximum densities determined by AASHTO T99 Standard Specifications.
- B. A tolerance of plus or minus .5 inches from the established grade will be permitted after the subgrade has been graded to a uniform surface. Perform the grading operation such that the maximum difference between the established grade and the graded subgrade within any 100-foot section is .5 inches.

3.03 BASE COURSE

- A. The finished base course of all paving shall be ABC and shall be of the thickness shown on the Drawings, formed true to crown and grade.
- B. Machine and compact the layer of base within 48 hours after beginning the placing of a layer of the base. Maintain each layer to the required cross section during compaction and compact each layer to the required density prior to placing the next layer. Compact each layer of the base to a density equal to at least 100% of that obtained by compacting a sample of the material in accordance with AASHTO T180.
- C. Gravel roads, including repair to existing gravel roads shall be ABC and shall be of the thicknesses shown on the Drawings, formed true to crown and grade. No fill material except new ABC shall be placed on top of existing gravel.
- D. Construct base and gravel roadways so the thickness of each is within a tolerance of plus or minus .5 inches of the base thickness required by the plans. Construct the base so that the maximum differential between the established grade and the base within any 100-foot section is .5 inches.

3.04 ASPHALT BASE COURSE (OR INTERMEDIATE COURSE)

- A. Asphalt Concrete Base (or Intermediate) Course shall meet the requirements of Superpave BM-25.0C (IM-19C for Intermediate) and be placed in lifts with a minimum thickness of 3-inches (2.5-inches for Intermediate) and a maximum thickness of 4-inches for IM-19C in accordance with NCDOT Standard Specifications for Roads and Structures 610-8, Spreading and Finishing. Asphalt Concrete Base (or Intermediate) Course shall be compacted in accordance with NCDOT Standard Specifications for

Roads and Structures 610-9, Compaction. Thicknesses shall be as shown on the Drawings. During asphalt base (or intermediate) course laydown, the paving equipment screed height should be set to achieve final design thickness as shown on the Drawings after compaction.

- B. Immediately after the base course asphalt mixture has been spread, stuck off and surface and edge irregularities adjusted, thoroughly and uniformly compact the pavement. Compact the mix to the required degree of compaction for the type of mixture being placed.
- C. Construct the base course surface smooth and true to the plan grade and cross slope. Immediately correct any defective areas with satisfactory material compacted to conform with the surrounding area. Pavement imperfections resulting from unsatisfactory workmanship such as segregation, improper longitudinal joint placement or alignment, non-uniform edge alignment or excess pavement repairs will be determined unsatisfactory by the Engineer and repaired or replaced by the Contractor at no additional cost to the Owner.

3.05 ASPHALT CONCRETE SURFACE COURSE

- A. Prior to placement of the asphalt concrete surface course, the base/intermediate course shall be inspected for damage or defects and repaired to the satisfaction of the Engineer. The surface of the base/intermediate course shall be approved by the Engineer.
- B. The asphalt tack coat shall be applied to the surface of the approved base/binder course as described in NCDOT Section 605. Equipment for applying the tack coat shall be power-oriented pressure spraying or distributing equipment suitable for the materials to be applied and approved by the Engineer.
- C. The Asphalt Concrete Surface Course shall meet the requirements of Superpave SM-9.5B and be placed and compacted on the base/intermediate course in layers with a minimum thickness of 1-1/2-inches and a maximum thickness of 3-inches and at the rate of 110-pounds per square yard per inch. Surface Course shall be compacted in accordance with NCDOT Standard Specification for Roads and Structures, Article 610-9. Thicknesses shall be as shown on the Drawings. During asphalt surface course laydown, the paving equipment screed height should be set to achieve final design thickness as shown on the Drawings after compaction.
- D. Immediately after the surface course asphalt mixture has been spread, stuck off and surface and edge irregularities adjusted, thoroughly and uniformly compact the pavement. Compact the mix to the required degree of compaction for the type of mixture being placed.

- E. Construct the surface course smooth and true to the plan grade and cross slope. Immediately correct any defective areas with satisfactory material compacted to conform with the surrounding area. Pavement imperfections resulting from unsatisfactory workmanship such as segregation, improper longitudinal joint placement or alignment, non-uniform edge alignment or excess pavement repairs will be determined unsatisfactory by the Engineer and repaired or replaced by the Contractor at no additional cost to the Owner.
- F. A tolerance of plus or minus .5 inches from the established grade will be permitted after the surface course has been spread and compacted. The maximum difference between the established grade and slope of the surface course within any 100-foot section is .5 inches and 0.5% slope

3.06 ASPHALT CONCRETE PAVEMENT COMPACTION

- A. Asphalt concrete pavement compaction shall be performed as per NCDOT Standard Specification for Roads and Structures, Article 610-9.
- B. Contractor shall provide Quality Control (QC) for proper asphalt concrete pavement placement and compaction using equipment in good working order which has been properly calibrated at the start of each round of testing. Quality Assurance (QA) of paving operations will be performed by an independent third-party representative hired by Owner.
- C. Immediately after the asphalt mixture has been spread, struck off and surface and edge irregularities adjusted, thoroughly and uniformly compact the pavement. Compact the mix to the required degree of compaction for the type of mixture being placed, as noted in Table 610-7 of the 2018 NCDOT Standard Specification for Road and Structures, or latest edition, and reproduced below in Table 3-1.

TABLE 3-1
SUPERPAVE DENSITY REQUIREMENTS

Superpave Mix Type	Minimum % Gmm (Maximum Specific Gravity)
SF9.5B	90.0
S9.5C, S9.5D, I19.0C, B25.0C	92.0

Note: Marshall mix types and densities are no longer valid.

3.07 ASPHALT CONCRETE DENSITY ACCEPTANCE

- A. The Engineer will evaluate the asphalt pavement for density acceptance after the asphalt mix has been placed and compacted using the Contractor's QC test results, the Owner's QA test results (including verification samples) and by observation of the Contractor's density QC process conducted in accordance with NCDOT Standard Specification for Roads and Structures, Section 609.
- B. Minimum density requirements for all mixes will be as specified in Table 3-1. Density acceptance will be as provided herein. Core sample shall be obtained and tested by the Owner's representative at the same frequency and location as the Contractor's QC testing, if possible, and densities will be determined by use of the requirements as outlined in NCDOT Standard Specification for Roads and Structures, Section 610-14.
- C. A failing lot for density acceptance purposes is defined as a lot for which the average of all test sections, and portions thereof, fails to meet the minimum specification requirement. A lot will consist of one day's production of a given JMF, for each layer of asphalt concrete placed. If additional density sampling and testing, beyond the minimum requirement, is performed and additional test sections are thereby created, then all test results shall be included in the lot average.
- D. Any lot or portion of a lot deemed obviously unacceptable by the Owner or Engineer will be rejected for use in the work. If the Engineer determines that a given lot of mix does not meet the minimum specification requirements, but the work is reasonably acceptable, the lot will be accepted at a reduced pay factor in accordance with the following formula. The reduced pay factor will apply only to the contractor's schedule of values.

$$\text{Reduced Pay Factor} = 100 + \frac{(\text{Actual Density} - \text{Specified Density}) \times 30}{2}$$

Where: Actual Density = the lot average density, not to exceed 2.0% of the specified density

 Specified Density = the density in Table 3-1 or as specified in the contract

3.08 ASPHALT CONCRETE PAVEMENT PHASING

- A. Contractor shall be responsible for phasing the placement of asphalt concrete pavement sections and courses to account for individual construction activities, the construction traffic volume, and vehicle loading expected throughout construction activities. The placement of asphalt concrete pavement shall also be phased so the aggregate base course, once installed, is not exposed to freeze/thaw cycles.

3.09 RIGID PORTLAND CEMENT CONCRETE

- A. The subgrade and base course beneath portland cement concrete pavement shall be prepared in accordance with the applicable Sections of these Specifications and

referenced Standard Specifications, except that the Contractor shall use an approved automatically controlled fine grading machine to produce final subgrade and base surfaces meeting the lines, grades, and cross sections (thicknesses) shown on the Drawings or established by the Engineer.

- B. The surface of the base shall be damp at the time the concrete is placed. The Contractor shall sprinkle the base when necessary to provide a damp surface. The Contractor shall satisfactorily correct all soft areas in the subgrade or base prior to placing concrete.
- C. Hauling over the base course shall not be allowed except where specifically permitted by and in writing by the Engineer. The Engineer may allow equipment dumping concrete to operate on the base to the extent and under the conditions the Engineer deems necessary to facilitate placing and spreading the concrete.
- D. Installation of the rigid concrete pavement shall be in accordance with the details shown on the Drawings and Division 03 - Concrete. The rigid concrete pavement shall cure a minimum of ten (10) calendar days and until the concrete has attained a minimum flexural strength of 550 psi as indicated by flexural strength testing. The Contractor shall coordinate and pay for all flexural strength testing with a minimum of four (4) 6-inch by 6-inch by 20-inch beams for every fifty (50) cubic yards of pavement concrete installed.
- E. Transverse and longitudinal joints shall be spaced at intervals as shown on the Drawings and installed as per the requirements of NCDOT Standard Specification for Road and Structures Section 610-11. Transverse contraction joints shall be formed by an approved joint insert. Longitudinal joints shall be formed by allowing the paver to deposit the mixture adjacent to the joint to such depth that maximum compaction can be obtained along the joint. Pinch the joint by rolling immediately behind the paver. Expansion joints shall be placed when the pavement abuts a structure using 1 inch expansion joint material (filler) and sealant as specified herein.

3.10 CONCRETE CURB AND GUTTER AND SIDEWALK

- A. The expansion joint filler for concrete curb and gutters shall be cut to conform with the cross section of the curb. Expansion joints shall be spaced at intervals of not more than 50 feet. Formed control joints shall be installed at intervals not exceeding 10 feet. (Expansion joints can be placed at intervals of 45 feet and control joints at 15 feet if curb and gutter is machine placed.) Depth of joint shall be 1/3 the thickness. Curved forms shall be used where radii are indicated; straight segments shall not be permitted. Upon removal of the forms, exposed curb faces shall be immediately rubbed down to a smooth and uniform surface. No plastering shall be permitted.
- B. Concrete sidewalks shall include contraction joints between each panel of sidewalk and when sidewalk width exceeds 6-feet, longitudinal contraction joints shall be placed as required. Additionally, 1/2" expansion joints and sealer shall be placed at a maximum

spacing of 50-feet of sidewalk. ½" expansion joint material and sealer shall also be where sidewalks abut and rigid structure or curb and gutter.

3.11 UNDERGROUND UTILITY LINES

- A. Where an underground utility line is beneath the new roadway, the backfilling shall be carried out with special care, and the final consolidation shall be accomplished by a vibratory roller. Construction of the roadway over the trench shall be deferred as long as practicable.

3.12 JUNCTION WITH OTHER PAVING

- A. Where new asphalt concrete pavement abuts existing asphalt concrete pavement, the existing pavement shall be cut back to insure obtaining the specified compaction of the new pavement courses and interlocking adjoining courses. Existing subbase courses shall be cut back from the subgrade level of the new pavement on a one-on-one slope into the existing pavement, and the asphalt courses of the existing pavement shall be removed for an additional 6-inches back from the slope. The edge of the existing asphalt courses shall be saw cut straight and true. The faces between new and existing asphalt courses shall receive an application of tack coat.
- B. Where new rigid concrete pavement abuts existing rigid concrete or asphalt concrete paving, the existing paving shall be saw cut straight and true. An expansion joint of a 1/2-inch minimum thickness with filler material and sealant shall be placed between the new concrete pavement and the existing rigid concrete or asphalt concrete paving.

3.13 ASPHALT CONCRETE OVERLAY

- A. Where asphalt concrete is proposed to be placed over an existing asphalt or rigid concrete surface, the surfaces shall be thoroughly cleaned by power brooming and a tack coat shall be applied in accordance with NCDOT Section 605, Asphalt Tack Coat, of the NCDOT Standard Specifications for Roads and Structures, prior to installing the overlay. The overlay shall be applied in accordance with Subsections 2.06 and 3.05 and Standard Details shown on the Drawings.

END OF SECTION

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SECTION 32 11 00
SURFACE RESTORATION

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. Provide all labor, equipment, and materials necessary for final grading, topsoil placement, and miscellaneous site work not included under other Sections but required to complete the work as shown on the Drawings and specified herein.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 31 00 01 – Earthwork
- B. Section 31 25 00 – Erosion and Sedimentation Control
- C. Section 32 90 00 – Final Grading and Landscaping

PART 2 – MATERIALS

2.01 TOPSOIL

- A. Topsoil shall meet the requirements of Section 31 00 01 – Earthwork.

PART 3 – EXECUTION

3.01 FINAL GRADING

- A. Following approval of rough grading the subgrade shall be prepared as follows:
 - 1. For riprap, bare soil 24 inches below finish grade or as directed by Engineer.
 - 2. For topsoil, scarify 2-inches deep at 4 inches below finish grade.

3.02 TOPSOIL PLACEMENT

- A. Topsoil shall be placed over all areas disturbed during construction under any contract except those areas which will be paved, graveled or rip rapped.
- B. Topsoil shall be spread in place for lawn and road shoulder seed areas at a 4-inch consolidated depth and at a sufficient quantity for plant beds and backfill for shrubs and trees.

- C. Topsoil shall not be placed in a frozen or muddy condition.
- D. Final surface shall be hand or mechanically raked to an even finished surface to finish grade as shown on Drawings.
- E. All stones, roots over 4-inches, rubbish, and other deleterious materials shall be removed and disposed of.

END OF SECTION

SECTION 32 31 13
STEEL FENCING

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. The Contractor shall furnish and install steel fencing, posts, gates, etc., where shown on the Drawings and in compliance with these Specifications.
- B. Fencing shall be of the chain link type topped with barbed wire. The 6-foot high fabric shall clear the final grade by 3 inches and shall be topped with three strands of barbed wire. The barbed wire shall be angled outward at the top. All components which are to be galvanized shall be hot dipped galvanized, coating to be 1.8 ounces per square foot of surface. Alternate coatings which employ a zinc coating of less than 1.8 ounces per square foot are not acceptable.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 03 30 00 – Cast-in-Place Concrete.

1.03 SUBMITTALS

- A. Shop Drawings shall be furnished in accordance with Section 01 33 00 – Submittal Procedures.

PART 2 – PRODUCTS

2.01 CHAIN LINK FABRIC

- A. Fabric shall be 9-gauge aluminum coated wire woven in a 2-inch diamond mesh conforming to ASTM A491. Top and bottom selvage to have a barbed finish. Minimum weight of coating shall be 0.40 ounce per square foot of wire surface. The coated wire shall have a minimum tensile strength of 80,000 lbs. per square inch.
- B. Install fabric 3 inches above ground level. Fence shall be stretched tight and securely fastened to posts at points spaced 12 inches apart maximum.

2.02 POSTS

- A. Posts and rails shall be galvanized standard weight pipe conforming to the requirements of ASTM F1083.

1. Line Posts: Line posts shall be Schedule 40, 2-7/8 inch O.D. galvanized pipe with minimum bending strength of 201 pounds under a 6-foot cantilever load. Line posts shall be spaced at a maximum 10-foot O.C.
2. Terminal Posts: All end, corner, intermediate, and pull posts and gate leaves 6'0" wide and less shall be 3-1/2 inch O.D. galvanized Schedule 40 pipe with minimum bending strength of 381 pounds on 6-foot cantilever load. Gate posts for gate leaves shall be Schedule 40 pipe complying with ASTM F1083 of diameters as follows:

Gate Leaf Width	Pipe O.D.	Weight per Ft.
0' to 6'	3-1/2"	9.11 lbs.
Over 6' to 13'	4"	10.79 lbs.
Over 13' to 18'	6-5/8"	18.97 lbs.
Over 18'	8-5/8"	24.7 lbs.

2.03 TENSION WIRE

- A. Top and bottom tension wire shall be No. 7 gauge aluminum coated steel wire. Fabric shall be securely tied to tension wire at intervals not to exceed 24-inches.

2.04 POST TOPS AND BARBED WIRE SUPPORTS

- A. Gate, end, corner and line post tops shall be malleable iron or pressed steel and shall be hot dipped galvanized conforming to ASTM A153.
- B. Extension arms for supporting the three (3) strands of barbed wire for line posts shall be of pressed steel with malleable iron base, or solid aluminum alloy castings.
- C. Angles for line post extension arms shall be approximately 45 degrees from the vertical and the top slot for barbed wire shall be a minimum of 12 inches above the fabric and a minimum of 10 inches from the fence line.

2.05 BARBED WIRE

- A. Barbed wire shall consist of three strands of 12-1/2 gauge aluminum coated steel wire with 4-point barbs of 14 gauge aluminum wire spaced 5 inches apart, conforming to ASTM A585.
- B. Additional strands of barbed wire shall be added beneath the chain link fabric at all ditch crossings to maintain the security of the fence installation.

2.06 BRACES AND TOP RAILS

- A. Braces and top rails (where shown on the Drawings) shall be 1.66-inch O.D., Schedule 40 galvanized pipe with minimum vertical bending strength of 202 pounds on 10-foot span.
- B. Top rails shall be continuous and shall pass through the post tops. The coupling used to join the top rail lengths shall allow for expansion. Brace rails shall be provided at all terminal posts, located between the top and grade lines and extend from the terminal post to the first adjacent post. Braces shall be securely fastened at both ends. Brace ends for receiving brace rails shall be malleable iron or castings of 356.0 (formerly SG70A) alloy, or equivalent of ASTM B26 or B108.
- C. Truss and stretcher bands shall be 1/8-inch x 7/8-inch pressed steel, supplied with carriage bolts and nuts. Bolts shall be 5/16-inch by 1 1/4-inch. Truss rods shall be 3/8-inch nominal diameter.

2.07 FABRIC TIES

- A. Wire ties shall be pre-formed 0.148-inch diameter (9 gauge) aluminum. Flat band type ties shall be 1100-H18 or 3003-H14, .064-inch thick by 1/2-inch wide.
- B. Hog rings for attaching tension wire to fabric shall be 0.105-inch diameter, Alloy 1100-H14.

2.08 GATES

- A. Gate frames shall be made of 2-inch O.D. ASTM F1083 pipe, 2.72 lbs. per foot hot dipped galvanized. Fabric shall match fence. Gate frames shall be welded or assembled with riveted corner castings. Gate frames shall be equipped with 3/8-inch diameter adjustable truss bars. Hinges shall be ball and socket.
- B. Gate shall be equipped with positive latching device with provision for padlocking. Personnel gates shall be minimum 36-inch clear opening.

PART 3 – EXECUTION

3.01 INSTALLATION

- A. All line posts shall be spaced equidistant in the fence line on a maximum of 10-foot centers. Posts shall be set plumb in concrete bases as detailed on Drawings. The top of the posts shall be brought to a smooth grade line. The wire fence shall be set accurately to line and grade and shall be plumb.

- B. End, corner, pull or intermediate posts shall be placed in the following locations: corners; changes in direction; abrupt changes in grade; intervals no greater than 500 feet in the fence line. Each end or gate post shall have one brace assembly and each corner or intermediate post shall have two brace assemblies.
- C. Horizontal braces shall be provided at all terminal posts, corner posts, and intermediate posts between top rail and ground and shall extend from the above-mentioned posts to the first adjacent line posts. Braces shall be securely fastened to the line posts by brace ends and brace bands and to the terminal posts by approved rail end connectors. Diagonal brace rods shall be trussed from the brace end on the line post back to the terminal post, corner post or intermediate post and fastened to it by an approved connector.

3.02 POST FOUNDATIONS

- A. Post holes shall be in true alignment and of sufficient size to provide a permanent foundation of concrete. Holes shall be well centered on the posts. A minimum diameter of 12 inches shall be required for all posts.
- B. Post foundations shall be carefully rodded or tamped into place. The top of concrete shall extend 2 inches above ground line and shall be neatly troweled and leveled up from edges to the posts so as to have a pitch outward in all directions.
- C. No materials shall be installed on the posts, nor shall any load be applied to the posts within 3 days after the individual post foundation is completed.
- D. All concrete shall be Class "B" in conformance with Section 03 30 00 – Cast-in-Place Concrete.

3.03 RESETTING OF EXISTING FENCE

- A. Where shown on the Drawings that resetting of existing fence is required, the fence, after resetting, shall be in a condition that is equal to or better than before the fence was removed.
- B. The Contractor shall replace any of the fence components which have been unnecessarily damaged by him.

3.04 PADLOCK AND KEYS

- A. One solid brass padlock shall be furnished with each gate. Padlocks shall be master keyed to the system specified under Section 08 71 00 – Finish Hardware.

3.05 TEMPORARY FENCING

- A. The Contractor shall furnish and install all temporary fencing and appurtenances as shown on the Drawings or as required during construction to adequately secure the site prior to installation of the permanent fence.

END OF SECTION

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SECTION 32 90 00
FINAL GRADING AND LANDSCAPING

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. Furnish all labor, equipment, and materials necessary for final grading, topsoiling, seeding, and miscellaneous site work not included under other Sections, but required to complete the work as shown on the Drawings and specified herein. Under this Section, all areas of the project site disturbed by excavation, materials storage, temporary roads, etc., shall be reseeded as specified herein.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 31 00 01 - Earthwork
- B. Section 31 25 00 – Erosion and Sedimentation Control
- C. Section 32 11 00 – Surface Restoration

1.03 SUBMITTALS

- A. Submit the following in accordance with Section 01 33 00 – Submittal Procedures:
 - 1. Product Data
 - 2. Certification of all materials
 - 3. Three (3) copies of soils test report with fertilizer recommendation (or biotic soil amendment recommendation, if applicable) from the N.C. Department of Agriculture.
 - 4. Three (3) copies of composition and germination certification and of test results for grass seed.
 - 5. Biotic soil amendment manufacturer's product data and installation instructions. Include required substrate preparation, list of materials and application rate, if applicable.

PART 2 – PRODUCTS

2.01 CONTRACTOR'S RESPONSIBILITIES

- A. Furnish and submit certification for the materials used as specified in the General Conditions, Division 01 and Division 02.

2.02 TOPSOIL

- A. Upon completion and approval of the rough grading, the Contractor shall place the topsoil over all areas disturbed during construction under any contract except those areas which will be paved, graveled, rip rapped, or otherwise covered with an impervious surface. Topsoil shall be tested and amended as necessary according to the requirements of Section 31 00 01 – Earthwork prior to being placed over the site. Topsoil shall not be placed in a frozen or muddy condition and shall contain no toxic materials harmful to grass growth.

2.03 WATER

- A. Water shall be furnished to the Contractor by the Owner from existing facilities as directed by the Engineer.
- B. The Contractor shall furnish all hoses and connections necessary to complete the landscaping work.

2.04 FERTILIZER

- A. Fertilizer shall be a complete commercial fertilizer with components derived from commercial sources. Fertilizer analysis shall be determined from field soil sampling in appropriate number taken by the Contractor and analyzed by the N.C. Department of Agriculture or other independent laboratory. Contractor shall furnish fertilizer in accordance with the recommendations of the N.C. Department of Agriculture.
- B. One-quarter of the Nitrogen shall be in the form of nitrates, one-quarter in the form of ammonia salts, and one-half in the form of natural organic Nitrogen. Available Phosphoric Acid shall be free from superphosphate, bone, or tankage. Potash shall be Sulphate of Potash. Elements shall conform to the standards of Association of Official Agricultural Chemists.
- C. Fertilizer shall be delivered in standard size bags marked with the weight, analysis of contents, and the name of the manufacturer. Fertilizer shall be stored in weatherproof storage areas and in such a manner that its effectiveness will not be impaired.

2.05 LIME

- A. At least 50% shall pass a No. 200 U.S.S. mesh sieve. At least 90% shall pass a No. 100 U.S.S. mesh sieve and 100% shall pass a No. 10 U.S.S. mesh sieve. Total carbonates shall not be less than 80% or 44.8% Calcium Oxide equivalent. For the purpose of calculation, total carbonates shall be considered as Calcium Carbonate.

2.06 GRASS SEED

- A. The Contractor shall furnish the kinds and amounts of temporary and permanent seed to be planted in all areas disturbed by the construction work. All seed shall be labeled to show that it meets the requirements of the North Carolina Seed Law. All seed must have been tested within six (6) months immediately preceding the planting of such material on the job.
- B. Contractor may submit alternate grass seed types, rates, and planting dates specific to the project site based on consultation with, and the recommendations of, the N.C. Department of Agriculture, a local Soil Conservation District, local Agricultural Extension Program, or other qualified organization for approval by the Engineer before planting.
- C. The inoculant for treating legume seed shall be a pure culture of nitrogen fixing bacteria prepared specifically for the species. Inoculants shall not be used later than the date indicated on the container. The quality of the seed shall conform to the following:

Type	Minimum Seed Purity (%)	Minimum Germination (%)	Maximum Weed Seed (%)
Fescue (fungus free)	98	90	1.00
Hybrid Rye	98	85	0.10
German Millet	98	85	0.50
Browntop Millet	98	85	0.50

- D. All seed shall be in conformance with N.C. Seed Law restrictions for restricted noxious weeds.
- E. Seed mixtures to be used on the project shall be as follows:

Permanent Seeding (Warm)	100#/acre Kentucky 31 Tall Fescue (<i>Schedonorus phoenix</i>), 25#/acre German Millet (<i>Setaria Italica</i>) and 25#/acre Hulled Bermuda (<i>Cynodon dactylon</i>).
Permanent Seeding (Cool)	100#/acre Kentucky 31 Tall Fescue (<i>Schedonorus phoneix</i>), 30#/acre Wheat (<i>Triticum aestivum</i>), and 25#/acre Unhulled Bermuda (<i>Cynodon dactylon</i>)

Temporary Summer Seeding	40#/acre German Millet (<i>Setaria italica</i>), and 80#/acre Kentucky 31 Tall Fescue (<i>Schedonorus phoneix</i>)
Temporary Fall Seeding	120#/acre Rye Grain (<i>Secale cereale</i>) and 80#/acre Kentucky 31 Tall Fescue (<i>Schedonrus phoneix</i>)
Temporary Winter Seeding	120#/acre Rye Grain (<i>Secale cereale</i>), 80#/acre Kentucky 31 Tall Fescue (<i>Schedonorus phoneix</i>), and 50#/acre Kobe Lespedeza (<i>Kummerowia striata v. kobe</i>)
Riparian Seeding	25#/acre Mellow Marsh Farm 'MMF Wetland Mix' (Add 30#/acre Rye Grain (<i>Secale cereale</i>) in Sept 1 – Apr 30 season. Add 10#/acre Japanese Millet (<i>Echinochloa esculenta</i>)

- F. On cut and fill slopes 2:1 or steeper add 30#/acre of German Millet or Browntop Millet to the P seed mixture.

2.07 WOOD CELLULOSE FIBER MULCH

- A. For use in hydroseeding grass seed in combination with fertilizers and other approved additions, shall consist of especially prepared wood cellulose fibers such as "Wood-Lok 300" manufactured by Applegate Mulch, "Enviro-Mix" manufactured by Profile, or equal, and have no growth or germination inhibiting factors, and be dyed green.
- B. The wood cellulose fiber shall have the additional characteristic of dispersing rapidly in water to form a homogeneous slurry and remain in such state when agitated in the hydraulic mulching unit, or adequate equal, with the specified materials.
- C. When applied, the wood cellulose fiber with additives will form an absorptive mat but not a plant inhibiting membrane, which will allow moisture, natural or mechanical, to percolate into underlying soil.
- D. The mulch shall be supplied, compressed in packages containing 50 pounds of material having an equilibrium air dry moisture content at time of manufacture of 12% plus or minus 3%. Wood cellulose fiber mulch shall be stored in a weatherproof storage area and in such a manner that effectiveness will not be impaired.

2.08 STRAW MULCH

- A. Straw mulch shall be spread manually or by use of a straw blower. Straw used for mulch shall be small grain hay. Hay shall be undamaged, air dry, threshed straw, free of undesirable weed seed. Straw mulch is not required for seeded areas treated by hydroseeding or with a temporary soil stabilizer.
- B. Tackifier for securing straw mulch shall be Contact AT manufactured by Profile Products, M-Binder manufactured by Granite Seed, or Lawn Tack as manufactured by Rhino, or approved equal.

2.09 TEMPORARY SOIL STABILIZER

- A. Temporary soil stabilizers may be used in place of temporary seeding, as approved by the Owner or Engineer. The temporary agent for soil erosion control shall consist of an especially prepared plant-based or cementitious highly concentrated powder which, when mixed with water, forms a thick liquid such as "DustOut" manufactured by DustOut™, "Stabilizer" manufactured by Stabilizer Solutions, or "SoiLok™" as manufactured by Prime Resins, or equal, and having no growth or germination inhibiting factors. The agent shall be used for bare soil stabilization or hydroseeding grass seed in combination with other approved amendments resulting in a highly viscous slurry which, when sprayed directly on the soil, forms a wind and rain resistant crust.

2.10 ROLLED EROSION CONTROL MATTINGS

- A. The rolled erosion control products (RECMs) shall be as specified in Section 31 25 00 – Erosion and Sedimentation Control.

2.11 RIPRAP AND HERBICIDES

- A. Furnish and install sufficient quantity of landscape gravel or riprap to cover over the ground to a minimum 4-inch depth for gravel and 24-inch depth for riprap, unless otherwise noted, or indicated on the Drawings. Also furnish and apply an approved herbicide to the subgrade surface just prior to installing the landscape gravel or riprap.
- B. During placing, the stone shall be graded so that the smaller stones are uniformly distributed through the mass. The Contractor may place the stone by mechanical methods, augmented by hand placing where necessary or ordered by the Engineer. The placed riprap shall form a properly graded, dense, neat layer of stone.
- C. All topsoil and vegetative matter shall be removed from the subgrade surfaces prior to the application of the weed killer (herbicide) and to the placement of landscape gravel or riprap. Apply commercial-type herbicide as preemergence control of miscellaneous grasses and broadleaf weeds in granular or liquid form such as "Treflan", "Dymid", or equal. Methods and rates of application shall be in strict compliance to manufacturer's directions and acceptable to the Engineer.
- D. The herbicide selected shall be safe for use around ornamental plantings, have long-lasting weed control, and shall be resistant to leaching away under excessive rainfall.
- E. A second application of the herbicide shall be made on the surface of the landscape gravel or riprap sometime after the first six (6) months, but not later than 12-months. Same methods and rates apply as specified previously.

PART 3 – EXECUTION

3.01 GRADING

- A. After approval of the rough grading, the Contractor shall commence preparations of the subgrade for the various major conditions of the work as follows:
 - 1. Bare soil for riprap area at subgrade (24-inches below final grade, or as directed by the Engineer).
 - 2. Topsoil for lawn and road shoulder seed area - scarify 2-inch depth of subgrade (4-inches below final grade) prior to placing topsoil.
- B. Final surface grading of the top-soiled, landscape graveled, and ripped areas shall be mechanically raked or hand raked to an even finished surface alignment.

3.02 TOPSOIL

- A. Topsoil shall be spread in place for quantity required for lawn and road shoulder seed areas at 4-inch consolidated depth, and sufficient quantity for certain plant beds and backfill for shrubs and trees as specified.

3.03 SEEDBED PREPARATION

- A. Contractor shall prepare all areas to receive temporary or permanent seeding measures prior to planting.
- B. Topsoil shall be placed in areas to be seeded and roughened with tracked equipment or other suitable measures. Slopes steeper than 3:1 may be roughened by grooving, furrowing, tracking, or stairstep grading. Slopes flatter than 3:1 should be grooved by disking, harrowing, raking, operating planting equipment on the contour.
- C. Soil amendments including, but not limited to, lime and fertilizer shall be spread as necessary, and at the rates specified in this Section. Seeding shall be as per the type and rates specified in this Section. Seed shall be broadcast as soon as possible following roughening and before surface has been sealed by rainfall.

3.04 GRASS ESTABLISHMENT AND HYDROSEEDING

- A. Prepare of the topsoil and bare soil seed bed, apply fertilizer, limestone, mulching, inoculant, temporary soil stabilizer, water, and all other operations necessary to provide a satisfactory growth of sod at the end of the one-year maintenance period. Areas without satisfactory sod at the end of one (1) year shall be replanted until satisfactory growth is obtained and acceptable to the Engineer.
- B. For areas to be seeded by the hydraulic seeding method, include all additives and amendments required. a "Reinco", "Finn", or "Bowie" type hydromulcher with adjustable

nozzles and extension hoses, or equal, shall be utilized. general capacity of tank should range from 500 to 2,500 gallons, or as approved by the engineer.

- C. Hydraulic seeding shall be carried out in three steps. Step one shall consist of the application of lime. In step two the seed mixture shall be mixed with the biotic soil amendment (if used), fertilizer, wood cellulose fiber mulch, and any required inoculants and applied to the seed bed. Step three shall consist of an application of top dressing during the first spring or fall, whichever comes first, after step two.
- D. Top dressing shall consist of a commercial grade fertilizer plus Nitrogen or other analysis as may be recommended by soil testing. Contractor shall submit results of soils testing and recommendations to Engineer for review before applying top dressing. Types and application rates of seed mixtures, lime, fertilizer, and wood cellulose fiber mulch shall be as shown in the Seeding Schedule.
- E. Ingredients for the mixture and steps should be dumped into a tank of water and thoroughly mixed to a homogeneous slurry and sprayed out under a minimum pressure as recommended by the Manufacturer, in suitable proportions to accommodate the type and capacity of the hydraulic machine to be used. Applications shall be evenly sprayed over the ground surface. The Contractor shall free the topsoil of stones, roots, rubbish, and other deleterious materials and dispose of same off the site. The bare soil, except existing steep embankment area, shall be rough raked to remove stones, roots, and rubbish over 4-inches in size, and other deleterious materials and dispose of same off the site.
- F. No seeding should be undertaken in windy or unfavorable weather, when the ground is too wet to rake easily, when it is in a frozen condition, or too dry. Any bare spots shown in two to three weeks shall be recultivated, fertilized at half the rate, raked, seeded, and mulched again by mechanical or hand broadcast method acceptable to the Engineer.
- G. Areas that have been manually seeded or hydroseeded with a temporary seed mixture shall be mowed to a height of less than 2 inches and scarified prior to hydroseeding with the permanent seed mixture.
- H. The Contractor shall provide, at the Contractor's own expense, protection for all seeded areas against trespassing and damage at all times until acceptance of the work. Slopes shall be protected from damage due to erosion, settlement, and other causes and shall be repaired promptly at the Contractor's expense.
- I. The Contractor shall water newly seeded areas of the lawn and road shoulder mix once a week until the grasses have germinated sufficiently to produce a healthy turf (a minimum of 80% ground coverage), or unless otherwise directed by the Engineer. Each watering shall provide three (3) gallons per square yard. The Contractor shall furnish all necessary hoses, sprinklers, and connections.

- J. The first and second cutting of the lawn grasses only shall be done by the Contractor. All subsequent cuttings will be done by the Owner's forces in a manner specified by the Contractor.

3.05 DITCH AND SWALE EROSION PROTECTION

- A. All ditches and swales indicated on the Drawings shall be lined with a rolled erosion control matting (RECM). The area to be covered shall be properly graded and hydroseeded before the RECM is installed. Installation shall be in accordance with Section 31 25 00 – Erosion and Sedimentation Control.

3.06 MAINTENANCE

- A. The Contractor shall be responsible for maintaining all seeded areas through the end of a one-year warranty period, beginning from the date of acceptance of final seeding and landscaping as determined by the Engineer. Maintenance shall include but not be limited to, annual fertilization, mowing, repair of seeded areas, irrigation, and weed control. The Contractor shall provide, at the Contractor's own expense, protection for all seeded areas against trespassing and damage at all times until acceptance of the work. Slopes shall be protected from damage due to erosion, settlement, and other causes and shall be repaired promptly at the Contractor's expense.
- B. Annual fertilization shall consist of an application of 500#/acre of 10-10-10 commercial grade fertilizer, or its equivalent and 60#/acre of nitrogen in early fall, or other analysis as may be determined by soil test. Annual fertilization shall be in addition to top dressing and shall be performed by the Contractor each fall season after planting until the work is substantially complete.
- C. Mowing shall be scheduled to maintain a minimum stand height of 4-inches or as directed by the Engineer. Stand height shall be allowed to reach 8 to 10-inches prior to mowing.
- D. All seeded areas shall be inspected on a regular basis and any necessary repairs or reseedings made within the planting season, if possible. If the stand should be over 20% damaged, it shall be re-established following the original seeding recommendations.
- E. Weed growth shall be maintained mechanically and/or with herbicides. When chemicals are used, the Contractor shall follow the current North Carolina Agricultural Experiment Stations' weed control recommendations and adhere strictly to the instructions on the label of the herbicide. No herbicide shall be used without prior approval of the Engineer.

3.07 CLEANUP

- A. The Contractor shall remove from the site all subsoil excavated from their work and all other debris including, but not limited to, branches, paper, and rubbish in all landscape areas, and remove temporary barricades as the work proceeds.

- B. All areas shall be kept in a neat, orderly condition at all times. Prior to final acceptance, the Contractor shall clean up the entire landscaped area to the satisfaction of the Engineer.

3.08 SEEDING SCHEDULE

- C. All seeding and mulching to be completed by the Contractor shall conform to the following schedule. Temporary seed mixtures will be used during these times if seeding is necessary. Areas seeded with temporary seed mixtures shall be reseeded by the Contractor at no additional cost to the Owner with permanent seed as directed by the Engineer.
- D. Application rates of seed mixtures, lime, fertilizer, mulch and top dressing are shown in the schedule.

SEEDING SCHEDULE

Application Rates (Pounds/Acre)						
Seed Mixture	Planting Season	Lime ^a	Seed ^b	Fertilizer	Straw ^c Mulch	Topdressing ^a
PW	Mar. 15 to Sept. 15	4000	150	1000	4000	500 of 10-10-10 60 of Nitrogen
PC	Sept. 15 – Mar. 15	4000	155	1000	4000	500 of 10-10-10 60 of Nitrogen
TS	May 1-Aug. 15	2000	120	750	4000	-
TF	Oct 25-Dec. 30	2000	200	750	4000	-
TW	Dec. 30 – Feb. 15	2000	250	750	4000	-
Annual Fertilizer Same as Topdressing Same as Topdressing Same as Topdressing Same as Topdressing Same as Topdressing						
Comments Over seed with Type P seed mixture during next planting season. Over seed with Type P seed mixture during next planting season. Over seed with Type P seed mixture during next planting season. Over seed with Type P seed mixture during next planting season. Over seed with Type P seed mixture during next planting season.						

Notes:

- a. Application rates and/or chemical analysis shall be confirmed or established by soil test.
- b. On cut and fill slopes 2:1 or steeper, add 30#/acre German Millet or Browntop Millet to Type P seed mixture.
- c. Apply tackifier at rate of 0.10 gallon per square yard (10 gal/1000 ft²), or as recommended by manufacturer, to tack straw mulch.

END OF SECTION

SECTION 33 01 10.58
DISINFECTION OF WATER TREATMENT FACILITIES

PART 1 – GENERAL

1.01 GENERAL

- A. Contractor shall clean and disinfect the water treatment facilities including, but not limited to contactor cells and gutters, flumes and channels, and all piping that conveys water that is or will become potable, prior to placing the facilities into service in accordance with the regulations of the State of North Carolina and as specified herein. Any existing potable water piping shall also be disinfected if it is taken out of service as part of the work. All costs of such service shall be borne by the Contractor.
- B. Before being placed into service and before Certification of Substantial Completion can be issued by the Engineer, all new or modified potable water systems shall be disinfected in accordance with the requirements of these Specifications and the applicable AWWA Standard(s).

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 01 14 00 – Coordination with Owner's Operations
- B. Division 33 - Utilities
- C. Division 40 – Process Interconnections
- D. Section 46 61 00 – Contactor Underdrains
- E. Section 43 31 13.13 – GAC Adsorption System Media

1.03 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

- A. Without limiting the generality of other requirements of the Specifications, all work hereunder shall conform to the applicable requirements of the following documents to the extent that the requirements therein are not in conflict with the provisions of this Section.
 - 1. AWWA C651 – Disinfecting Water Mains
 - 2. AWWA C652 – Disinfection of Water Storage Facilities
 - 3. AWWA C653 – Disinfection of Water Treatment Plants
 - 4. AWWA C655 – Field Dechlorination

5. AWWA B300 – Hypochlorites
6. AWWA B301 – Liquid Chlorine
7. NSF/ANSI 60 – Drinking Water Treatment Chemicals – Health Effects
8. NSF/ANSI 61 – Drinking Water System Components – Health Effects
9. Chlorine Manual – Chlorine Institute Inc.
10. AWWA M20 - Water Chlorination/Chloramination Practices and Principles

1.04 SUBMITTALS

- A. Submit to the Engineer and Owner procedures for completing the disinfection of the water plant facilities described herein, along with necessary de-chlorination and disposal of waste. Procedures to be submitted by Contractor shall include the proposed methods of storing, handling, and dispensing the disinfectant and de-chlorination chemicals, and shall include the associated chemical feed systems.
- B. Submit a "Record of Compliance" stating that bacteriological testing has been accomplished and certifying that the water is free of coliform bacteria contamination, before returning all potable water facilities and pipelines into service. Results of this testing shall meet all State of North Carolina requirements and regulations.
- C. Contractor shall record and submit the following information:
 1. Type and form of disinfectant and any de-chlorination chemicals used.
 2. Date and time of disinfectant injection start and time of completion.
 3. Test and injection locations.
 4. Initial and 24-hour disinfectant residuals (quantity in treated water) in ppm for each outlet tested.
 5. Date and time of flushing start and completion.
 6. Disinfectant residual in ppm after flushing for each outlet tested.
- D. Testing and disinfection shall be accomplished in the presence of the Engineer.
- E. Quality Assurance - Disinfection of facilities shall be performed by Contractor who has at least ten (10) years prior experience in disinfection of similar facilities at Water Treatment Plants. The Contractor shall provide a list of previous work experience where they have performed disinfection activities on similar projects at Water Treatment Plants. The list shall include pertinent experience for a minimum of three (3) projects within the

last ten (10) years, where they have performed work similar to the work to be performed on this project.

- F. Submit Disinfection procedure safety plan.

PART 2 – PRODUCTS

2.01 WATER SUPPLY

- A. Reasonable quantities of water necessary for initial and subsequent flushing, testing, and disinfection of all facilities associated with this Project shall be provided by the Owner.
- B. No permanent connections shall be made to the potable water system for the purpose of flushing and disinfecting new water lines. A temporary connection with an Owner-approved backflow prevention device shall be utilized to deliver potable water to new waterlines. Utilizing a portable pump with check valves is one method of preventing backflow and achieving the high flows that are needed to adequately flush large diameter waterlines.
- C. All chemical equipment (pumps, testing kits, etc.) associated with leakage testing, cleaning, or rinsing of the facilities, disinfection, and de-chlorination shall be furnished by the Contractor. The Owner has limited facilities for potable water use and reserves the right to limit the volume of water used per day and the times of the day when the use of water is permitted for the project. Disposal of water for leak testing, cleaning and rinsing, disinfection, and de-chlorination shall be performed by the Contractor in accordance with all federal, state and local requirements in such a manner as to cause no adverse environmental effects such as fish kills or soil erosion.
- D. The Contractor shall have no claim for monetary compensation from the Owner for the inability of the Owner to provide adequate water at the proposed time of disinfection. Compensation to the Contractor is limited to an extension of time to the Contract only.
- E. All basins, pipes, vessels, and appurtenances shall be filled slowly either through an existing valve or through taps. Special care shall be exercised in loading lines and filling basins, vessels and pipes to prevent damage. The Contractor shall coordinate with the Owner the operation of all existing valves. All valve operations shall be performed by the Owner's personnel only.

2.02 CHEMICALS

- A. All chemicals and chemical feed systems required for disinfection shall be furnished by the Contractor – including chemical feed pumps, chemical storage tanks, piping, valves, chemical injectors, and power and control systems required for disinfection de-chlorination efforts. Any equipment used either for disinfection or de-chlorination shall be

either new or previously used only for disinfection or de-chlorination in potable water supply applications.

- B. All chemicals used for disinfection and de-chlorination shall be NSF/ANSI 60 approved for use in potable water.
- C. Chlorine for disinfection shall be in the form of sodium hypochlorite solution or calcium hypochlorite granules or tablets, in accordance with the requirements of AWWA Standards B300, C651, C652, and C653 (as applicable), or as per local health department requirements.

2.03 BACTERIOLOGICAL TESTING

- A. The Owner and Engineer shall be notified by the Contractor when the respective water plant facilities are ready for bacteriological sampling after proper disinfection.
- B. The Owner shall perform bacteriological testing for verification of proper disinfection. The Contractor shall provide disinfected sample taps at locations approved by the Engineer for collection of bacteriological samples in accordance with AWWA Standards and local health department requirements. Samples for bacteriological analysis shall be collected in sterile bottles treated with sodium thiosulfate.

2.04 SAFETY PRACTICES DURING DISINFECTION PROCEDURES

- A. Safety practices outlined in Division 01 shall be followed during all disinfection activities and procedures.
- B. Disinfection activities performed in the field by the Contractor shall be under the direct supervision of personnel who are familiar with chlorine's physiological, chemical, and physical properties. Personnel shall be trained and equipped to handle any emergency that may arise during disinfection activities. Safety data sheets for all disinfection and de-chlorination chemicals shall be posted at the worksite and shall be reviewed closely by the Contractor and their field staff. Safety practices to protect working personnel, the Owner's staff, and the public shall be observed at all times.
- C. Appropriate OSHA personal protective equipment and proper safety procedures shall be used when handling chemicals for all disinfection and de-chlorination activities described herein.
- D. The Contractor shall be prepared for work in confined spaces, ensuring proper safety procedures are followed while performing all work.
- E. The Contractor shall ensure the safety of all workers and plant staff in the disinfection work areas at all times and shall fully comply with all OSHA, Federal, State, and Local rules and regulations.

- F. The Contractor's safety plan shall be submitted to the Owner and Engineer for approval before disinfection and de-chlorination activities commence.

PART 3 – EXECUTION

3.01 GENERAL

A. Scheduling

1. The Owner and Engineer shall be provided with a detailed plan for cleaning, flushing, bacteriological sampling and testing, maintaining disinfected conditions in working areas, treatment and/or disposal of super-chlorinated water, and disinfection plan for approval. **The Owner and Engineer reserve the right to adjust, modify, and/or alter the proposed plan to serve the best interests of the Owner at no additional cost to the Owner.**
2. The final disinfection plan shall be approved by the Owner and Engineer prior to all on-site disinfection activities.
3. The Contractor shall coordinate all work with the Engineer and Owner's Site Representative at a time mutually agreeable to the Owner and shall give the Owner at least one (1) week advance notice of the intent to begin flushing, testing, and disinfecting any portion of the water treatment and potable water distribution system.
4. All flushing, testing, and disinfection shall be witnessed by the Engineer and a representative of the Owner. All work shall be coordinated with the Engineer at a time mutually agreeable to the Owner, and Contractor shall provide at least twenty-four (24) hours' advance notice prior to performing any work.
5. The Owner shall be advised when the tank, vessel, or pipe is ready for bacteriological sampling. The pipe shall be sampled in accordance with the applicable AWWA Standard(s).

B. Cleaning and Flushing

1. Contractor shall clean and flush all facilities described herein in accordance with these Specifications. The times for flushing shall be coordinated with the Owner and Engineer. There shall be no claim for monetary compensation from the Owner for the inability of the Owner to provide adequate water at the proposed time of flushing. Compensation is limited to an extension of time to perform flushing activities.
2. All materials required for cleaning and flushing shall be furnished by the Contractor.

3. When disinfection methods generate chlorine solutions for disinfection, after all disinfection activities are complete the chlorine disinfection solution shall be thoroughly flushed out and directed to an approved means of disposal prior to bacteriological testing of disinfected facilities, as described in the applicable AWWA Standard(s). The Contractor shall observe all OSHA rules and regulations and safety procedures while performing the disinfection work. A disposal plan shall be submitted by the Contractor to the Owner and the Engineer's Site Representative prior to tank, vessel, and pipe cleaning, filling, or disinfection.
4. Cleaning via physical means and/or flushing of all facilities will be required prior to initiating disinfection activities. The Engineer will inspect facilities after cleaning and flushing and shall provide approval of work before the Contractor proceeds with disinfection of facilities, as described herein.
5. The Contractor shall prevent contaminating materials from entering piping systems by removing, through flushing or other means, those materials that have entered the piping and/or appurtenances. Openings in the piping shall be closed with water-tight plugs when pipe laying is stopped at the close of the day's work.
6. If the piping is flooded during construction, the Contractor shall clear the floodwater by draining, followed by flushing the main with potable water until the main is clean – before proceeding with pipeline disinfection activities.
7. Spent chlorine solution shall be disposed of in such a way so as not to be detrimental to animal, plant, or fish life, per local, State and Federal rules and regulations. An NSF-approved reducing agent may be added to the highly chlorinated water to neutralize and reduce the chlorine residual to an acceptable regulatory level before returning flow to the plant stormwater collection system or to receiving surface water bodies. Reducing agents shall be added to chlorinated water as part of the Contractor's disinfection schedule and plan.
8. The Contractor shall prevent excessive chlorinated wastewater from flowing onto private property or into receiving streams. Wastewater from cleaning, flushing, and de-chlorination shall be directed to on-site locations, as directed by the Owner and Engineer, for further treatment. Wastewater disposal sites shall be approved by the Owner. Any discharge of wastewater shall be in full compliance with all Federal, State, and local rules and regulations. Care shall be exercised to prevent all wastewater from entering trenches or from wetting backfill material. All materials required for cleaning, flushing and de-chlorination shall be furnished by the Contractor. All civil penalties, fines, permitting costs, assessments, etc., associated with any discharge of spent chlorine solution associated with this work shall be paid accordingly by the Contractor.
9. Chlorine residual tests will be made after flushing to assure that the chlorine residual is not in excess of 1 ppm.

C. General Disinfection Requirements

1. All basins, pipes, vessels, and appurtenances shall be filled slowly either through an existing valve or through taps. Special care shall be exercised in loading lines and filling basins, vessels, and pipes to prevent damage and ensure proper evacuation of air. The Contractor shall coordinate with the Owner the operation of all existing valves. All valve operations shall be performed by the Owner's personnel only.
2. The Contractor shall install all chemical systems, test and operate the systems, and remove them from the site when work has been completed.

3.02 DISINFECTION OF GAC CONTACTORS

- A. Disinfection of the GAC contactor cells, inclusive of all fixed internal contents (underdrains, troughs, gullets, valves, etc.), shall be conducted in accordance with the instructions herein and AWWA C653 unless an alternate procedure is required by the State of North Carolina.
- B. Prior to installing the GAC media, the Contractor shall wash down each contactor cell to remove all dirt and loose materials prior to disinfection. Potable water shall be used to clean each gravity contactor cell. Prior to both testing and disinfecting procedures, cells shall be cleaned thoroughly by hosing down all surfaces with a high-pressure hose and nozzle. All water, dirt and foreign matter accumulated during this cleaning operation shall be properly de-chlorinated as needed, discharged from the structure, and disposed.
- C. Following washdown, each contactor cell shall be filled to the maximum water level. Sufficient chlorine shall be injected into the fill water to produce a free chlorine residual of at least 25 mg/L throughout the cell. The chlorinated water shall stand in the contactor for a minimum of 12 hours. At the end of the 12-hour contact time, the chlorinated water shall be tested to determine the amount of free chlorine residual. If the free chlorine residual is less than 15 mg/L, the chlorination process shall be repeated. When satisfactory chlorine residuals are obtained after the chlorine contact period, a bacteriological test shall be performed. Alternative methods of disinfection may be employed as permitted by AWWA C653.
- D. The Contractor shall advise the Owner when each contactor cell is ready for bacteriological sampling and testing. The cell shall be sampled for the bacteriological test by the Owner in accordance with the requirements specified herein and AWWA C653.
- E. After satisfactory test results are achieved on the contents of the chlorinated GAC Contactor, water shall be directed to waste, or a backwash sequence shall be performed to remove the highly chlorinated water from the GAC contactor cell. The chlorinated

water shall be properly dechlorinated by the Contractor in a manner acceptable to the Owner and Engineer and in accordance with AWWA C655.

- F. After the chlorinated water has been removed from the contactor cell, the GAC media shall be placed into the cell as specified in Section 43 31 13.13 - GAC Adsorption System Media. The GAC media shall be stored and handled to avoid any contamination. Any equipment used in placing the GAC media into the contactor cell must be cleaned and disinfected with a 200 mg/L solution of free residual chlorine immediately before use. In addition, workers coming into contact with the GAC media or entering the contactor shall wear rubber boots and gloves that have been previously disinfected with a 200 mg/L free residual chlorine solution in accordance with AWWA C653.

3.03 DISINFECTION OF FILTERED WATER, GAC INFLUENT, AND GAC EFFLUENT CHANNELS

- A. Disinfection of channels shall be conducted in accordance with the instructions herein and AWWA C653 unless an alternate procedure is required by the State of North Carolina.
- B. The Contractor shall wash down the interior of each channel to remove all dirt and loose materials prior to disinfection. Potable water shall be used to clean each surface. Prior to both testing and disinfecting procedures, channels shall be cleaned thoroughly by hosing down all surfaces with a high-pressure hose and nozzle. All water, dirt and foreign matter accumulated during this cleaning operation shall be properly de-chlorinated as needed, discharged from the structure, and disposed.
- C. Following washdown, each channel shall be filled to the maximum water level. Sufficient chlorine shall be injected into the fill water to produce a free chlorine residual of at least 25 mg/L throughout the volume. The chlorinated water shall stand in the channel for a minimum of 12 hours. At the end of the 12-hour contact time, the chlorinated water shall be tested to determine the amount of free chlorine residual. If the free chlorine residual is less than 15 mg/L, the chlorination process shall be repeated. When satisfactory chlorine residuals are obtained after the chlorine contact period, a bacteriological test shall be performed. Alternative methods of disinfection may be employed as permitted by AWWA C653.
- D. The Contractor shall advise the Owner when each channel is ready for bacteriological sampling and testing. Sampling for the bacteriological test shall be conducted by the Owner in accordance with the requirements specified herein and AWWA C653.
- E. After satisfactory test results are achieved on the contents of the chlorinated volume, the fill water shall be directed to waste. The chlorinated water shall be properly dechlorinated by the Contractor in a manner acceptable to the Owner and Engineer and in accordance with AWWA C655.

3.04 DISINFECTION OF PUMP CANS, FILTERED WATER PIPING, AND GAC EFFLUENT PIPING

- A. Disinfection of pump cans and all filtered water and GAC effluent piping and valves shall be performed by the Contractor as specified herein, in Section 40 05 00, and in accordance with AWWA C651.
- B. The Contractor shall clean and disinfect all new pump cans and water piping (new or existing) impacted by construction activities. All disinfection activities shall be performed as described herein, prior to returning the water piping systems into service, in accordance with the regulations of the local health department and the State regulatory agency, and as specified herein.
- C. Potable water shall be used for all disinfection activities. Cleaning via physical means and/or flushing of all pipelines will be required prior to initiating disinfection activities.
- D. Before a new or existing water main is chlorinated for disinfection, it shall be filled with potable water to eliminate air pockets, and then flushed to remove all particulates. The times for flushing shall be coordinated with the Engineer and Owner as part of the disinfection schedule and plan.
- E. The Contractor shall pressure test the water mains to ensure that each main meets the allowable leakage rate prior to disinfection. Potable water shall be used for all pressure testing activities.
- F. Pump cans, filtered water piping, and GAC effluent piping shall be disinfected after all piping has been pressure/leak tested and cleaned through flushing. Each shall be filled with potable water that has been chlorinated to 25 mg/L for the minimum holding period defined in AWWA C651 (temperature dependent), and there shall be a free chlorine residual of not less than 10 mg/L after the holding period. Alternative methods of disinfection may be employed as permitted by AWWA C651.
- G. The Contractor shall be responsible for maintaining acceptable drinking water chlorine residuals, sanitary conditions, and any subsequent bacteriologic testing needed to verify that the water is suitable for distribution should a component of the project stand idle for an extended period. The means of maintaining water quality through circulation or supplementation of treated drinking water shall be approved by the Owner and Engineer.

END OF SECTION

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SECTION 33 05 39.23
REINFORCED CONCRETE PIPE

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. Furnish all labor, equipment and materials in connection with the installation of exterior underground reinforced concrete pipe for sewer, low-head pressure piping, and concrete culverts and storm drains as shown on the Contract Drawings and specified herein.
- B. Special care shall be exercised during delivery, distribution and storage of the pipe and fittings to prevent damage. Damaged pipe will be rejected and shall be replaced at the Contractor's expense. Storage of pipe and fittings, prior to use, shall be in such a manner as to keep the materials clean and dry.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 01 11 00 – Summary of Work
- B. Section 31 00 01 – Earthwork
- C. Section 33 05 61 – Utility Structures
- D. Section 40 05 00 – Basic Mechanical Requirements.
- E. Section 40 06 20 – Schedules

1.03 REFERENCES

- A. ASTM C 76 - Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe.
- B. ASTM C 150 - Standard Specification for Portland Cement
- C. ASTM C 361 - Standard Specification for Reinforced Concrete Low-Head Pressure Pipe
- D. ASTM C 443 - Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets
- E. ASTM D 698 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12 400 ft-lbf/ft³ (600 kN-m/m³))

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- F. ASTM C 990 - Standard Specification for Joints for Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint Sealants
- G. ASTM C 1479 - Standard Practice for Installation of Precast Concrete Sewer, Storm Drain, and Culvert Pipe Using Standard Installations
- H. ASTM C 1628 - Standard Specification for Joints for Concrete Gravity Flow Sewer Pipe, Using Rubber Gaskets
- I. ASTM D 2487 - Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
- J. ASTM D 4253 - Standard Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table
- K. ASTM D 4254 - Standard Test Methods for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density
- L. AASHTO M 43 - Standard Specification for Sizes of Aggregate for Road and Bridge Construction

1.04 SUBMITTALS

- A. Furnish and submit shop drawings and certificates for the piping work as outlined in the General Conditions and Division 1.
- B. Product Data – Contractor shall submit complete reinforced concrete pipe product data showing conformance to the Contract Drawings and these specifications, including, but not limited to materials used and conformance to the noted standards and specifications.

PART 2 – PRODUCTS

2.01 REINFORCED CONCRETE SEWER PIPE

- A. Reinforced concrete sewer pipe (RCP) shall be manufactured in accordance with ASTM C 76, Wall Type B or C, unless otherwise specified herein; and shall be of the class that equals or exceeds the pipe class as specified in Section 40 06 20 – Schedules. Minimum pipe laying lengths shall be four (4) feet. Portland cement shall conform to ASTM C 150, Type II.
- B. Pipe shall have bell and spigot ends with O-ring rubber gaskets. The spigot end of the pipe shall contain a special groove or slot to receive and hold the gasket in position during the joint assembly. The complete joint shall be subjected to hydrostatic tests conforming to ASTM C 443.

- C. All pipe and specials shall be aged at the manufacturing plant for at least fourteen (14) days before delivery to the job site.
- D. The interior of all pipe shall have a heavy-bodied coal tar coating. The coating shall consist of two (2) coats of Ruff Stuff 2100, as manufactured by Indurall Coatings, Inc., Bitumastic Super Service Black, as manufactured by KOP-COAT, Inc., or equal. Each coat shall have a minimum thickness of 12 mils dry film. The coal tar shall be applied as recommended by the manufacturer. Steel or cast-iron bell wall fittings shall be provided wherever the pipe is connected to a structure.

2.02 REINFORCED CONCRETE LOW-HEAD PRESSURE PIPE (RCP-ASTM C361)

- A. Reinforced concrete low-head pressure pipe shall be manufactured in accordance with ASTM C361, and shall be of the class that equals or exceeds the pipe class as specified in Section 40 06 20 - Schedules. Minimum pipe laying lengths shall be twelve (12) feet.
- B. Pipe shall have steel joint rings with O-ring rubber gaskets. The gaskets shall be smooth solid rubber of circular and uniform cross section and shall be confined in an annular space formed by shoulders on the bell and spigot or in a special groove in the spigot to receive and hold the gasket in position during the joint assembly. The complete joint shall be subjected to hydrostatic tests conforming to ASTM C361.
- C. All pipe and specials shall be aged at the manufacturing plant for at least fourteen (14) days before delivery to the job site.
- D. The interior of the pipe shall have a heavy-bodied coal tar coating. The coating shall consist of two (2) coats of Ruff Stuff 2100, as manufactured by Indurall Coatings, Inc., Bitumastic Super Service Black, as manufactured by KOP-COAT, or equal. Each coat shall have a minimum thickness of 12 mils dry film. The coal tar shall be applied as recommended by the manufacturer. Steel or cast-iron bell wall fittings shall be provided wherever the pipe is connected to a structure.

2.03 REINFORCED CONCRETE CULVERT AND STORM DRAIN PIPE

- A. Pipe and Joints
 - 1. Reinforced concrete pipe for storm drains and culverts shall conform to ASTM Standard C76, Class III, Wall thickness B, unless otherwise noted on the Contract Drawings. Elliptical reinforcement will not be permitted. All pipe shall be aged at the manufacturing plant for at least fourteen (14) days before delivery to the job site. All pipe shall be of the sizes indicated on the drawings
 - 2. Pipe joints shall be designed per ASTM C-443-19a and ASTM C-1628 –19. Pipe shall be provided with bell and spigot ends.
- B. Gaskets

1. Gaskets shall be leak-resistant with elastomeric seals (gaskets) made of natural rubber, synthetic rubber, or a blend of both meeting the physical requirements prescribed in Specification ASTM 1619-19 for Class A, C, or E gaskets.

C. Joint Lubricant

1. Joint lubricant shall be of the type recommended by the manufacturer. Use of petroleum-based lubricants is not permitted.

2.04 BACKFILL MATERIAL

- A. The material obtained from excavation of the pipe trench or elsewhere on site with a particle size not greater than 3 inches shall be used for pipe backfill if they conform with the soil classes given in Table 1. Imported materials meeting the criteria of Table 1 may also be used.

Table 1: Acceptable Backfill Material and Compaction Requirements

Soil Classifications				
Description	ASTM D 1479	ASTM D 2487	AASHTO M 43	Minimum Standard Proctor Density %
Graded or crushed, crushed stone, gravel	Class I	--	5 56	Dumped
Well-graded sand, gravels and gravel/sand mixtures, poorly graded sand, gravels and gravel/sand mixtures; little or no fines	Class II	GW GP SW SP	57 6	95%
Silty or clayey gravels, gravel/sand/silt or gravel and clay mixtures; silty or clayey sands, sand/clay or sand/silt mixtures	Class III	GM GC SM SC	Gravel and Sand (<10% fines)	95%

PART 3 – EXECUTION

3.01 INSPECTION

- A. Each length of pipe and fittings delivered to the property shall be inspected by the Contractor, in the presence of the Engineer, for flaws, cracks, dimensional tolerances and compliance with the referenced Standards. The Contractor shall provide the Engineer with suitable templates or calipers for checking pipe dimensions. Only lengths of pipe and fittings accepted by the Engineer and so marked may be installed in the work.

3.02 INSTALLATION

- A. The laying of reinforced concrete pipe shall conform to the applicable sections of the Concrete Pipe Handbook as published by the American Concrete Pipe Association.
- B. Trenching, bedding and backfilling shall be as specified in Section 31 00 01 – Earthwork of these Specifications and Paragraph 2.04 - Backfill Material of this Specification. Under no condition shall pipe be laid in water or when trench conditions or weather are unsuitable for such work.
- C. All pipes and fittings shall be handled carefully in loading and unloading. They shall be lifted by hoists or lowered on skidways in such a manner as to avoid shock. Derricks, ropes or other suitable equipment shall be used for lowering the pipe into the trench. Pipe and fittings shall not be dropped or dumped.
- D. Each pipe and fitting shall be inspected before it is lowered into the trench. The interior of the pipe and all joint surfaces shall be thoroughly cleaned and shall thereafter be maintained clean. The open ends of pipe shall be securely plugged whenever pipe laying is not in progress.
- E. Pipe and fittings shall be selected so that there will be as small a deviation as possible at the joints and so that inverts present a smooth surface. All joints shall be installed, made up and inspected in accordance with approved printed instructions of the manufacturer. Pipe and fittings which do not fit together to form a tight joint will be rejected.
- F. Cutting of reinforced concrete pipe will be permitted only at connections to structures and be accomplished by abrasive saws. Cutting of other pipe materials shall be done only with mechanical cutters and in accordance with the manufacturer's recommendations.
- G. Pipe shall be laid accurately to the lines and grades shown on the drawings or as directed by the Engineer.
- H. If an adequate foundation for the pipe is not available at the desired depth, additional excavation shall be required, and the foundation brought to desired grade with suitable granular material.
- I. Rock outcroppings, very soft soils such as muck, and other similar materials not providing proper foundation support shall be removed/replaced with suitable granular material.
- J. Bedding material directly under the pipe invert shall be left in native condition and not compacted. Pipe shall be placed on the bedding, then backfilled under the pipe haunches before further backfill is placed.

- K. Class I materials may be dumped around pipe. Voids shall be eliminated by knifing under and around the pipe or by other approved technique.
- L. Inorganic silts, and gravelly, sandy, or silty clays, and other Class IV materials (not shown in Table 1) shall not be used for pipe backfill.
- M. Any section of the pipe that is found defective in material, alignment, grade, joints, or otherwise, shall be satisfactorily corrected by the Contractor at no additional cost to the Owner.

3.03 COMPACTION

A. General

- 1. Place and assure backfill and fill materials achieve an equal or higher degree of compaction than undisturbed materials adjacent to the work.
- 2. In no case shall degree of compaction below "Minimum Compactions" specified be accepted.

- B. Compaction Requirements: Unless noted otherwise on the Drawings or more stringently by other Sections of these Specifications, comply with following trench compaction criteria:

Table 2: Minimum Compactions

Location	Soil Type	Density
Compacted Select Backfill		
All applicable areas	Cohesive soil	95 percent of maximum dry density by ASTM D698
	Cohesionless soils	75 percent of maximum relative density by ASTM D4253 and ASTM D4254
Common Trench Backfill		
Under pavements roadways surfaces, D698 within highway rights-of-way, adjacent to retaining walls	Cohesive soils	95 percent of maximum dry density by ASTM D698
	Cohesionless soils	75 percent of maximum relative density by ASTM D4253 and ASTM D4254
Under turf, sodded plant seeded, non-traffic areas	Cohesive soils	95 percent of maximum dry density by ASTM D698
	Cohesionless soils	75 percent of maximum relative density by ASTM D4253 and ASTM D4254

- C. Ensure backfill materials have moisture content within three (3) percent of optimum moisture content at the time of placement.

3.04 INSPECTION AND TESTING

A. General

1. The Contractor shall provide at his own expense, all labor, material, video and measuring devices, water, plugs, or other equipment necessary to perform the required tests. All tests shall be performed in the presence of the Engineer and evaluated in accordance with the AASHTO LRFD Bridge Construction Specification Sections 27.6.4 & 5 and the ACPA "Post Installation and Evaluation and Repair of Installed Reinforced Concrete Pipe" Manual. Disposal of water shall be in accordance with Section 01 11 00 – Summary of Work.

B. Tests by Manufacturer

1. DIP, PVC, and HDPE - An infiltration and exfiltration test for the pipe shall be made at the place of manufacture. Certified test results shall be submitted. The infiltration or exfiltration allowance shall not exceed 250 gallons per inch of pipe diameter per mile per day. One joint test for each two hundred feet of pipe to be furnished.

C. Field Test - Visual Inspection of installed RCP

1. Examine structures and pipes for:
 - a. Physical damage.
 - 1) Crack less than or equal to 0.01" – Acceptable
 - 2) Crack between 0.01" and 0.10" – Evaluation required: Is crack detrimental and in a corrosive environment? (PH<5.5)
 - a) If non-corrosive or not detrimental – OK
 - b) If corrosive and detrimental – Seal crack
 - 3) Crack equal to or greater than 0.10". Evaluation is required
 - a) If not detrimental – OK
 - b) If detrimental – Repair and seal crack
 - c) If not repairable – remediate or replace
 - b. Indication of displacement of pipes or structures, reinforcement, forms, or bedding.

- c. Deflection and joint separation shall be within the tolerances as specified by AASHTO or the manufacturer, which is more restrictive
 - c. Slabbing or spalling. Porous areas or voids.
 - d. Proper placement of seals, gaskets, and embedments.
 - e. Visible infiltration.
- 2. Verify structures and pipes are set to proper line, grade as per the Contract Drawings, and are plumb.
- 3. Verify structure and pipe dimensions and thickness match Contract Drawings.
- 4. Measure inside dimensions of all flexible (HDPE) pipe prior to installation. Use these dimensions when sizing the mandrel should deflection testing be required.
 - a. Using light to inspect pipe shall be done following pipe trench backfill is compacted and brought to grade or pavement subgrade.
 - b. Full pipe diameter shall be visible for entire length of each section between structures.
 - c. No less than half pipe diameter shall be visible for horizontal alignment.
- 5. The Contractor shall be responsible for providing video recording of the all installed storm sewer systems at least 30 days after completion of backfill and one month before Owner or Engineer gives final acceptance for the two-year warranty. The recording shall be made using a color camera, self-propelled or other, having sufficient light to show detail of problem areas and joints. Camera speed shall not exceed 3 feet per second. If problems or concerns are seen by the operator, then the camera shall be reversed and an extended look at the area will be recorded. All recordings will have time, date, and footage displayed. Supplement the video recording with a written log or orally recorded tape log noting observations, findings, and deficiencies shown on the video tape.
 - a. The video recording inspection shall be performed by an outside independent testing agency acceptable to the Owner or Engineer.
 - b. The video tape and log will be given to the Engineer for review. If the Engineer finds any problems with the storm sewer, the Contractor will repair the problem and re-camera the repaired area before final acceptance will be given, at no added cost to the Owner.

- c. Video recording of storm sewer may be waived if pipe diameter is sufficient for human access, as determined by the Engineer. A log shall be developed for such inspection.
- d. One copy of the video tape and log will become permanent property of the Engineer and Owner as record.

D. Field Test - Manhole Testing

- 1. The finished manholes shall be as watertight as the pipe system of which it is part. See Section 33 05 61 – Utility Structures for manhole testing criteria.
- 2. Observed leaks (infiltration or exfiltration) at any time within the warranty period shall be cause for rejection.

E. Deflection Test – Flexible Pipe

- 1. If after the visual or video inspection of the storm trunk or lateral lines, the Inspector finds there is “egging or deflection” of a section of pipe, a deflection test shall be performed on the defective section of pipe installed. Test shall be performed using an odd-legged mandrel pulled through the pipe without mechanical assistance or by laser profiling. The mandrel size shall be the measured inside diameter of the subject pipe minus 5% of the measured diameter. The mandrel shall have no less than nine legs.
- 2. Any pipe failing any deflection test shall be removed, replaced, and retested.
- 3. At the end of the two-year warranty period, the flexible storm pipe will be visually inspected for “egging or deflection”. If excess deflection is observed, the Owner/Warranty Holder will, at his/her expense, retest questionable portions per this section.

F. Repair

- 1. Repair or replace any damage pipe or work found unacceptable by the Engineer at no additional cost to the Owner. Repairs to RCP shall be made according to the requirements of AASHTO, ASTM C990 14.1 and the ACPA “Post Installation and Evaluation and Repair of Installed Reinforced Concrete Pipe” Manual.
- 2. Repair all visible leaks.
- 3. Remove any concrete webs or protrusions.
- 4. Remove form ties and repair tie holes.

END OF SECTION

SECTION 33 05 61
UTILITY STRUCTURES

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. Furnish all materials, labor, equipment, and tools required for the design, fabrication, delivery and installment of utility structures and appurtenances in accordance with the Drawings and as specified herein.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 03 21 00 – Reinforcing Steel
- B. Section 03 30 00 – Cast-in-Place Concrete
- C. Section 03 60 00 – Grout
- D. Section 04 05 13 – Mortar and Masonry Grout
- E. Section 05 05 23 – Metal Fastening
- F. Section 05 56 00 – Castings
- G. Section 31 00 01 - Earthwork
- H. Section 33 24 00 – Storm Drains and Roof Drains
- I. Section 40 05 00 - Basic Mechanical Requirements

1.03 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

- A. Without limiting the generality of the other requirements of the specifications, all work herein shall conform to the applicable requirements of the following documents. All referenced specifications, codes, and standards refer to the most current issue available at the time of Bid.
 - 1. ASTM C32 - Standard Specification for Sewer and Manhole Brick (Made from Clay or Shale)
 - 2. ASTM C139 - Standard Specification for Concrete Masonry Units for Construction of Catch Basins and Manholes

3. ASTM C443 – Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets
4. ASTM C478 – Standard Specification for Circular Precast Reinforced Concrete Manhole Sections
5. ASTM C857 – Minimum Structural Design Loading for Underground Precast Concrete Utility Structures
6. ASTM C858 – Standard Specification for Underground Precast Utility Structures
7. ASTM C890 – Minimum Structural Design Loading for Monolithic or Sectional Precast Concrete Water and Wastewater Structures
8. ASTM C913 – Standard Specification for Precast Water and Wastewater Structures
9. ASTM C923 – Standard Specification for Resilient Connectors Between Reinforced Concrete Manhole Structures, Pipes, and Laterals
10. ASTM C990 – Standard Specifications for Joints in Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint Sealants
11. ASTM C1244 - Standard Test Method for Concrete Sewer Manholes by the Negative Air Pressure (Vacuum) Test Prior to Backfill
12. ASTM C1478 - Standard Specification for Storm Drain Resilient Connectors Between Reinforced Concrete Storm Sewer Structures, Pipes, and Laterals
13. ASTM C1802 - Standard Specification for Design, Testing, Manufacture, Selection, and Installation of Horizontal Fabricated Metal Access Hatches for Utility, Water, and Wastewater Structures
14. ASTM F2510 – Standard Specification for Resilient Connectors Between Reinforced Concrete Manhole Structures and Corrugated Dual- and Triple-Wall Polyethylene and Polypropylene Pipes
15. ASCE/SEI 7-16 – Minimum Design Loads and Associated Criteria for Buildings and other Structures

1.04 SUBMITTALS

- A. Submit samples and/or Shop Drawings in accordance with Section 01 33 00 – Submittal Procedures.
- B. Shop Drawings shall include, but not be limited to:
 - 1. Shop drawings for all precast concrete items showing all dimensions, locations, and type of lifting inserts, and details of reinforcement and joints.
 - 2. Complete layout and installation Drawings and schedules with clearly marked dimensions.
 - 3. Material certificates on all piping materials.
 - 4. A list of the design criteria used by the manufacturer for all manufactured, precast items.
 - 5. Structural design calculations sealed by a Professional Engineer registered in the State or Commonwealth in which the project is located. Design calculations for precast manholes and vaults shall include confirmation structures adequately resist flotation when they are totally empty and subjected to groundwater full height of structure. The factor of safety for buoyancy due to groundwater conditions as noted above shall be 1.25. Factors of safety for other design conditions shall be as per ASCE 7-16, Section 4.2 - Safety Factors.
 - 6. Certified reports for all lifting inserts, indicating allowable design loads.
 - 7. Information on lifting and erection procedures.
 - 8. Results of leakage test

PART 2 – PRODUCTS

2.01 PRECAST MANHOLES AND UTILITY STRUCTURES

- A. Design requirements vary for manholes, for utility structures exposed to internal liquid, and for utility structures not exposed to internal liquid, as follows:
 - 1. All precast manholes shall conform to the following requirements (regardless of exposure to internal liquid):
 - a. Precast manholes shall conform to the requirements of ASTM C478 and shall be designed for loads in accordance with ASTM C890.

- b. Precast manholes shall be watertight for infiltration and exfiltration. Joints between manhole riser sections and at base slabs shall conform to the requirements of ASTM C443.
 - c. Manhole section shall have an internal diameter of 4'-0", unless noted otherwise. Clear lid openings shall be minimum of 24-inch diameter.
 - 2. Precast utility structures exposed to internal liquid (other than manholes) shall include but not be limited to water and wastewater distribution boxes, yard inlets, and catch basins. These structures shall conform to the following requirements:
 - a. Precast utility structures exposed to internal liquid (other than manholes) shall conform to the requirements of ASTM C913 and shall be designed for loads in accordance with ASTM C890.
 - b. Precast utility structures exposed to internal liquid shall be watertight for infiltration and exfiltration. Joints between riser sections and at base slabs shall conform to the requirements of ASTM C443.
 - 3. Precast utility structures not exposed to internal liquid (other than manholes) shall include but not be limited to vaults and meter boxes for piping, and utility structures for electric, gas, or communication lines. These structures shall conform to the following requirements:
 - a. Precast utility structures not exposed to internal liquid (other than manholes) shall conform to the requirements of ASTM C858 and shall be designed for loads in accordance with ASTM C857.
 - b. Precast utility structures not exposed to internal liquid shall be soil-tight and shall be watertight for infiltration when below groundwater. Joints between riser sections and at base slabs shall conform to the requirements of either ASTM C443 or ASTM C990.
- B. In addition to the requirements above, the following requirements are typical for all precast manholes and utility structures:
- 1. Precast manholes and utility structures shall be furnished with sleeves and openings as noted on the Drawings, conforming accurately to the sizes and elevations of the adjoining pipes or conduits.
 - 2. Precast manholes and utility structures shall include ballast concrete and/or other means necessary to ensure they resist flotation when empty and subjected to groundwater full height of structure.

3. Precast manholes and utility structures shall be as manufactured by Oldcastle, Tindall Corporation, or equal.
4. The date and name of manufacturer shall be marked inside each precast section.
5. No more than two lift holes may be cast or drilled in each section.
6. Dimensions shall be as shown on the Drawings.
7. Covers and frames shall be as specified herein.
8. Mechanical Details such as piping, electrical, and other details shall be as shown on the Drawings.

2.02 BRICK

- A. Brick shall be sound, hard-burned common brick conforming to ASTM C32, Grade MS.

2.03 MORTAR

- A. Mortar shall conform to Section 04 05 13 – Mortar and Masonry Grout.

2.04 CONCRETE

- A. Concrete shall conform to Section 03 30 00 – Cast-in-Place Concrete.

2.05 REINFORCING

- A. Reinforcing shall conform to Section 03 21 00 – Reinforcing Steel.

2.06 CONCRETE BLOCK

- A. Concrete block shall be solid, rectangular concrete masonry units conforming to ASTM C139.

2.07 CASTINGS

- A. Castings shall conform to Section 05 56 00 – Castings. Casting shall be of the type and size indicated on the Drawings.

2.08 STEPS

- A. Steps shall be constructed of Grade 60 steel reinforcing rod (min. 1/2-inch) and completely encapsulated with a wear resistant and chemical resistant rubber.

- B. Each step shall have a minimum vertical load resistance of 800 pounds and a minimum pull-out resistance of 400 pounds.
- C. The steps shall have 11-inch minimum tread width and shall be placed at 16-inches on center, as shown on the Drawings.
- D. Steps shall be cast in place with the concrete.
- E. Steps shall only be installed as shown on the Drawings or required in the Specifications.

2.09 JOINT SEALANTS AND GASKETS

- A. For precast utility structure joints required to conform to ASTM C990, joint sealant shall be a preformed flexible sealant conforming to the requirements of ASTM C990, paragraph 6.2, Butyl Rubber Sealant. Joint sealant shall be Pro-Stik Butyl Sealant by Press-Seal Corporation, Butyl-Nek Join Sealant by Henry Company, CS-102 Butyl Rubber Sealant for all Precast Structures by ConSeal Concrete Sealants, Inc., or equal.
- B. For precast utility structure joints required to conform to ASTM C443, gaskets shall be rubber gaskets conforming to the requirements of ASTM C443.

2.10 PIPE TO MANHOLE CONNECTIONS

- A. The spring set type shall have a stainless-steel interior power sleeve or expander and shall be the PSX assembly by Press-Seal Gasket Corporation, the Kor-N-Seal® | 106-406 Series assembly by National Pollution Control Systems, or QUIK-LOK Boot Connector by A-LOK Products, Inc, or equal.
- B. The cast-in-place type shall conform to ASTM C923-18 for sanitary sewer connections between reinforced concrete manhole structures, pipes, and laterals, ASTM C1478-19 for storm drain connections between pipes, and laterals, and ASTM F2510 for storm drain connections between reinforced concrete manhole structures, and dual and triple-wall polyethylene and polypropylene pipes. Sleeves shall include stainless steel take up clamps.
- C. Flexible seal assemblies shall permit at least an eight (8) degree deflection from the center line of the opening in any direction while maintaining a watertight connection.

2.11 COVERS AND FRAMES

- A. Covers and frames shall comply with Section 05 56 00 – Castings and shall be provided by the utility structure manufacturer.
- B. Manhole covers and frames shall meet the following requirements:

1. Locate so that there is ready access to the manhole steps
 2. Clear opening shall be a minimum of 22 inches, unless otherwise indicated on the Drawings.
 3. Watertight manhole frames and covers shall be suitable for 20 psi internal pressure and shall be Neenah Model R-1915, Type E or equal, cast in place.
 4. Non-watertight manhole covers shall be perforated and shall be Neenah Model R-1668, or equal.
 5. Storm drain grated inlet frames and grates shall be Neenah R-1878-B7L, East Jordan Iron Works V-4873, or equal.
 6. Curb inlet frames and grates shall be Neenah R-3067, East Jordan Iron Works EJ 7030, or equal, and shall include frame, grate, and hood.
- C. Vault covers shall have lifting handles and shall be bolted with stainless steel bolts complying with Section 05 05 23 – Metal Fastening.
- D. The Load Level capacity of fabricated metal access hatches as noted on the Contract Drawings shall be in conformance with the requirements of ASTM C1802.
- E. Frames and covers shall be identical throughout the Contract.

2.12 GRATES

- A. Grates shall comply with Section 05 56 00 – Castings.

2.13 CONCRETE BALLAST

- A. Concrete ballast shall be Class B concrete in conformance with Section 03 30 00 – Cast-in-Place Concrete. Ballast shall be provided as necessary to ensure manhole resists flotation when empty and subjected to full height groundwater conditions.

2.14 EPOXY BONDING AGENT

- A. Epoxy bonding agent shall conform to ASTM C881 and shall be Sikadur 32 Hi-Mod, Sika Corporation, Lyndhurst, N.J.; Euco #452 Epoxy System, Euclid Chemical Company, Cleveland, OH, MasterEmaco ADH Series by Master Builders Solutions.

PART 3 – EXECUTION

3.01 DESIGN CRITERIA

- A. Minimum structural design loading for underground precast concrete manholes and utility structures shall be in accordance with the applicable document of ASTM C890 or ASTM C857 unless otherwise noted herein. Precast items subjected to vehicular traffic shall be designed for HS-20 traffic loading. Other precast items shall be designed for a vertical live load of 300 psf.
- B. Walls of precast items shall be designed for a vertical surcharge resulting in a 100 psf horizontal load.
- C. Precast manholes and vaults shall be designed to resist flotation when totally empty and subjected to groundwater full height of the manhole/vault.

3.02 FABRICATION AND CASTING

- A. Fabrication and casting of precast manholes and utility structures shall conform to the applicable ASTM documents specified herein.
- B. All base sections designated to receive concrete ballast and all electrical manholes shall extend monolithically a minimum of 6 inches beyond the outside face of the wall for the entire periphery. All other utility structures shall have a standard base.
- C. Utility structures built around existing pipe shall have a cast-in-place base slab.

3.03 HANDLING, TRANSPORTING, AND STORING

- A. Precast members shall not be transported away from the casting yard until the concrete has reached the minimum required 28-day compressive strength and a period of at least 5 days has elapsed since casting, unless otherwise permitted by the Engineer.
- B. No precast member shall be transported from the plant to the job site prior to approval of that member by the plant inspector. This approval will be stamped on the member by the plant inspector.
- C. During handling, transporting, and storing, precast concrete members shall be lifted and supported only at the lifting or supporting points as indicated on the shop drawings.
- D. All precast members shall be stored on solid, unyielding, storage blocks in a manner to prevent torsion, objectionable bending, and contact with the ground.
- E. Precast concrete members shall not be used as storage areas for other materials or equipment.

- F. Precast members damaged while being handled or transported will be rejected or shall be repaired in a manner approved by the Engineer.

3.04 INSTALLATION

- A. Installation of precast manholes and utility structures shall conform with the manufacturer's recommendations.
- B. Frames and covers or grates shall be set so that tops are at elevations indicated on the Drawings or flush with finished grade where no elevation is indicated.
- C. Joints between riser sections shall be sealed with joint sealant or gaskets as specified herein.
- D. All openings in utility structures shall have flexible rubber sleeves sized to fit the connecting pipe and installed to provide watertight joints in accordance with the manufacturer's recommendations. The interior of the sleeve shall be filled with Class B concrete.
- E. Openings that are too large for flexible rubber sleeves shall utilize rubber bladder seals which are expanded by water injected using a pressure pump.
- F. All units shall be installed plumb and level.
- G. All lift holes and joints shall be filled with non-shrink grout conforming to Section 03 60 00 – Grout, grout inside and out.
- H. The manhole frames shall be set to their required elevations either with grade rings or with two or three courses of brick masonry laid around the top of the upper wall section. Such brick work shall be given a 1-inch mortar coat on the inside and out.
- I. Concrete ballast shall be placed so that it bears directly on the utility structure base against the outer wall monolithically encircling the structure for the full height indicated on the Drawings. Additional ballast may be required where the depth or elevation of the structure varies from the Drawings.
- J. Brick or Concrete Block
 - 1. Brick or concrete blocks shall be laid with broken joints and all horizontal and vertical joints filled with cement-sand mortar. The outside of walls shall be plastered with a minimum 1-inch-thick coat of cement-sand mortar troweled smooth.
- K. Connection to Existing Pipe

1. Verify the diameter and invert elevation of existing pipe to be connected to new utility structures prior to beginning work on the structures.
 2. Provide adequate protection to prevent damage to the existing pipe.
 3. Provide adequate means for plugging and/or transferring the existing flow in the pipe to allow for the construction of inverts and grouting.
 4. Cut off the existing pipe sufficiently for connection to the new structure and remove.
 5. Thoroughly clean all foreign matter and coat the pipe surface with epoxy adhesive where the pipe joins the new structure.
 6. Install a flexible joint sealer around the pipe.
 7. Grout inside and outside of wall penetration with non-shrink grout.
- L. Backfill structures in accordance with Section 31 00 01 – Earthwork.
- M. Clean all structures of any accumulation of silt, debris, or foreign matter and keep clean until final acceptance of the work.
- N. Excavation shall conform to Section 31 00 01 – Earthwork.
- O. Structure bases shall bear on a minimum of 8-inches of compacted stone unless otherwise indicated on the Drawings.
- P. Channel Inverts
1. Inverts shall be placed using Class B concrete with forms sufficient to provide a smooth half-round shape as shown on the Drawings. Manhole bases employing full depth precast inverts are acceptable.
 2. Where the slope of the line does not change through a manhole, a constant slope shall be maintained in the invert. Where slope changes occur within a given manhole, the transition shall be smooth and shall occur at the approximate center of the manhole.
 3. Inverts shown on the Drawings are taken at the center of the manhole unless otherwise noted.

3.05 ADJUSTMENTS TO EXISTING UTILITY STRUCTURES

- A. Adjust structures as indicated on the Drawings using concrete or cast-iron adjustment rings by approved methods.

- B. Clean covers and inlet castings of all foreign material.

3.06 ADJUSTING COLLARS AND FINAL ADJUSTMENTS

- A. Adjusting collars shall be as shown on the Drawings, or as necessary meet final grade. Final adjustments shall be made so that the manhole ring and cover will be smooth and flush with the finished grade of the adjacent surface, or as otherwise indicated on the Drawings for manholes shown above grade.

3.07 LEAKAGE TESTING FOR MANHOLES

- A. All manholes shall be vacuum tested as specified below. Refer to Section 33 24 00 – Storm Drains and Roof Drains for storm water pipe testing methods and requirements and Section 40 05 00 – Basic Mechanical Requirements for sanitary pipe testing methods and requirements.
- B. Manhole vacuum testing shall include the following minimum requirements:
1. Testing shall be done in accordance with ASTM C1244 (latest revision).
 2. Prior to testing all pipes, holes, and vents entering manhole shall be plugged and braced.
 3. Contractor shall have an approved test head and copy of instructions for use by the manufacturer.
 4. Contractor shall furnish two (2) certified and calibrated vacuum test gauges for the test.
 - a. A vacuum of 10-inch hg shall be drawn on the manhole, the valve on the vacuum line of the test head closed, and the vacuum pump shut off. The time for the vacuum pressure to drop to 9-inch hg shall be measured. If the test time meets or exceeds the test time as specified in Table 1, the manhole is acceptable; otherwise, the test has failed and the manhole should be checked for leaks, repaired, and re-tested.

Table 1
Minimum Vacuum Test Times (Seconds) for Various Manhole Diameters and Depths

Depth (ft)	Manholes Ø (inches)						
	48	60	72	84	96	108	120
6'	15	20	25	29	34	38	43
8	20	26	33	38	45	51	57

Depth (ft)	48	60	72	84	96	108	120
10	25	33	41	48	56	63	71
12	30	39	49	57	67	76	85
14	35	46	57	67	78	89	100
16	40	52	67	76	89	101	114
18	45	59	73	86	100	114	128
20	50	65	81	95	111	126	142
22	55	72	89	105	122	139	156
24	59	78	97	114	133	152	170
26	64	85	105	124	144	164	185
28	69	91	113	133	155	177	199
30	74	98	121	143	166	189	213
Add. VF	+2.5	+3.25	+4.0	+4.75	+5.5	+6.5	+7.0

3.08 FLUSHING AND TESTING OF SEWERS

- A. After backfilling, all sewers shall be inspected for obstructions and shall be flushed with water. Flushing shall be a minimum velocity of 2.5 feet per second for a duration acceptable to the Engineer. Flushing shall remove all dirt, stones, pieces of wood and other debris which accumulated in the sewer during construction. The Contractor shall provide a means acceptable to the Engineer for removal of debris flushed from each section of sewer. If after flushing, any obstructions remain, they shall be removed at the Contractor's expense.
- B. Visual Inspection – Sewer lines shall be visually inspected from every manhole by use of mirrors, television cameras, or other devices for visual inspection, and the lines shall all exhibit a fully circular pattern when viewed from one manhole to the next. Lines which do not exhibit a true line and grade or have structural defects shall be corrected to meet these qualifications. Any visual water infiltration of water into the manhole shall be repaired using hydraulic cement or other approved materials.
- C. Leakage – Sewers shall be tested for leakage. The program of testing shall fit the conditions as mutually determined by the Engineer and the Contractor. The Contractor shall take all necessary precautions to prevent any joints from drawing while the sewers or their appurtenances are being tested. The Contractor shall, at the Contractor's own expense, correct any excess leakage and repair any damage to the pipe and their appurtenances, or to any structures resulting from or caused by these tests.
- D. Leakage Test Procedure – Each section of sewer shall be tested by closing the lower end of the sewer to be tested and the inlet sewer of the upper manhole with stoppers and filling the pipe and manhole with water to a point 6 feet above the crown of the open sewer in the upper manhole, or, if ground water is present, 6 feet above the sections average adjacent ground water level as indicated by a monitor well installed adjacent to

each manhole. The line shall be filled with water prior to testing and allowed to stand until the pipe has reached its maximum absorption, but not less than two (2) hours. After maximum absorption has been reached, the head shall be reestablished and tested for at least six (6) hours maintaining the head specified above by measured additions of water. The sum of these additions shall be the leakage for the test period.

1. If ground water is present to a height of at least 6 feet above the crown of the sewer at the upper end of the pipe section to be tested, the leakage test may be made by measuring the rate of infiltration using a suitable weir or other measuring device approved by the Engineer. Whether the test is made by infiltration or exfiltration, the allowable leakage shall not exceed 100 gallons per day per inch of diameter per mile of sewer being tested.
 2. Where the actual leakage exceeds the allowable, the Contractor shall discover the cause and correct it before the sewer will be accepted. A section of sewer is defined as that length of sewer between successive manholes or special structures or stub-outs for future connections.
- E. Low Pressure Compressed Air Test – If the leakage cannot be located by infiltration or exfiltration testing, this type test may be used. The pipeline shall be considered acceptable, when tested at an average pressure of 3.0 psi greater than the average back pressure of any groundwater that may submerge the pipe if the section under test does not lose air at a rate greater than 0.0030 cfm per sq. ft. of internal pipe surface.
- F. Deflection Test – No sooner than thirty (30) days after final backfill installation, each section of PVC pipe shall be checked for vertical deflection using an electronic deflectometer or a rigid "GoNoGo" device. Vertical deflection shall not exceed five (5) percent of the inside pipe diameter for PVC pipe.
1. Where the actual deflection exceeds the allowable, the Contractor shall discover the cause and correct before the pipe will be acceptable. A section of sewer is defined as that length of sewer between successive manholes or special structures or stubouts for future connections.
- G. Cost of Testing and Repairs – Any and all work necessary to bring the line into conformance with the infiltration and deflection specifications shall be performed by the Contractor at no extra cost to the Owner. All apparent sources of infiltration and excessive deflection shall be repaired by the Contractor.
1. The Contractor shall provide all water, plugs, hoses, pumps, equipment, etc. necessary for the proper flushing and testing of the sewers.

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SECTION 33 71 19
UNDERGROUND ELECTRICAL

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. The Contractor shall furnish and install underground duct systems, electric manholes, and electric handholes as specified herein and as indicated on the Drawings. The work shall be complete and shall include excavation, concrete construction, backfilling, and all materials, items, and components required for a complete system.
- B. The provisions of this Section are applicable to all underground conduit work. All work shall be coordinated with that of the various utility companies and other Contractors. The Contractor shall adhere to all utility company requirements including the serving electric utility.
- C. Reference the following Specification Sections:
 - 1. Section 26 05 00 – Basic Electrical Requirements
 - 2. Section 26 05 33.13 – Conduit for Electrical Systems
 - 3. Section 26 05 26 – Grounding and Bonding for Electrical Systems
 - 4. Applicable sections of Division 31, Earthwork
 - 5. Section 03 21 00 – Reinforcing Steel
 - 6. Section 03 30 00 – Cast-In-Place Concrete
 - 7. Section 33 05 61 – Utility Structures

1.02 CODES AND STANDARDS

- A. Products specified herein shall be designed, manufactured, and/or listed to the following standards as applicable:
 - 1. AASHTO H20
 - 2. ANSI/SCTE 77-2010 – Specification for Underground Enclosure Integrity

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1.03 SUBMITTALS

- A. In accordance with the procedures and requirements set forth in the General Conditions and Section 01 33 00 – Submittal Procedures, the Contractor shall obtain from the equipment manufacturer and submit Shop Drawings. Each submittal shall be identified by the applicable Specification Section.

1.04 SHOP DRAWINGS

- A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.
- B. Partial, incomplete, or illegible submittals will be returned to the Contractor without review for resubmittal.
- C. Shop drawings shall include but not be limited to, the following:
 - 1. Product data sheets.
 - 2. Outline and dimensional drawings including detailed sections of the manholes and/or handholes.
 - 3. Materials specifications and structural calculations for the manholes sealed by a Professional Engineer licensed in the State or Commonwealth in which the project is located.

1.05 IDENTIFICATION

- A. Each electric manhole and handhole cover shall be lettered with the word "Electric", the manhole or handhole identification number (e.g., UMH-1, EMH-1, EHH-1, etc.), manufacturer's name or trademark, and such other information as the manufacturer may consider necessary, or as specified, for complete identification. Manhole covers for the manholes furnished and installed as part of the medium voltage underground raceway system for the electric utility shall be lettered with the acronym "15 kV".

PART 2 – PRODUCTS

2.01 MANUFACTURERS

- A. The material covered by this Specification is intended to be standard material of proven performance as manufactured by reputable concerns. Material shall be fabricated, constructed, and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as specified herein and indicated on the Drawings.

2.02 DUCT SYSTEM

- A. The underground duct system shall be comprised of conduits, conduit bends, and conduit fittings as specified in Section 26 05 33.13 – Conduit for Electrical Systems. Conduits shall be encased in reinforced concrete envelopes, unless otherwise specified herein or indicated on the Drawings.
- B. Base and intermediate conduit spacers shall be furnished to provide a minimum of two-inch (2") separation between conduits. Conduit spacers shall be provided in the proper size as required for the conduit that they secure. For example, a 4" conduit spacer shall not be used to secure a 2" conduit. Conduit spacers shall be as manufactured by Carlon Electrical Products Company, Aeroquip Corporation, Underground Devices, Incorporated, or Engineer approved equal.

2.03 ELECTRIC MANHOLES

- A. The concrete manholes shall be complete with metal frames and covers of size and location as specified herein and shown on the Drawings.
- B. Manhole frames and covers shall be Neenah R-1640C1, or equal, with Type A anchor ring. Entire manhole assembly shall be AASHTO H20 heavy duty rated. Precast manholes shall be constructed in accordance with the applicable requirements of Section 33 05 61, Utility Structures. Covers shall be furnished with drop handles.
- C. All electric manholes shall be provided with non-metallic cable racks. Cable racks shall be rated for the application, with a minimum loading capacity of 450 lbs. per rack arm. Cable rack system shall be Heavy Duty type as manufactured by Underground Devices, Incorporated or Engineer approved equal.

2.04 ELECTRIC HANDHOLES

- A. The electric handholes shall be a precast polymer concrete enclosure suitable for use as part of an underground electric raceway system. The enclosure shall meet or exceed the requirements of ANSI/SCTE 77-2010.
- B. The enclosure and cover design and test load rating shall be Tier 15. Covers shall be provided with cover hooks.
- C. The enclosure shall be the straight side design to allow easy adjustment of box to grade. The box shall be stackable for increased depth.
- D. Handhole opening size shall be as required to suit the application, 6" x 8", minimum.
- E. The electric handholes shall be manufactured by Hubbell, Pencil Plastics equivalent, Highline Products equivalent, or Engineer approved equal.

PART 3 – EXECUTION

3.01 GENERAL

- A. The underground duct system, manholes, and handholes shall be installed as specified herein, indicated on the Drawings, and in accordance with manufacturers' instructions.

3.02 DUCT SYSTEM

- A. All underground conduits shall be encased in concrete and shall be reinforced. Encasement and reinforcement shall be as indicated in the Standard Details. Concrete shall be furnished and installed in accordance with Section 03 30 00 – Cast-In-Place Concrete. Reinforcing steel shall be furnished and installed in accordance with Section 03 21 00 – Reinforcing Steel.
- B. Concrete pours shall be complete from handhole to handhole and from manhole to manhole where practicable. Partial pours in general shall not be permitted. Where a complete pour is impractical, written authorization shall be obtained from the Engineer for the partial pour.
- C. Conduit ductbank elevations at the manholes and handholes shall be based on minimum ductbank cover as indicated in the Standard Details, or deeper to avoid conflicts with other obstacles. Refer to Drawings for routing options. Where deviation is necessary to clear unforeseen obstacles, the elevations may be changed after authorization by the Engineer.
- D. Slope all conduits continuously away from structures and buildings with a minimum slope of 3" per 100' unless otherwise indicated on the Drawings.
- E. The minimum clearance from the top of the concrete encasement and finished grade shall be as indicated in the Standard Details, except where otherwise accepted in writing by the Engineer or shown on the Drawings.
- F. Care shall be exercised during excavation for the duct banks to prevent digging too deep. Backfilling of low spots with earth fill will not be permitted unless thoroughly compacted and acceptable to the Engineer.
- G. If a specific ductbank arrangement is shown on the Drawings, the conduits in that ductbank shall be arranged as shown. Where no specific ductbank arrangement is shown on the Drawings, the Contractor shall arrange conduits within each ductbank based on field conditions. Spare conduits shown going from ductbanks into buildings or structures shall be stubbed up in the location(s) as indicated on the Drawings.
- H. The ends of the bare copper cables embedded in the concrete ductbank shall be connected to structure and/or building ground rings where the ductbanks terminate, and to each other in manholes and handholes as specified herein.

- I. Care shall be exercised and temporary plugs shall be installed during installation to prevent the entrance of concrete, mortar, or other foreign matter into the conduit system. Conduit spacers shall be utilized to support conduit during the pouring of concrete to prevent movement and misalignment of the conduits. Conduit spacers shall be installed in accordance with manufacturer's instructions unless otherwise noted. Horizontal spacing of conduit spacers along ductbank shall be as indicated on the Standard Details.
- J. Where connections to existing underground conduits are indicated, excavate to the maximum depth necessary. After addressing the existing conductors, cut the conduits and remove loose concrete from the conduits before installing new concrete encased ducts. Provide a reinforced concrete collar, poured monolithically with the new duct line, to take the shear at the joint of the duct lines.
- K. Construct concrete-encased conduits connecting to underground structures to have a flared section adjacent to the manhole to provide shear strength. Construct underground structures to provide shear strength. Construct underground structures to provide for keying the concrete encasement of the duct line into the wall of the structure. Use vibrators when this portion of the encasement is poured to ensure a seal between the encasement and the wall of the structure.
- L. Six (6) inches above all duct banks, the Contractor shall furnish and install a two (2) inch wide red plastic electrical hazard tape. Tapes shall be metallic detectable type and shall have a continuous message in bold black letters: "ELECTRIC LINE BURIED BELOW." Tape shall be Detectable Identoline by Brady or Engineer approved equal.
- M. The Contractor shall perform all earthwork including excavation, backfill, bedding, compaction, shoring and bracing, grading, and restoration of surfaces and seeded areas disturbed during the execution of the Work.
- N. All conduit joints in the duct system shall be staggered such that adjacent conduits do not have joints in the same location.

3.03 ELECTRIC MANHOLES

- A. Electric manholes shall be installed to a sufficient depth to accommodate the required grading of ducts as well as maintaining a minimum distance of 14" from the bottom of the lowest duct centerline entrances to finished floor line and/or highest duct centerline entrance to the roof. All manholes shall be built on or placed over a 6" layer of well-tamped gravel.
- B. Duct envelopes and conduit with bell ends shall enter at approximately right angles to the walls, except as may otherwise be shown on the Drawings.
- C. All concrete work and fully assembled manholes shall be completely watertight and shall be furnished with sloped floors that pitch towards a sump pit. The outside surfaces shall be coated with an approved asphaltic waterproofing compound (all sides, bottom, and

roof). Precast concrete manholes may be installed; however, all requirements of this Section and other Divisions of the Specifications and the details shown on the Drawings shall apply.

- D. Install pulling eye irons imbedded in walls opposite each duct entrance securely fastened to manhole reinforcing rods. All hardware shall be hot-dipped galvanized steel.
- E. A ground rod and a ground bar, furnished in accordance with Section 26 05 26 – Grounding and Bonding for Electrical Systems, shall installed at each manhole. Ground rod shall be driven within each manhole. The ground bar shall be installed inside each manhole. The area around the ground rod shall be grouted after ground rod installation. A No. 4/0 AWG bare copper ground cable shall be connected between the ground rod and the ground bar. The bare copper ground cable located within each duct bank shall also be connected to the ground bar. No. 6 AWG bare copper cables shall be connected from all non-current carrying metal parts in the manhole to the ground bar. All cable connections at the ground bar shall be NEMA 2-hole style lugs with irreversible compression style barrel made of copper or aluminum. Aluminum lugs shall be marked with an AL/CU rating for use on copper conductors.
- F. All cables shall be well supported by non-metallic cable racks. The cable racks shall be heavy-duty type for medium and low voltage power cables and light -duty type for control, signal, communications, and similar small conductors. All racks shall be rigidly attached to the wall and equipped with adjustable rack arms.

3.04 ELECTRIC HANDHOLES

- A. Electric handholes shall be installed to a sufficient depth to accommodate the required grading of ducts as well as maintaining a minimum distance of 9" from the bottom of the lowest duct centerline entrances to finished floor line and/or highest duct centerline entrance to roof. All handholes shall be installed in accordance with Standard Detail E-33-0103.
- B. Duct envelopes and conduit with bell ends shall enter at approximately right angles to the walls, except as may otherwise be shown on the Drawings.
- C. All individual cables and/or bundles of conductors shall be identified and "dressed" along the wall of the enclosure. Cable racks as specified herein shall be provided if any handhole dimension exceeds 24 inches.

3.05 TESTING

- A. All tests shall be performed in accordance with the requirements of the General Conditions and Division 01. The following tests are required:
 - 1. Field tests

- a. Field tests for all completed duct systems shall consist of pulling a swab through each conduit followed by a mandrel equal in size to 85% of the conduit inside diameter.
- b. After testing, all conduits shall be capped after installation of a suitable pull rope. All field tests shall be witnessed by the Engineer.

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SECTION 40 05 00
BASIC MECHANICAL REQUIREMENTS

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. The Contractor shall furnish and install to the required line and grade, all piping together with all fittings and appurtenances, required for a complete installation. Piping to be backfilled and/or encased in concrete is considered to be buried piping. Piping that is not buried is considered to be exposed.
- B. The Contractor shall furnish and install fittings, couplings, connections, sleeves, adapters, harness rods and closure pieces as required to connect pipelines of dissimilar materials and/or sizes herein included under this Section and other concurrent Contracts for a complete installation.
- C. The Contractor shall furnish all labor, materials, equipment, tools, and services required for the furnishing, installation and testing of all piping as shown on the Drawings, specified in this Section and required for the Work. Piping shall be furnished and installed of the material, sizes, classes, and at the locations shown on the Drawings and/or designated in this Section. Piping shall include all fittings, adapter pieces, couplings, closure pieces, harnessing rods, hardware, bolts, gaskets, wall sleeves, wall pipes, hangers, supports, and other associated appurtenances for required connections to equipment, valves, or structures for a complete installation.
- D. Piping assemblies under 4-inch size shall be generally supported on walls and ceilings, unless otherwise shown on the Drawings or ordered by the Engineer, being kept clear of openings and positioned above "headroom" space. Where practical, such piping shall be run in neat clusters, plumb and level along walls, and parallel to overhead beams.
- E. The Contractor shall provide taps on piping where required or shown on the Drawings. Where pipe or fitting wall thicknesses are insufficient to provide the required number of threads, a boss or pipe saddle shall be installed.
- F. The work shall include, but not be limited to, the following:
 - 1. Connections to existing pipelines.
 - 2. Test excavations necessary to locate or verify existing pipe and appurtenances.
 - 3. Installation of all new pipe and materials required for a complete installation.
 - 4. Cleaning, testing and disinfecting as required.

- G. All piping, fittings, and valves conveying potable water, used in potable water treatment, or conveying chemicals used in potable water treatment shall be NSF/ANSI 61 certified.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Division 01 – General Requirements
- B. Division 02 – Existing Conditions
- C. Division 05 – Metals
- D. Division 09 – Finishes
- E. Division 26 – Electrical
- F. Division 46 – Water and Wastewater Equipment

1.03 MATERIAL CERTIFICATION AND SHOP DRAWINGS

- A. The Contractor shall furnish to the Owner (through the Engineer) a Material Certification stating that the pipe materials and specials furnished under this Section conform to all applicable provisions of the corresponding Specifications. Specifically, the Certification shall state compliance with the applicable standards (ASTM, AWWA, etc.) for fabrication and testing.
- B. Shop Drawings for major piping (2-inches in diameter and greater) shall be prepared and submitted in accordance with Section 01 33 00 – Submittal Procedures. In addition to the requirements of Section 01 33 00 – Submittal Procedures, the Contractor shall submit laying schedules and detailed Drawings in plan and profile for all piping as specified and shown on the Drawings.
- C. Shop Drawings shall include, but not be limited to, complete piping layout, pipe material, sizes, class, locations, necessary dimensions, elevations, supports, hanger details, pipe joints, and the details of fittings including methods of joint restraint. No fabrication or installation shall begin until Shop Drawings are approved by the Engineer.

PART 2 – PRODUCTS

2.01 GENERAL

- A. All specials and every length of pipe shall be marked with the manufacturer's name or trademark, size, class, and the date of manufacture. Special care in handling shall be exercised during delivery, distribution, and storage of pipe to avoid damage and unnecessary stresses. Damaged pipe will be rejected and shall be replaced at the Contractor's expense. Pipe and specials stored prior to use shall be stored in such a manner as to keep the interior free from dirt and foreign matter.

- B. Testing of pipe before installation shall be as described in the corresponding ASTM or AWWA Specifications and in the applicable standard specifications listed in the following sections. Testing after the pipe is installed shall be as specified in Part 3.
- C. Joints in piping shall be of the type as specified in the appropriate Piping System Schedule in Section 40 06 20 – Process Pipe, Valve, and Gate Schedules.
- D. All buried piping shall have restrained joints for thrust protection unless otherwise specified or shown on the Drawings. All exposed piping shall have flanged joints, unless otherwise specified or shown on the Drawings.
- E. The Drawings indicate work affecting existing piping and appurtenances. The Contractor shall excavate test pits as required of all connections and crossings which may affect the Contractor's work prior to ordering pipe and fittings to determine sufficient information for ordering materials. The Contractor shall take whatever measurements that are required to complete the work as shown or specified.

2.02 WALL PIPES

- A. Where wall sleeves or wall pipes occur in walls that are continuously wet on one or both sides, they shall have water stop flanges at the center of the casting or as shown on the Drawings. Ends of wall pipes shall be flange, mechanical joint, plain end, or bell as shown on the Drawings, or as required for connection to the piping. Wall pipes shall be of the same material as the piping that they are connected to. If welded waterstop flanges are employed, welds shall be 360 degree continuous on both sides of flange. Unless otherwise shown on the Drawings, waterstop flanges shall conform to the minimum dimensions shown below:

Pipe Size	Waterstop Flange Diameter	Waterstop Flange Thickness
4" - 12"	OD + 3.10"	0.50"
14" - 24"	OD + 4.15"	0.75"
30" - 36"	OD + 4.50"	1.00"
42" - 48"	OD + 5.00"	1.25"
54"	OD + 5.90"	1.50"

2.03 SLEEVES

- A. Unless shown otherwise, all piping passing through walls and floors shall be installed in sleeves or wall castings accurately located before concrete is poured or placed in position during construction of masonry walls. Sleeves passing through floors shall extend from the bottom of the floor to a point 3 inches above the finished floor, unless shown otherwise. Water stop flanges are required on all sleeves located in floors or

walls which are continually wet or under hydrostatic pressure on one or both sides of the floor or wall.

- B. Sleeves shall be cast iron, black steel pipe, or fabricated steel in accordance with details shown on the Drawings. If not shown on the Drawings, the Contractor shall submit to the Engineer the details of sleeves he proposes to install; and no fabrication or installation thereof shall take place until the Engineer's approval is obtained. Steel sleeves shall be fabricated of structural steel plate in accordance with the standards and procedures of AISC and AWS. Steel sleeve surfaces shall receive a commercial sandblast cleaning and then be shop painted in accordance with Section 09 90 00 – Painting.
- C. When shown on the Drawings or otherwise required, the annular space between the installed piping and sleeve shall be completely sealed against a maximum hydrostatic pressure of 20 psig. Seals shall be mechanically interlocked, solid rubber links, trade name "Link-Seal", as manufactured by Garlock Pipeline Technologies (GPT) or equal. Rubber link, seal-type, size, and installation thereof, shall be in strict accordance with the manufacturer's recommendations. For non-fire rated walls and floors, pressure plate shall be glass reinforced nylon plastic with EPDM rubber seal and 316 stainless steel bolts and nuts. For fire rated walls and floors, two independent seals shall be provided consisting of low carbon steel, zinc galvanized pressure plates, silicon rubber seals and 316 stainless steel bolts and nuts.
- D. Cast iron mechanical joint adapter sleeves shall be Clow # 1429, as manufactured by the Clow Corp., or equal. Mechanical joint adapter sleeves shall be provided with suitable gasket, follower ring, and bolts to affect a proper seal. In general, sleeves installed in walls, floors, or roofs against one side of which will develop a hydrostatic pressure, or through which leakage of liquid will occur, shall be so sealed. If welded waterstop flanges are employed, welds shall be 360 degree continuous on both sides of flange.

2.04 SOLID SLEEVE COUPLINGS (FOR BURIED SERVICE THROUGH 54-INCH)

- A. Solid sleeve couplings shall be used to connect buried service piping where shown on the Drawings. Solid sleeves shall be ductile iron, long body and shall conform to the requirements of ANSI A21.10 (AWWA C110). Unless otherwise shown or specified, solid sleeve couplings shall be Style A11760 as manufactured by American Cast Iron Pipe Co., or equal. Solid sleeve couplings shall be restrained with wedge-type restraining glands to meet the pressures specified in 40 06 20 – Schedules.
- B. Alternatively, EBAA Iron 3800 Mega-Coupling is acceptable.

2.05 SLEEVE TYPE COUPLINGS (FOR EXPOSED SERVICE AND BURIED SERVICE ABOVE 54-INCH)

- A. Sleeve type, flexible couplings shall be furnished and installed where shown on the Drawings or otherwise required to resist internal operating pressures. In addition to that specified herein, harnessed, sleeve type flexible couplings shall be provided on all exposed pipe 3 inches and larger in diameter that spans any expansion joint in a building or structure.
- B. Materials shall be of high strength steel and couplings shall be rated for the same pressures as the connecting piping.
- C. Gaskets shall be rubber. Bolts and nuts shall be alloy steel, corrosion-resistant and prime coated.
- D. Harnessing for exposed applications shall be by rodding across the sleeve type coupling to the nearest pipe joint on either side of the coupling using threaded rods and rod tabs unless otherwise approved by the Engineer.
- E. Couplings shall be as manufactured by Smith-Blair Model 411, Romac Industries Model 400, Dresser Industries Style 38, or equal as required and shown on the Drawings. All couplings shall be provided without interior pipe stop.
- F. Couplings shall be provided with manufacturer's fusion bonded epoxy painting system.

2.06 FLANGED COUPLING ADAPTERS

- A. Flanged coupling adapters shall be furnished as required and as shown on the Drawings.
- B. Flanged coupling adapters shall be of ductile iron or carbon steel construction and shall be rated for the same pressure as the connected piping.
- C. All flanged coupling adapters shall be harnessed by tying the adapter to the nearest pipe joint flange using threaded rods and rod tabs unless otherwise approved by the Engineer.
- D. Flanged coupling adapters shall be manufactured by Smith-Blair Model 912 or 913, Romac Industries Model FCG or FC 400, Dresser Industries Model 128-W, or equal.
- E. Flanged coupling adapters shall be provided with manufacturer's fusion bonded epoxy painting system.

2.07 DISMANTLING JOINTS

- A. Dismantling joints shall be furnished at locations shown on the Drawings.

- B. Dismantling joints for sizes less than 12-inch shall be of ductile iron or carbon steel construction and shall be rated for the same pressure as the connected piping. Dismantling joints for sizes greater than 12-inches shall be of carbon steel construction and shall be rated for the same pressure as the connected piping.
- C. Flanges for dismantling joints shall match the bolt pattern and pressure rating of the flanges for the connected piping.
- D. All dismantling joints shall be restrained utilizing restraining rods provided by the manufacturer. Restraining rods shall be constructed from ASTM A193 Grade B7 steel. Restraining rods and restraint system shall be installed in strict accordance with manufacturer's recommendations.
- E. Dismantling joints shall be provided with manufacturer's fusion bonded epoxy painting system.
- F. Dismantling joints shall be manufactured by Smith Blair Model 975, Romac Industries Model DJ400, or equal.

2.08 GROOVED COUPLINGS

- A. Grooved end pipe couplings shall be furnished as specified or shown on the Drawings.
- B. Materials shall be of malleable iron and couplings shall be rated for the same pressures as the connecting piping.
- C. Gaskets shall be rubber. Bolts and nuts shall be heat treated carbon steel track bolts and shall be plated.
- D. After installation, buried couplings shall receive two heavy coats of an approved coal tar which is compatible with the finish of the coupling. Exposed couplings shall be painted in accordance with Section 09 90 00 – Painting.
- E. Couplings shall be manufactured by Victaulic Company of America Style 31 or equal.

2.09 TAPPING SLEEVES AND TAPPING SADDLES

- A. Tapping sleeves shall be similar to Mueller Outlet Seal, American Uniseal or Kennedy Square Seal. All sleeves shall have a minimum working pressure of 150 psi. All sleeves larger than twelve (12) inches shall be ductile iron. All taps shall be machine drilled; no burned taps will be allowed.
- B. Tapping saddles may be used on mains sixteen (16) inches and larger where the required tap size does not exceed one-half the size of the main (i.e. 8-inch tapping saddle for use on a 16-inch main). Tapping saddles shall be manufactured of ductile iron providing a factor of safety of at least 2.5 at a working pressure of 250 psi. Saddles shall

be equipped with a standard AWWA C-110-77 flange connection on the branch. Sealing gaskets shall be "O" ring type, high quality molded rubber having an approximate seventy durometer hardness, placed into a groove on the curved surface of the tapping saddles. Straps shall be of alloy steel. The tapping saddle shall be the American tapping saddle, U.S. Pipe tapping saddle, or equal. All taps shall be machine cut, no burned taps will be allowed.

2.10 UNIONS

- A. For ductile iron, carbon steel, and grey cast iron pipes assembled with threaded joints and malleable iron fittings, unions shall conform to ANSI B16.39.
- B. For copper piping, unions shall have ground joints and conform to ANSI B16.18.
- C. For PVC and CPVC piping, unions shall be socket weld type with Viton O-ring.

2.11 THERMOPLASTIC TUBING AND FITTINGS

- A. Thermoplastic tubing shall be manufactured from polyallomor tubing. Tubing shall be protected from ultraviolet radiation degradation with a black coating or integral color conforming to ASTM D-1248, Type 1, Class C, Category 3. Fittings and connectors used with thermoplastic tubing shall be the flareless tube type constructed of brass conforming to SAE CA377, SAE CA360 or equal. Brass sleeves shall be used.
- B. Assembly of the thermoplastic tubing shall consist of pushing the tubing into the fitting and hand tightening the nut with final tightening with a wrench. Care shall be taken not to overtighten the nut. Plastic tube racks and bend holders shall be provided for holding the tubing in position. Needle valves used with thermoplastic tubing shall be the globe type constructed with a brass body, stem and seat and Buna-N "O"-ring seals. Installation shall be in accordance with the manufacturer's recommendations. Thermoplastic tubing shall be the Impolene (polyallomor) system and needle valves, fittings and connectors shall be the Poly-Flo with 261 UB Universal Nut and Sleeve system as manufactured by Imperial Eastman, or equal.

2.12 HEAT TRACED PIPING

- A. Exposed pipes to be insulated shall also be protected from freezing by heat tracing where indicated on the Drawings and in the Specifications. Heat tracing of piping shall be provided as specified in Section 40 06 20 – Process Pipe, Valve and Gate Schedules and in Section 40 41 13 – Heat Tracing Systems.

2.13 FLEXIBLE RESTRAINED EXPANSION JOINTS

- A. Restrained expansion joints shall be manufactured of 60-42-10 ductile iron conforming to material and other applicable requirements of ANSI/AWWA C153/A21.53.

- B. Each pressure containing component shall be lined with a minimum of 15 mils of fusion bonded epoxy conforming to the materials requirements of, and tested in accordance with, ANSI/AWWA C213 and shall meet or exceed the requirements of ANSI/AWWA C550.
- C. Seals shall conform to the applicable requirements of ANSI/AWWA C111/A21.11.
- D. All bolts used in the assemblies shall be stainless steel and shall be coated with a premium quality epoxy.
- E. Flanged ends shall comply with ANSI/AWWA C110/A21.10, with the addition of O-ring groove and O-ring.
- F. Mechanical joint ends shall comply with ANSI/AWWA C153/A21.53.
- G. Restrained expansion joints shall have a minimum pressure rating of 350 psi with a minimum safety factor of 3:1. Each assembly shall be tested at 350 psi before shipment.
- H. Restrained expansion joints shall provide for self-restraint without tie rods and shall provide for expansion and contraction capabilities cast as an integral part of the end connection.
- I. Flexible restrained expansion joints shall allow for 8-inches (+6"-2") minimum expansion.
- J. Flexible restrained expansion joints shall consist of an expansion joint designed and cast as an integral part of a ball and socket type flexible joint having a minimum of 15□ deflection per ball.
- K. Restrained expansion joints shall be the Single Ball or Double Ball FLEX-TEND Expansion Joint as manufactured by EBAA Iron Inc., or equal.

PART 3 – EXECUTION

3.01 INSTALLATION

- A. All piping shall be installed by skilled workmen and in accordance with the best standard practice for piping installation as shown on the Drawings, specified or recommended by the pipe manufacturer. Proper tools and appliances for the safe and convenient handling and installing of the pipe and fittings shall be used. Great care shall be taken to prevent any pipe coating from being damaged on the inside or outside of the pipe and fittings. All pieces shall be carefully examined for defects, and no piece shall be installed which is known to be cracked, damaged, or otherwise defective. If any defective pieces should be discovered after having been installed, it shall be removed and replaced with a sound one in a satisfactory manner by the Contractor and at his own expense. Pipe and fittings shall be thoroughly cleaned before they are installed and shall be kept clean until they

are accepted in the complete work. All piping connections to equipment shall be provided with unions or coupling flanges located so that piping may be readily dismantled from the equipment. At certain applications, Dresser, Victaulic, or equal, couplings may also be used. All piping shall be installed in such a manner that it will be free to expand and contract without injury to itself or to structures and equipment to which it is connected. All piping shall be erected to accurate lines and grades with no abrupt changes in line or grade and shall be supported and braced against movement, temporary, or permanent. All exposed piping shall be installed with vertical and horizontal angles properly related to adjoining surfaces or pipes to give the appearance of good workmanship. Unless otherwise shown or approved, provided a minimum headroom clearance under all piping of 7 feet 6 inches.

- B. Unless otherwise shown or specified, all waste and vent piping shall pitch uniformly at a 1/4-inch per foot grade and accessible cleanouts shall be furnished and installed as shown and as required by local building codes. Installed length of waste and vent piping shall be determined from field measurements in lieu of the Drawings.
- C. All excavation shall be made in such a manner and to such widths as will provide ample room for properly installing the pipe and permit thorough compaction of backfill around the pipe. The minimum trench widths shall be in strict accordance with the "Trench Width Excavation Limits" as shown on the Drawings. All excavation and trenching shall be done in strict accordance with these specifications and all applicable parts of the OSHA Regulations, 29CFR 1926, Subpart P.
- D. ALL EXCAVATION REQUIRED BY THIS CONTRACT SHALL BE UNCLASSIFIED. NO ADDITIONAL PAYMENT WILL BE MADE FOR ROCK EXCAVATION REQUIRED FOR THE INSTALLATION OF PIPE OR STRUCTURES SHOWN ON THE DRAWINGS.
- E. Enlargements of the trench shall be made as needed to give ample space for operations at pipe joints. The width of the trench shall be limited to the maximum dimensions shown on the Drawings, except where a wider trench is needed for the installation of and work within sheeting and bracing. Except where otherwise specified, excavation slopes shall be flat enough to avoid slides which will cause disturbance of the subgrade, damage to adjacent areas, or endanger the lives or safety of persons in the vicinity.
- F. Hand excavation shall be employed wherever, in the opinion of the Engineer, it is necessary for the protection of existing utilities, poles, trees, pavements, or obstructions.
- G. No greater length of trench in any location shall be left open, in advance of pipe laying, than shall be authorized or directed by the Engineer and, in general, such length shall be limited to approximately one hundred (100) feet. The Contractor shall excavate the trenches to the full depth, width and grade indicated on the Drawings including the relevant requirements for bedding. The trench bottoms shall then be examined by the Engineer as to the condition and bearing value before any pipe is laid or bedding is placed.

- H. No pressure testing shall be performed until the pipe has been properly backfilled in place. All pipe passing through walls and/or floors shall be provided with wall pipes or sleeves in accordance with the specifications and the details shown on the Drawings. All wall pipes shall be of ductile iron and shall have a water stop located in the center of the wall. Each wall pipe shall be of the same class, thickness, and interior coating as the piping to which it is joined. All buried wall pipes shall have a coal tar outside coating on exposed surfaces.
- I. JOINT DEFLECTION SHALL NOT EXCEED 75 PERCENT OF THE MANUFACTURER'S RECOMMENDED DEFLECTION. Excavation and backfilling shall conform to the requirements of Section 31 00 01 – Earthwork, and as specified herein. Maximum trench widths shall conform to the Trench Width Excavation Limits shown on the Drawings. All exposed, submerged, and buried piping shall be adequately supported and braced by means of hangers, concrete piers, pipe supports, or otherwise as may be required by the location.
- J. Following proper preparation of the trench subgrade, pipe and fittings shall be carefully lowered into the trench so as to prevent dirt and other foreign substances from gaining entrance into the pipe and fittings. Proper facilities shall be provided for lowering sections of pipe into trenches. UNDER NO CIRCUMSTANCES SHALL ANY OF THE MATERIALS BE DROPPED OR DUMPED INTO THE TRENCH.
- K. Water shall be kept out of the trench until jointing and backfilling are completed. When work is not in progress, open ends of pipe, fittings, and valves shall be securely closed so that no water, earth, or other substance will enter the pipes, fitting, or valves. Pipe ends left for future connections shall be valved, plugged, or capped, and anchored as required.
- L. All piping shall be installed in such a manner that it will be free to expand and/or contract without injury to itself or to structures and equipment to which it is connected. All piping shall be erected to accurate lines and grades with no abrupt changes in line or grade and shall be supported and braced against movement, temporary, or permanent. All exposed piping shall be installed with vertical and horizontal angles properly related to adjoining surfaces or pipes to give the appearance of good workmanship. Pipes crossing within a vertical distance of less than or equal to one (1) foot shall be encased and supported with concrete at the point of crossing to prevent damage to the adjacent pipes as shown on the Drawings.
- M. The full length of each section of pipe shall rest solidly upon the bed of the trench, with recesses excavated to accommodate bells, couplings, joints, and fittings. Before joints are made, each pipe shall be well bedded on a solid foundation; and no pipe shall be brought into position until the preceding length has been thoroughly bedded and secured in place. Pipe that has the grade or joint disturbed after laying shall be taken up and relaid by the Contractor at his own expense. Pipe shall not be laid in water or when trench conditions are unsuitable for work.

- N. Proper and suitable tools and appliances for the safe convenient handling and laying of pipe shall be used and shall in general agree with manufacturer's recommendations.
- O. AT THE CLOSE OF EACH WORK DAY, THE END OF THE PIPELINE SHALL BE TIGHTLY SEALED WITH A CAP OR PLUG SO THAT NO WATER, DIRT, OR OTHER FOREIGN SUBSTANCE MAY ENTER THE PIPELINE, AND THIS PLUG SHALL BE KEPT IN PLACE UNTIL PIPE LAYING IS RESUMED.
- P. During the laying of pipe, each pipe manufacturer shall provide his own supervisor to instruct the Contractor's pipe laying personnel in the correct procedure to be followed.
- Q. Ordinarily only full lengths of pipe (as furnished by the pipe manufacturer) shall be used exceptions: closure pieces at manholes and areas where joint deflection is required.
- R. For gravity sewer installations, the Contractor shall use a laser device to maintain the trench and pipe alignment. The laser device shall be re-checked for correct elevation and pipe alignment prior to pipe installation if the device is left in the pipe overnight. Corrected invert elevations at each manhole and any adjustments will be coordinated and approved by the Engineer.
- S. ALL PIPING SHALL HAVE TYPE "A" BEDDING AS SHOWN ON THE DRAWINGS, UNLESS OTHERWISE SPECIFIED HEREIN OR INDICATED ON THE DRAWINGS.
- T. Detector tape shall be installed 12 inches below final grade and directly above all buried potable water piping. The tape shall be blue and silver and shall be clearly and permanently labeled "Water". Detector tape shall be Lineguard III as manufactured by Lineguard, Inc., or equal.
- U. AT THE CLOSE OF WORK EACH DAY, PIPELINE TRENCHES SHALL BE COMPLETELY BACKFILLED. IN PAVED AREAS THE SURFACE SHALL BE RESTORED AS SPECIFIED IN SECTION 32 10 00 – PAVING AND SURFACING, TO ALLOW FOR TRAFFIC OVER THE TRENCH DURING NON-WORKING HOURS. UNDER NO CONDITIONS SHALL ANY PIPELINE TRENCH BE LEFT OPEN DURING NON-WORKING HOURS.

3.02 CARBON AND STAINLESS STEEL PIPE

- A. Installation of steel pipe shall be by skilled workmen and shall conform to the applicable sections of AWWA Manual M-11. Joints for steel piping shall be either screwed, welded, or flanged as shown on the Drawings or as specified.

- B. Welding in the field shall be performed only when requested on the shop drawings and permitted by the Engineer for carbon steel pipe. No welding of stainless steel pipe shall be allowed in the field. All field welds shall be radiographically inspected.
- C. Installation of the steel casing pipe shall be by skilled workmen and in accordance with the best standard practice for steel pipe installation. Joints for steel casing pipe shall be butt welded.
 - 1. The boring equipment to be used for installing the jacked casing shall be of such size and capacity to allow the boring to proceed in a safe and expeditious manner. The installation of the casing and boring of the hole shall be done simultaneously to avoid cave-ins or settlement and for safety of traffic above.
 - 2. The Contractor shall check the vertical and horizontal alignment of the casing by survey instrument at least once during each four feet of advance, or as directed by the Engineer. Pits shall be well sheeted and braced as necessary for safe and adequate access for workmen, inspectors and materials and shall be of a size suitable to equipment and material handling requirements.
 - 3. Under no conditions shall jetting or wet boring of encasement under pavement be allowed.
 - 4. After installation of the carrier pipe, each end of the casing pipe shall be made watertight with a brick masonry bulkhead. In addition, a Class B concrete cradle shall be provided from each end of the bulkhead to the first pipe joint outside of the bulkhead.

3.03 JOINTS IN PIPING

- A. Restrained joints shall be provided on all pipe joints as specified herein and shown on the Drawings. Restrained joints shall be made up similar to that for push-on joints.
- B. Push-on joints include a single rubber gasket which fits into the bell end of the pipe. The gasket shall be wiped clean, flexed and then placed in the socket. Any bulges in the gasket which might interfere with the entry of the plain end of the pipe shall be removed. A thin film of lubricant shall be applied to the gasket surface which will come into contact with the spigot end of the pipe. The lubricant shall be furnished by the pipe manufacturer. The plain end of the pipe, which is tapered for ease of assembly, shall be wiped clean and a thick film of lubricant applied to the outside. The pipe shall be aligned and carefully entered into the socket until it just makes contact with the gasket. The joint assembly shall be completed by entering the pipe past the gasket until it makes contact with the bottom of the socket. The pipe shall be pulled "home" with an approved jack assembly as recommended by the pipe manufacturer. If assembly is not accomplished by reasonable force, the plain end shall be removed, and the condition corrected.

- C. Flanged joints shall be brought to exact alignment and all gaskets and bolts or studs inserted in their proper places. Bolts or studs shall be uniformly tightened around the joints. Where stud bolts are used, the bolts shall be uniformly centered in the connections and equal pressure applied to each nut on the stud. Pipes in all lines subject to temperature changes shall be cut short and cold sprung into place to compensate for expansion when hot.
- D. Mechanical joints shall be made up with gaskets, glands and bolts. When a joint is to be made up, the bell or socket and plain end shall be cleaned and washed with a solution of mild soap in water; the gland and gasket shall be slid onto the plain end and the end then entered into the socket until it is fully "home" on the centering ring. The gasket shall then be painted with soapy water and slid into position, followed by the gland. All bolts shall be inserted and made up hand tight and then tightened alternately to bring the gland into position evenly. Excessive tightening of the bolts shall be avoided. All nuts shall be pulled up using a torque wrench which will not permit unequal stresses in the bolts. Torque shall not exceed the recommendations of the manufacturer of the pipe and bolts for the various sizes. Care shall be taken to assure that the pipe remains fully "home" while the joint is being made. Joints shall conform to the applicable AWWA Specifications.
- E. Threaded and/or screwed joints shall have long tapered full depth threads to be made with the appropriate paste or jointing compound, depending on the type of fluid to be processed through the pipe. All pipe up to, and including 1-1/2-inches, shall be reamed to remove burr and stood on end and well pounded to remove scale and dirt. Wrenches on valves and fittings shall be applied directly over the joint being tightened. Not more than three pipe threads shall be exposed at each connection. Pipe, in all lines subject to temperature changes shall be cut short and cold sprung into place to compensate for expansion when hot. Joints in all piping used for chlorine gas lines shall be made up with a glycerine and litharge cement. Joints in plastic piping (PVC/CPVC) shall be laid and joints made with compounds recommended by the manufacturer. Installation shall conform to the requirements of ASTM D2774 and ASTM D2855. Unions required adjacent to valves and equipment.
- F. Soldered joints shall have the burrs removed and both the outside of pipe and the inside of fittings shall be thoroughly cleaned by proper tools recommended for that purpose. Flux shall be applied to both pipe and inside of fittings and the pipe placed into fittings and rotated to insure equal distribution of flux. Joints shall be heated and solder applied until it shows uniformly around the end of joints between fitting and pipe. All joints shall be allowed to self-cool to prevent the chilling of solder. Combination flux and solder paste manufactured by a reputable manufacturer is acceptable. Unions required adjacent to valves and equipment.
- G. Welded joints shall be made by competent operators in a first class workmanlike manner, in complete accordance with ANSI B31.1 and AWWA C206. Welding electrodes shall conform to ASTM A233, and welding rod shall conform to ASTM A251. Only skilled

welders capable of meeting the qualification tests for the type of welding which they are performing shall be employed. Tests, if so required, shall be made at the expense of the Contractor, if so ordered by the Engineer. Unions shall be required adjacent to valves and equipment.

- H. Copper joints shall be thoroughly cleaned and the end of pipes uniformly flared by a suitable tool to the bevels of the fittings used. Wrenches shall be applied to the bodies of fittings where the joint is being made and in no case to a joint previously made. Dimensions of tubing and copper piping shall be in complete accordance with the fittings used. No flare joints shall be made on piping not suited for flare joints. Installations for propane gas shall be in accordance with NFPA 54 and/or 58.
- I. Solvent or adhesive welded joints in plastic piping shall be accomplished in strict accordance with the pipe manufacturer's recommendations, including necessary field cuttings, sanding of pipe ends, joint support during setting period, etc. Care shall be taken that no droppings or deposits of adhesive or material remain inside the assembled piping. Solvent or adhesive material shall be compatible with the pipe itself, being a product approved by the pipe manufacturer. Unions are required adjacent to valves and equipment. Sleeve-type expansion joints shall be supplied in exposed piping to permit 1-inch minimum of expansion per 100 feet of pipe length.
- J. Dielectric isolation such as flange isolation kits, dielectric unions, or similar, shall be installed wherever dissimilar metals are connected according to the following table.

	Zinc	Galvanized Steel	Aluminum	Cast Iron	Ductile Iron	Mild Steel/ Carbon Steel	Copper	Brass	Stainless Steel
Zinc			•	•	•	•	•	•	•
Galvanized Steel			•	•	•	•	•	•	•
Aluminum	•	•		•	•	•	•	•	•
Cast Iron	•	•	•				•	•	•
Ductile Iron	•	•	•				•	•	•
Mild Steel/ Carbon Steel	•	•	•				•	•	•
Copper	•	•	•	•	•	•			•
Brass	•	•	•	•	•	•			•
Stainless Steel	•	•	•	•	•	•	•	•	

	Zinc	Galvanized Steel	Aluminum	Cast Iron	Ductile Iron	Mild Steel/ Carbon Steel	Copper	Brass	Stainless Steel

Notes:

- signifies dielectric isolation is required between the two materials noted.

Consult Engineer for items not listed in table.

Provide flange isolation kits for all flanged connections of dissimilar metals and hardware including connections to equipment.

Contractor shall include all isolation descriptions with piping submittals.

- K. Eccentric reducers shall be installed where air or water pockets would otherwise occur in mains because of a reduction in pipe size.
- L. Joints in polypropylene and polyvinylidene fluoride pipe shall be butt fusion weld. All butt welding shall follow the requirements of ASTM D-2657 and the manufacturer's recommendations.

3.04 FLUSHING AND TESTING

- A. All piping shall be properly flushed and tested unless specifically exempted elsewhere in the Specifications or otherwise approved by the Engineer. Air and gas pipelines shall be flushed and tested with compressed air. Gravity sewer piping shall be flushed and tested as specified in Section 33 05 61 – Utility Structures. Polymer piping shall be tested with mineral oil or as recommended by the polymer chemical supplier. All other liquid conveying pipelines shall be flushed and tested with water. The Contractor shall furnish and install all means and apparatus necessary for getting the air or water into the pipeline for flushing and testing including pumps, compressors, gauges, and meters, any necessary plugs and caps, and any required blow-off piping and fittings, etc., complete with any necessary reaction blocking to prevent pipe movement during the flushing and testing. All pipelines shall be flushed and tested in such lengths or sections as agreed upon among the Owner, Engineer, and Contractor. Test pressures shall be as specified in Section 40 06 20 – Process Pipe, Valve and Gate Schedules and shall be measured at the lowest point of the pipe segment being tested. The Contractor shall give the Owner and Engineer reasonable notice of the time when he intends to test portions of the pipelines. Do not test exterior, exposed pipelines if air temperature is expected to fall below 32 degrees F. The Engineer reserves the right, within reason, to request flushing and testing of any section or portion of a pipeline.
- B. The Contractor shall provide water for all flushing and testing of liquid conveying pipelines. Raw water or non-potable water may be used for flushing and testing liquid pipelines not connected to the potable water system. Only potable water shall be used for flushing and testing the potable water system.

- C. Air and gas piping shall be completely and thoroughly cleaned of all foreign matter, scale, and dirt prior to start-up of the air or gas system.
- D. At the conclusion of the installation work, the Contractor shall thoroughly clean all new liquid conveying pipe by flushing with water or other means to remove all dirt, stones, pieces of wood, etc., which may have entered the pipe during the construction period. If after this cleaning any obstructions remain, they shall be corrected by the Contractor, at his own expense, to the satisfaction of the Engineer. Liquid conveying pipelines shall be flushed at the rate of at least 5.0 feet per second for a duration suitable to the Engineer or shall be flushed by other methods approved by the Engineer.
- E. Compressed/service air and gas piping shall be flushed by removing end caps from the distribution lines and operating one (1) compressor, in accordance with the manufacturer's instructions.
- F. After flushing, all air piping shall be pressure and leak tested prior to coating and wrapping of welded joints. Immediately upon successful completion of the pressure and leak test, welded joints shall be thoroughly cleaned of all foreign matter, scale, rust, and discoloration and coated in accordance with the Specifications.
- G. All process air piping shall be leak tested by applying a soap solution to each joint. Leak tests shall be conducted with one (1) blower in service at normal operating pressure.
- H. During testing the piping shall show no leakage. Any leaks or defective piping disclosed by the leakage test shall be repaired or replaced by the Contractor, at his own expense, and the test repeated until all such piping shows tight.
- I. All buried process air piping shall be pressurized to 25 psig and tested for leaks by applying a soap solution to each joint. The air supply shall be stopped and the pipe pressure monitored. System pressure shall not fall by more than 0.5% of the 25 psig test pressure over a one hour test period. Should the system fail to hold the required pressure for one hour, the cause shall be determined and corrected and the test repeated until a successful test of the entire system is obtained.
- J. Field leakage tests shall be performed for all submerged process air piping. The procedure shall consist of operating the system under clear nonpotable water for visual identification of all leaks. All field leakage tests shall be witnessed by the Engineer. All submerged piping shall be installed free of any leaks.
- K. After flushing, all liquid conveying pipelines shall be hydrostatically tested at the test pressure specified in the appropriate Piping System Schedule in Section 40 06 20 – Process Pipe, Valve and Gate Schedules. The procedure used for the hydrostatic test shall be in accordance with the requirements of AWWA C600. Each pipeline shall be filled with water for a period of no less than 24 hours and then subjected to the specified test pressure for 2 hours. During this test, exposed piping shall show no leakage. Allowable leakage in buried piping shall be in accordance with AWWA C600.

- L. Any leaks or defective pipe disclosed by the hydrostatic test shall be repaired or replaced by the Contractor, at his own expense, and the test repeated until all such piping shows tight.
- M. After flushing, all gas piping shall be leak tested in accordance with all local codes and regulations and in conformance with the recommendations or requirements of any National Institute or Association for the specific service application.

3.05 DISINFECTION OF PIPELINES

- A. Following acceptable pressure testing, flush and disinfect all sections of the water distribution system and receive approval thereof from the appropriate agencies, prior to placing in service. Do not disinfect exterior, exposed pipelines if air temperature is expected to fall below 32 degrees F. Advance notice of 24 hours shall be provided to the Owner and Engineer before disinfecting procedures start. The flushing and disinfection shall be accomplished in accordance with the applicable provisions of AWWA Standard C651, "Disinfecting Water Mains" and all appropriate approval agencies.
- B. Administration shall be by any of the several methods described in AWWA Standard C651 and as proposed by the Contractor and approved by the Owner and Engineer. Contractor shall submit a proposal describing the desired disinfection method, which shall be approved by the Owner and Engineer prior to commencement of the disinfection process.
- C. The initial chlorine dose shall be as described in AWWA C651 for the selected disinfection method. Chlorinated water must be retained in the pipeline long enough to destroy all non-spore forming bacteria, and not less than the retention time recommended for the selected disinfection method per AWWA C651. After the chlorine treated water has been retained for the required time, the chlorine residual at the pipe extremities and at other representative locations shall be as described in AWWA C651 for the selected disinfection method.
- D. During the period that the chlorine solution or slug is in the section of pipeline, valves shall be opened and closed to obtain a chlorine residual at hydrants and other pipeline appurtenances. Care shall be taken to ensure that no chlorinated water enters any active pipeline.
- E. Following contact with chlorine solution, the system shall be thoroughly flushed out per Section 4.9 of AWWA C651. All highly chlorinated water shall be flushed out within 72 hours of filling the main with highly chlorinated water. Samples shall then be taken using sterile containers obtained from the local regulatory agency. Samples shall be taken by the Contractor and delivered to the local regulatory agency or approved laboratory for analysis at the Contractor's expense.
- F. If samples test positive for coliform organisms, the disinfection procedure shall be repeated until two series of satisfactory samples are obtained, the period between such

series of samples to be a minimum of 24 hours. Contractor is responsible for all costs associated with repeat tests. The Contractor shall obtain certificates of satisfactory bacteriological tests and furnish them to the Owner before the request is made for acceptance of the work. Bacteriological testing shall conform to Section 5 of AWWA C651.

- G. Chlorine residual tests will be performed after flushing to assure that residual is no higher than what is acceptable to the Owner based on the normal prevailing residual in the drinking water distribution system. Testing shall be performed at multiple locations throughout the piping system to verify residual values.
- H. Following disinfection, pipelines and appurtenances shall remain isolated from any operational water system facilities until evidence has been submitted to Owner demonstrating that the pipelines and appurtenances have been adequately and properly disinfected. Normally, pipelines and appurtenances shall be isolated for at least 48 hours, unless a longer period is dictated by the Owner.
- I. Sanitary construction methods must be followed during installation of the final connections so no contamination of the new or existing water main with foreign material or groundwater occurs. Materials used for final connections shall be disinfected in accordance with Section 4.10 of AWWA C651.
- J. All water used in testing and disinfecting the portions of pipeline, including that used for retesting, shall be disposed of following such testing, retesting, and disinfecting, by the Contractor at its own expense. If required by any agency having jurisdiction, the Contractor shall apply a reducing agent to the solution to neutralize residual chlorine or chloramines remaining in the water. The disposal of water shall, in all cases, be carried out in strict observance of the water pollution control requirements of the local and state regulatory agencies. The flow of water from the portions of the pipeline shall be controlled to prevent erosion of surrounding soil, damage to vegetation, and altering of ecological conditions in the area.

3.06 PAINTING AND COLOR-CODING SYSTEM

- A. All exposed piping specified shall be color coded in accordance with the Owner's standard color designation system for pipe recognition and in accordance with Section 40 05 97 – Piping and Equipment Identification Systems. In the absence of a standard color designation system, the Engineer will establish a standard color designation for each piping service category from color charts submitted by the Contractor in compliance with Section 09 90 00 – Painting.
- B. All piping specified in this Section shall be painted in accordance with Section 09 90 00 – Painting, except as follows:
 - 1. Copper pipe

2. Stainless steel pipe. Flanges and supports or hangers shall be painted.

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SECTION 40 05 01
PIPE AND VALVE ACCESSORIES

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. The Contractor shall furnish and install all pipe and valve accessories as shown and specified herein.
- B. All pipe and valve accessories shall be constructed of first quality materials which have strength, wearing, and corrosion resistance characteristics entirely suitable for the types of service for which the individual components are designated.

1.02 SUBMITTALS

- A. Shop Drawings conforming to the requirements of Section 01 33 00 – Submittal Procedures, are required for all pipe and valve accessories. Submittals shall include all layout dimensions, size and materials of construction for all components, information on support and anchoring where necessary, and complete descriptive information to demonstrate full compliance with the Documents.

PART 2 – PRODUCTS

2.01 FLOW INDICATORS

- A. Flow indicators shall be the ball-type as manufactured by Akron, or equal, and shall have bronze bodies, glass dome, and plastic ball.

2.02 CORPORATION STOPS

- A. Corporation stops shall be of bronze with tapered male iron pipe threads on inlets and outlets. Terminal outlets shall have screwed bronze hex head dust plugs or caps. Unions shall be used on all corporation stop outlets with connecting piping. Corporation stops shall have a minimum working pressure rating of 250 psi, shall be full port ball valve style, and shall be as manufactured by Mueller Co., or equal.

2.03 FLOOR BOXES

- A. Floor boxes shall be provided for all nut operated or floor accessed valves. Floor boxes shall be of the adjustable, sliding type, cast iron, suitable to withstand heavy traffic, as manufactured by James B. Clow & Sons, Kennedy Valve Mfg. Co., or equal. The covers shall be marked with appropriate designations of piping contents (i.e.: water, sewer) and bases shall be the round type. All nut operated valves in this Section shall be clearly

identified by stainless steel or laminated plastic identification tags. The tags shall be permanently affixed to the inside of the floor boxes, under grating, etc. and shall bear the embossed letters which clearly identify each valve by its appropriate designation.

- B. Two (2) valve operating wrenches shall be supplied in 4-foot lengths with tee handles for each size nut supplied. Valve wrenches shall be Model No. F-2520 as manufactured by James B. Clow & Sons, Kennedy Valve Mfg. Co., Figure No. 122, or equal.

2.04 VALVE BOXES

- A. The Contractor shall furnish and install valve boxes as shown on the Drawings and specified herein.
- B. All valve boxes shall be placed so as not to transmit shock or stress to the valve and shall be centered and plumb over the operating nut of the valve. The ground in the trench upon which the valve boxes rest shall be thoroughly compacted to prevent settlement. The boxes shall be fitted together securely and set so that the cover is flush with the finished grade of the adjacent surface. A concrete pad as detailed on the Drawings shall be provided around the valve box, sloped outwards.
- C. All valve boxes shall be 2-piece cast iron, sliding type, 5-1/4" shaft, with heavy duty traffic weight collar and the lid marked with the appropriate carrier product (i.e.: WATER). Boxes shall be as manufactured by James B. Clow & Sons, Kennedy Valve Mfg. Co., Charlotte Pipe and Foundry Company, or equal.

2.05 STRAINERS

- A. Y-Strainers shall be Y-pattern cast iron body, flanged or screwed ends with stainless steel or Monel, 20 mesh strainers. Strainers shall be 200 psi, cold-water service strainers, as manufactured by WATTS, Crane Co., Zurn, or equal.
- B. Y-strainers shall be Y-pattern bronze (ASTM B62) body, flanged ends with stainless steel or Monel, 1/16-inch perforations through 4-inch, 1/8-inch perforations in sizes larger than 4-inch. Strainers shall be 200 psi, cold water service strainers similar to No. 851 as manufactured Muessco, Neptune, or equal.
- C. Stainless steel Y-strainers shall be provided as shown on the drawings. Strainers shall be full port-full flow design manufactured of 304 or 316 stainless steel body. Y-strainers shall be furnished with flanged ends. The strainer screen shall be 1/32-inch perforation, easily removable, manufactured of the same material as the valve body.
- D. PVC and CPVC Y-strainers shall be provided in PVC and CPVC piping as shown on the Drawings and or as called for in the pipe schedule. Strainer material shall match pipe material. Strainer shall be provided with PVC or CPVC body and end cap, EPDM or Viton seal as required for the chemical service, and 20 mesh screen. Temperature rating

shall be 30°F to 140°F, and pressure rating shall be 150 psi @ 70°F, non-shock. PVC and CPVC Y-strainers shall be as manufactured by Asahi/America, Hayward, or equal.

- E. PTFE or PVDF flanged Y-strainers shall be provided in Halar piping for sulfuric acid service as shown on the Drawings and or as called for in the pipe schedule. Strainer shall be provided with PTFE or PVDF body and end cap, Viton or Teflon seal, and 20 mesh screen. Temperature rating shall be 30°F to 140°F, and pressure rating shall be 150 psi @ 70°F, non-shock.

2.06 QUICK DISCONNECT COUPLINGS FOR COMPRESSED/SERVICE AIR

- A. Quick disconnect type coupling for compressed/service air shall be provided where indicated on the Drawings. Coupling shall provide for instantaneous shutoff in socket end when lines are disconnected. Couplings shall be constructed of 303 stainless steel with a BUNA-N O-ring and integral safety lock. Couplings shall comply with Military Specification 4109 (interchangeable with standard plug of the same size). Parker, Hofmann Fluid Power, or equal.

2.07 QUICK CONNECT COUPLINGS FOR CHEMICAL FILL STATIONS

- A. Each bulk chemical storage tank fill line shall be provided with a cam and groove type quick connect coupling with downstream ball valve as shown on the Drawings for connection to the chemical delivery vehicle. Quick connect couplings installed in PVC or CPVC chemical fill lines shall be constructed of polypropylene, and quick connect couplings installed in carbon or stainless steel fill lines shall be constructed of stainless steel. Gasket materials shall be completely resistant to corrosion by the specified chemicals. Each quick connect coupling shall include a male adapter with female NPT threads and lockable dust cap. Coupling components that come into contact with the chemical shall be constructed of materials that meet NSF-61 certification standards. Couplings shall be as manufactured by Bee Valve, Inc., or equal.

2.08 QUICK CONNECT COUPLINGS FOR CHEMICAL PIPING

- A. Quick connect couplings for NPW, chemical, and sump pump discharge service shall be provided as shown on the Drawings. Quick connect couplings installed in PVC or CPVC piping shall be constructed of polypropylene, and quick connect couplings installed in carbon or stainless steel piping shall be constructed of stainless steel. Gasket materials shall be completely resistant to corrosion by the specified chemicals. Each quick connect coupling shall include a male adapter with male NPT threads and dust cap. Coupling components that come into contact with the chemical shall be constructed of materials that meet NSF-61 certification standards. Couplings shall be as manufactured by Bee Valve, Inc., or equal.

2.09 FLUSHING CONNECTIONS FOR CHEMICAL PIPING

- A. Flushing connections shall be PVC socket x $\frac{3}{4}$ " female threaded hose adapters with hose swivel.

PART 3 – EXECUTION

3.01 INSTALLATION

- A. All pipe and valve accessories shall be tested at the specified test pressures. Any leakage or "sweating" of joints shall be stopped, and all joints shall be tight.
- B. Provide accessories in quantity, size, and type with all required appurtenances as shown on the Drawings.
- C. Install all pipe and valve accessories in accordance with manufacturer's instructions. Install suitable corporation stops at all points shown or required where air binding of pipe lines might occur.
- D. Valve boxes shall be set plumb and centered with the bodies directly over the valves so that traffic loads are not transmitted to the valve. Earth fill shall be carefully tamped around each valve box to a distance of 4 feet on all sides of the box, or to the undisturbed trench face, if less than 4 feet.

END OF SECTION

SECTION 40 05 07
PIPE SUPPORTS

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. Furnish all equipment, labor, materials, and design calculations required to provide pipe supports in accordance with the Contract Documents.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 01 73 23 – Anchorage and Bracing of Non-Structural Components
- B. Division 03 – Concrete
- C. Section 05 05 13 – Galvanizing
- D. Section 05 05 23 – Metal Fastening
- E. Section 05 10 00 – Metal Materials
- F. Section 05 12 00 – Structural Steel
- G. Section 05 13 00 – Stainless Steel
- H. Section 05 50 00 – Metal Fabrications
- I. Section 40 05 00 – Basic Mechanical Requirements

1.03 SUBMITTALS

- A. Pipe support submittals will not be reviewed prior to review and acceptance of pipe layout submittal. Pipe support submittal shall be fully coordinated with approved pipe layout submittal. Contractor shall use approved piping layout submittal drawings to show proposed pipe support type and location with accurate dimensions to demonstrate that supports meet all specified requirements.
- B. Applicable and associated cut sheets and drawings for materials and support components shall be submitted with the Shop Drawings in accordance with or in addition to the submittal requirements specified in Section 01 33 00 – Submittals, Section 40 05 00 – Basic Mechanical Requirements and other referenced Sections above.

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1. Catalog cut information on all system components such as pipe supports, hangers, guides, anchors, and channel-type supports.
2. Drawings of the piping support systems, locating each support, brace, hanger, guide, component and anchor. Identify support, hanger, guide and anchor type by catalog number and Shop Drawing detail number.
3. With each piping support system Shop Drawing, the Contractor shall attach calculations prepared and sealed by a Professional Engineer, licensed in the State or Commonwealth in which the project is located, showing that the piping support system complies with the specified requirements, including all building code and seismic code requirements pertaining to support of piping and other non-structural components. See Section 01 73 23 – Anchorage and Bracing of Non-Structural Components.
4. Table showing the manufacturer's recommended hanger support spacing for PVC, CPVC and FRP pipe for the services listed in Section 40 06 20 – Process Pipe, Valve and Gate Schedules.

PART 2 – PRODUCTS

2.01 GENERAL

- A. **The Contractor shall be responsible for the design of all piping support systems unless noted otherwise herein. The absence of pipe supports and details on the Drawings shall not relieve the Contractor of the responsibility of providing a pipe support design sealed by a Professional Engineer, licensed in the State or Commonwealth in which the project is located. Standard details for pipe supports have been included on the Drawings to define minimum requirements as to the types of Contractor designed pipe supports that will be acceptable.**
- B. Where a specific location or type of support is shown on the Drawings, the location and type shall be incorporated in the Contractor's pipe support design.
- C. Where special pipe support fabrications are required, products and execution shall be as specified in Section 05 50 00 – Metal Fabrications and other related and referenced Sections of the Specifications.
- D. Existing piping support systems to support new piping shall only be used if the Contractor can show and demonstrate by submitting supporting calculations that they are adequate for the additional load imposed by the new piping, or if they are strengthened to support the additional load.
- E. Contractor's pipe support design should include, but not be limited to, the following criteria and loads imposed on the piping system:

1. Thrust Loads based on the design pressures as specified in Piping Schedules in Section 40 06 20 – Process Pipe, Valve and Gate Schedules. Pipe support design shall not utilize process equipment for thrust restraint or support of piping loads.
2. Dead loads and live loads per the latest version of ASCE/SEI 7 or the local building code if more stringent. Loads shall include, but not be limited to, the following:
 - a. Weight of pipe
 - b. Weight of pipe contents
 - c. Weight of insulation
 - d. Ice loads (If applicable by location, ice loads per code shall be applied as indicated in the governing building code)
 - e. Seismic loading requirements and conditions as specified in the governing building code and referenced seismic design codes. Refer to Section 01 73 23 – Anchorage and Bracing of Non-Structural Components and the structural code drawing for project specific seismic design criteria. Seismic and sway bracing shall be provided at maximum 10-foot centers.
 - f. Wind loads
3. Loads associated with thermal expansion and contraction of the piping system over the full range of potential temperatures the piping system could experience that should include, but not be limited to, the following:
 - a. Ambient temperature range per local historical weather data (historic high and low obtained from NOAA)
 - b. Process operating temperature range
 - c. Exposure to sunlight where applicable
4. Additional pipe support design considerations shall include the following:
 - a. A minimum safety factor of 2 or as approved by the Engineer, based upon the yield strength of the support material, shall be used for pipe supports, braces, hangers, and guides as well as for beam and column members used in channel-type support systems.
 - b. The horizontal pipe hanger and/or floor support spacing shall be as recommended by the pipe and/or hanger manufacturer but shall not exceed 10 feet on center unless indicated otherwise herein or on the Drawings.

- c. The design, sizing and spacing of anchor bolts, including concrete anchors, shall be based on withstanding shear and pullout loads imposed by loading at each particular support. The minimum anchor bolt size shall be ½ inches in diameter. Refer to Section 05 05 23 – Metal Fastening.

2.02 HANGERS AND SUPPORTS

- A. All piping shall be adequately supported and braced by means of steel hangers and/or supports, concrete piers, supplemental lateral and axial bracing components, pre-fabricated brackets, or otherwise as may be required by the location and forces applied per governing code, including gravity and lateral forces from earthquake and/or wind (if outdoors). Lateral and axial bracing shall be sufficient to prevent any and all movement of the piping except for required and / designed piping expansion. Generally, concrete supports shall be used where pipe centerline is less than 3 feet above floor, and hangers above 6 feet unless specified or shown otherwise. Supports shall be not more than 10 feet on center for steel and cast iron, 5 feet on center for plastic unless otherwise shown on the Drawings or required by the specific manufacturer. All necessary inserts or appurtenances shall be furnished and installed in the concrete or structures for adequately securing hangers and supports to the structure. Refer to Standard Detail Drawings.
 1. Metal pipe support materials, where stainless steel pipe is supported, shall be Type 304L stainless steel meeting the requirements of Section 05 13 00 – Stainless Steel.
 2. Metal pipe support materials, where carbon steel, ductile or other ferrous pipe is supported, shall be galvanized carbon steel meeting Section 05 12 00 – Structural Steel and Section 05 05 13 – Galvanizing unless indicated otherwise on the Drawings or in the Specifications or by the Engineer.
 3. Metal pipe supports indicated as standard type pipe hangers are designed and detailed for gravity loading only. Resulting lateral loads from wind, earthquake, or other lateral loads per code, or special loading conditions during construction, shall be applied to the pipe in accordance with the governing building code. Supplemental lateral stiffening members (when necessary) shall be provided along pipe or at gravity supports using appropriate supplemental members and connections when required by calculations. The Contractor shall include design calculations and details with all pipe hanger and support submissions for review by the Engineer. The main structure and structural components that will support the pipe hangers and other appurtenant components of the facility have been designed to resist all resulting secondary lateral loading from pipe hangers and other non-structural members for gravity and resulting lateral loads.
- B. Hangers and supports shall conform to the following requirements:

1. All fabricated metal hangers and supports shall be capable of adjustment after installation. Different types of hangers and supports along a pipe length, including bends, shall be kept to a minimum.
 2. Hanger rods shall be straight and vertical. Chain, wire, strap, or perforated bar hangers shall not be used. Hangers shall not be suspended from other piping.
 3. Vertical piping shall be properly supported at each floor and between floors by stays or braces to prevent rattling and vibration.
 4. Supports and hangers for plastic and FRP piping shall include wide saddles or bands as recommended by the manufacturer and approved by the Engineer to distribute load and thus avoid localized deformation of the pipe.
 5. Hanger and supports shall prevent contact between dissimilar metals by use of copper plated, rubber, vinyl coated or stainless-steel hangers.
 6. Ferrous pipes to be painted shall be painted in accordance with Section 09 90 00 – Painting. Ferrous pipes that require painting or galvanizing shall be supported by galvanized hangers and supports. Stainless steel piping shall be supported by stainless steel saddles and straps.
 7. Copper piping shall be supported by plastic coated or copper plated steel hangers and supports.
 8. Plastic piping shall be supported by plastic coated steel hangers and supports.
 9. Hangers and supports shall provide for thermal expansion throughout the full operating temperature range.
 10. Expansion and adhesive type anchors used for pipe hangers and supports shall be Type 316 stainless steel.
- C. Metallic hangers and supports may be standard make by Anvil International, Inc., "Witch" by Carpenter & Paterson, Ltd., B-Line Systems, Inc., or equal; and data on the types and sizes to be used shall be furnished to the Engineer for approval. Metallic support system brackets, rods, support clips, clevis hangers, hardware, etc. shall be cast iron or welded steel construction. All gravity type hangers and supports shall be restrained laterally to resist seismic loading and other loading as required by the governing code.
- D. Non-metallic support system shall be a heavy-duty channel framing system. Channel frames shall be manufactured by the pultrusion process using corrosion grade polyester or vinylester resins. All fiberglass construction shall include suitable ultraviolet inhibitors for UV exposure and shall have a flame spread rating of 25 or less per ASTM E84. Piping accessories, pipe clamps, clevis hangers, support posts, support racks, fasteners,

etc., shall be constructed of vinylester or polyurethane resin. Non-metallic support systems shall be standard make Aickinstrut by Aickinstrut, Inc., Unistrut Fiberglass by Unistrut, Inc., Enduro Fiberglass Systems, or equal. The Contractor shall submit data on the types and sizes of approval. Unless otherwise shown or specified the Contractor shall provide support spacings in the conformance with the pipe and support system manufacturer's requirements.

2.03 PROCESS AIR PIPE SUPPORTS

- A. Unless specifically designed and detailed on the Drawings, process air piping shall be supported by slide bearings as manufactured by Fluorocarbon Company, Anaheim, California, Anvil International, Inc., Portsmouth, New Hampshire, or equal.
- B. The slide bearing material shall be 3/32-inch-thick, 25 percent glass-fiber reinforced structural grade Teflon. The bearing material shall withstand at least 1000 psi (compression) at 250°F with a coefficient of friction between 0.05 and 0.08. The performance of bearing and bonding materials shall be unaffected by continual immersion in wastewater containing domestic and industrial waste at a temperature of 210°F.
- C. Non-submerged slide bearing type supports shall be provided with a bearing material covering a 120° arc centered at the bottom of the pipe. The Teflon shall be at least 4 inches wide at the underside of the pipe and 8 inches wide at the top of the support. The Teflon material shall be hot press bonded to 10 ga. stainless steel plates for welding to the bottom of the pipe and securing to the top of the support.
- D. Submerged slide bearing type supports shall be provided with Teflon bonded to the underside of the hold down strap and the top of the pipe such that the sliding surface is formed between two sheets of Teflon. Each surface shall cover a 120° arc centered at the top of the pipe. On the underside of the strap the Teflon bearing shall be hot press bonded directly to the stainless-steel strap or to a 10 ga. stainless steel plate for welding to the strap. At the top of the pipe, the Teflon shall be bonded to a 10 ga. stainless steel plate for welding to the pipe.
- E. Pipe straps shall not tightly bind the pipe, but shall provide 1/16-inch clearance over the top 180° of the pipe surface.
- F. Wall bracket supports shall be used where shown for pipe to be installed adjacent to a wall. Where it is not feasible to install hanger supports, adjustable pipe saddle supports may be used with the permission of the Engineer. Concrete pier supports shall be spaced at a maximum distance of 10 feet and shall be at least 12" wider than O.D. of pipe and 10 inches thick unless otherwise shown on the Drawings. Refer to the Standard Detail Drawings.

- G. Small diameter piping (6-inches in diameter or less) shall not be strapped or otherwise secured directly to walls. Suitable wall offset brackets of an approved type shall be used. Anchors shall not be attached using percussion fasteners.
- H. Sliding surfaces shall be protected from accumulation of dirt, grit, or other foreign matter.
- I. Slide bearings shall be capable of adequately supporting the design loads and shall be attached to pipe and supports as specified and recommended by the manufacturer.
- J. The slide bearings shall be installed in the locations shown or indicated on the Drawings, at required elevations, true to orientation and level, assuring that the correct half of each bearing is in its proper position. The Contractor shall store the bearings to protect them from mechanical damage prior to installation and shall protect the same during and after installation from contamination and damage due to placing of concrete and other materials. The Contractor shall clean the operating surfaces of bearings thoroughly before final assembly.
- K. The Contractor shall note that all pipe support locations are not shown on the Drawings and shall follow the Specifications herein in locating supports. Where deviations and modifications are required, they shall be made only with the permission of the Engineer. A detailed layout of pipe supports and hangers shall be submitted for approval.

PART 3 – EXECUTION

3.01 GENERAL INSTALLATION REQUIREMENTS

- A. Support piping connections to equipment by pipe support and not by the equipment.
- B. Support large or heavy valves, fittings, flow meters and appurtenances independently of the connected piping.
- C. Support no pipe from the pipe above it.
- D. Support piping at changes in direction or in elevation, adjacent to flexible joints, expansion joints, and couplings, and where shown.
- E. The Contractor shall not install piping supports and hangers in equipment access areas or bridge crane runs.
- F. Brace hanging pipes against horizontal movement by both longitudinal and lateral sway bracing.
- G. Install pipe anchors (fixed supports and/or guides) where shown and/or as may otherwise be required to withstand expansion thrust loads and to direct and control thermal expansion. The Contractor may install additional pipe anchors and flexible

couplings to facilitate piping installation, provided that complete details describing location, pipe supports and hydraulic thrust protection are submitted.

END OF SECTION

SECTION 40 05 19
DUCTILE IRON PIPE

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. Reference Section 09 90 00 – Painting.
- B. Reference Section 40 05 00 – Basic Mechanical Requirements
- C. Reference Section 40 06 20 – Process Pipe, Valve, and Gate Schedules, for pressure rating requirements for specific applications.

1.02 SUBMITTALS

- A. Submittals shall be provided in accordance with Section 01 33 00 – Submittal Procedures.
- B. The Contractor shall submit a certificate from the Manufacturer stating that all linings have been provided in accordance with the specification requirements herein.
- C. The Contractor shall submit spark testing report for all epoxy-lined ductile iron pipe and fittings 36-inches in diameter and larger.
- D. Provide detailed layout drawings of each piping system. Reference layout drawing requirements in 01 33 00.

PART 2 – PRODUCT

2.01 DUCTILE IRON PIPE AND FITTINGS

- A. All ductile iron pipe and specials shall be marked with the manufacturer's name or trademark, size, weight, thickness class, the date of manufacture, and the word "Ductile".
- B. Ductile iron pipe of the sizes shown or specified shall conform to AWWA C151/A21.51, Grade 60-42-10 for ductile iron pipe centrifugally cast in metal molds or sand-lined molds.
- C. Ductile iron pipe shall conform to AWWA C150/A21.50 for thickness design and shall be supplied in 18-foot or 20-foot nominal lengths or as required to meet the requirements of the Drawings.

- D. Fittings and specials shall be cast iron or ductile iron and conform to the requirements of AWWA C110/A21.10 and AWWA C153/A21.53.
- E. Minimum Class 53 pipe shall be used for flanged spools.

2.02 PIPE COATINGS

- A. All buried ductile iron pipe and fittings shall have a bituminous coating of standard thickness on the exterior surfaces in accordance with AWWA C151/A21.51.
- B. All exposed ductile iron pipe and fittings shall have a shop-applied prime coat in accordance with Section 09 90 00 – Painting.

2.03 PIPE LININGS

- A. All pipe and fittings, with the exception of epoxy and glass lined pipe and sleeves, shall be cement mortar lined. Cement mortar linings shall conform to American Standard Specifications for Cement Mortar Lining for Cast Iron Pipe and Ductile Iron Pipe and Fittings, AWWA C104/A21.4 and shall be standard thickness. The mortar lining shall be protected with a bituminous seal coat.
- B. Epoxy-Lined Pipe
 - 1. Epoxy-lined ductile iron pipe shall be furnished and installed where specified in Section 40 06 20 – Process Pipe, Valve, and Gate Schedules.
 - 2. Epoxy-linings shall be Induron Protecto 401 ceramic epoxy lining, Tnemec Perma-Shield PL Series 431, or equal.
 - 3. The finished lining shall have a minimum dry film thickness of 40 mils, except at the gasket groove and spigot end up to six inches back from the end of the spigot which shall be 6 mils dry film thickness, minimum.
 - 4. Lining application shall be performed in strict accordance with the manufacturer's instructions by an applicator approved by the coating manufacturer and under controlled conditions at the applicator's shop or the pipe manufacturer's plant.
- C. Glass-Lined Pipe
 - 1. Glass-lined ductile iron pipe shall be furnished and installed where specified in Section 40 06 20 – Process Pipe, Valve, and Gate Schedules.
 - 2. Glass-lined ductile iron pipe shall be provided in accordance with ASTM B1000.
 - 3. Glass linings shall be Ervite Type SG-14, as manufactured by the Ervite Corporation; Ferroch MEH 32, as manufactured by Water Works Supply and Manufacturing, Co; or equal.

4. The finished lining shall have a dry film thickness between 8 and 12 mils; a hardness between 5 and 6 on the Mohs Scale; a density between 40 and 50 grams per cubic inch (2.5 to 3.0 grams per cubic centimeter) as measured in accordance with the requirements of ASTM D792; and be capable of withstanding a thermal shock of 350°F without crazing, blistering, or spalling.
5. Glass-lined pipe and fittings that have been lined must be handled from the outside. No forks, chains, hooks, etc. shall be placed inside the pipe and fittings for lifting, positioning, or laying.
6. Cutting of glass lined pipe in the field shall be limited to only one piece per run of pipe, and this shall be for closure purposes only. Spalling of the glass liner shall be no more than 1/8 inch back from the cut. Flanges and bolt holes on spool pieces shall be aligned following the glass lining process and shall be sealed and tested prior to shipment in accordance with the manufacturer's recommendation. Warping of flanges and/or pipe may be cause for rejection as determined by the Engineer.

2.04 PIPE JOINTS

- A. Requirements for various types of joints are described in the following paragraphs.
UNLESS OTHERWISE NOTED HEREIN OR ON THE DRAWINGS, ALL EXPOSED DUCTILE IRON PIPING SHALL HAVE FLANGED JOINTS.
- B. Flanged Joints
 1. Flanged joints and fittings shall have a minimum pressure rating of 250 psi with 125 lb. American Standard flanges.
 2. All flanges and fittings shall conform to the requirements of ASME B16.1.
 3. Flanges shall be ductile iron and shall be of the threaded or screw on type.
 4. The face of the flanges shall be machined after installation of the flange to the pipe. No raised surface shall be allowed on flanges.
 5. Flanged pipe shall conform to the requirements of AWWA C115/A21.15.
 6. Pipe lengths shall be fabricated to meet the requirements of the Drawings.
 7. Gaskets shall be Toroseal by American Cast Iron Pipe Company, Flange-Tyte by US Pipe, or equal. Gaskets shall be full-face, 1/8-inch minimum thickness cloth inserted rubber, red rubber, neoprene, or superior elastomer and shall be compatible with the fluid being conveyed. Gaskets shall have an allowable maximum working pressure and temperature equal to or greater than the service in which it is installed.

8. Bolts shall be of the size and length called for and in accordance with the "American Standard" and comply with the requirements of the ANSI/AWWA Standards. Bolts used for exposed flanged joints shall be a minimum ASTM A307, Grade B carbon steel, and be in accordance with AWWA C110/A21.10. Bolts used for flanged joints in submerged applications shall be Type 316 stainless steel and installed with dielectric isolation flange kits and anti-seize. All bolts shall have hexagonal heads and nuts of the same material as the bolt. No washers shall be used.

C. Bell and Spigot Joints

1. Bell and spigot pipe shall be provided with push on, O-ring rubber gasket, compression type joints and shall conform to the requirements of AWWA C111/A21.11. Fittings and specials shall be supplied with mechanical joints as specified for mechanical joint pipe. If required by installation conditions, pipe shall have caston lugs for adequately tying it together.

D. Mechanical Joints

1. Mechanical joints and fittings shall conform to the requirements of AWWA C111/A21.11. Joints shall be made employing a tapered rubber gasket forced into a tapered groove with a ductile iron follower ring. If required by installation conditions, pipe and fittings shall have caston lugs for adequately tying the pipe and fittings together. These shall be in conformance with standard practice and as outlined under the appropriate AWWA Specifications.
2. Bolts for mechanical joints shall be high-strength low-alloy steel tee-head bolts with hexagonal nuts per AWWA C111/A21.11, both coated using a three-layer system consisting of a metallic base coat, an adhesion coat, and a heat cured fluoropolymer compound containing PTFE as topcoat.
3. Mechanical coupling joint pipe and fittings shall be split type, shouldered end. Coupling materials shall be malleable iron. Couplings shall have a minimum pressure rating and service equal to that of the connected piping.
4. Gaskets shall be of rubber.
5. After installation, buried couplings shall receive two heavy coats of coal tar epoxy (min. 24 mil thickness) which is compatible with the finish of the couplings.
6. Couplings shall be as manufactured by Victaulic Company of America Style 31, or equal.

E. Restrained Joints

1. Restrained joint pipe shall consist of factory manufactured bolted retainer rings, ductile iron locking segments held in place by rubber retainers, or ductile iron retaining rings that lock over the bell of the joint and are secured to prevent rotation, and factory welded retainer beads or rings on the spigot of the pipe. All components of the bolted or snap ring assemblies shall be constructed of corrosion-resistant, high strength, low-alloy steel coated using a three-layer system consisting of a metallic base coat, an adhesion coat, and a heat cured fluoropolymer compound containing PTFE as topcoat.
2. Restrained joint pipe shall be Flex-Ring or Lock-Ring type joints as manufactured by American Cast Iron Pipe Company, HP LOK or TR Flex as manufactured by US Pipe, Bolt-Lok or Snap-Lok as manufactured by Griffin Pipe Products, TR Flex or Super Lock as manufactured by Clow Water Systems Co., or approved equal.
3. Restrained fittings for piping systems 16-inches in diameter and greater shall have factory restraint systems identical to the factory restrained joint pipe specified above. All fittings shall be minimum pressure Class 250 unless otherwise specified.
4. Restrained fittings for pipe systems 14-inches in diameter and smaller shall be Mechanical Joint fittings with restraint assemblies such as Stargrip by Star Pipe Systems, Mega Lug by EBAA Iron, ONE LOK by Sigma, Grip Ring by Romac, or approved equal. Restraint assemblies including all hardware shall be painted with two heavy coats of coal tar epoxy after installation. Where threaded-rods are allowed, the rods and tabs shall be designed for the specified restraint system design pressure, shall have lengths less than 10 feet between fittings, and shall be painted with two heavy coats of coal tar epoxy after installation.
5. The manufactured systems for thrust restraint indicated above shall be used where restrained joint ductile iron pipe and fittings are specified or indicated on the drawings. Gripping gaskets are not an acceptable form of restraint. Thrust restraint and harnessing systems such as threaded-rods, friction clamps, retainer glands shall be used only where specifically specified herein, indicated on the drawings or if allowed by the Engineer in isolated applications where conditions warrant and necessitate their use. Concrete thrust blocks may be used in accordance with the schedule indicated on the drawings, if applicable.

2.05 OUTLETS

- A. The Contractor shall provide taps on piping where required or shown on the Drawings. Where pipe or fitting wall thicknesses are insufficient to provide the required number of threads, the Contractor shall not use taps and shall refer to Section 40 05 00 – Basic Mechanical Requirements for requirements.

2.06 POLYETHYLENE ENCASEMENT

- A. Wrap all buried ductile iron pipes, valves and fittings with 8 mil polyethylene film per ANSI A21.5/AWWA C-105. Use only tube type for pipe. Complete the wrap prior to placing concrete anchors, collars, supports or thrust blocks. Repair polyethylene if damaged during installation.

END OF SECTION

SECTION 40 05 24.43
STEEL PIPE FOR MISCELLANEOUS SERVICE

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. This specification shall apply to steel pipe only for applications as detailed in Part 2.
- B. The AWWA Specifications referenced in this Section are supplemented as follows:
 - 1. An affidavit of compliance is required from the pipe manufacturer.
 - 2. The steel manufacturer's certification that the material meets the ASTM Specification will be accepted in lieu of tests on specimens taken from the fabricated pipe.
 - 3. The fabricator may purchase steel plates on the chemical basis only and shall furnish to the Owner certified test reports.
- C. All parts of the materials furnished shall be amply designed, manufactured, and constructed for the maximum stresses occurring during fabrication, erection and operation. All materials shall be new and both workmanship and materials shall be of the very best quality, shall be entirely suitable for the service to which they will be subjected, and shall conform to all applicable Sections of these Specifications. Manufacturer's designs shall accommodate all of the requirements of these Specifications.
- D. The Contractor shall be responsible for the structural design of the steel and stainless steel pipe, fittings, and couplings. The Contractor shall submit certification that the steel and stainless steel pipe, fittings, and couplings have been designed to resist all loads implied and reasonably anticipated.
- E. Reference Section 40 05 00 – Basic Mechanical Requirements.

PART 2 – PRODUCTS

2.01 STAINLESS STEEL PIPE AND FITTINGS FOR GAC SLURRY

- A. Stainless steel pipe for GAC slurry service shall conform to the requirements of ASTM A312 – Standard Specification for Seamless and Welded Austenitic Stainless Steel Pipes. Piping shall be 304 Stainless Steel Schedule 40 as indicated in Section 40 06 20 – Process Pipe, Valve, and Gate Schedules.

- B. Stainless steel piping shall be provided with standard stainless-steel flanges with PTFE temperature rated gaskets.

2.02 MISCELLANEOUS STEEL PIPE AND FITTINGS

- A. Other steel pipe and fittings not specified elsewhere shall conform to ASTM A53, black or galvanized, as directed by the Engineer, seamless, Schedule 40 or 80 as indicated in the appropriate Piping System Schedule in Section 40 06 20 – Process Pipe, Valve, and Gate Schedules or as indicated on the Drawings.
- B. Unless otherwise shown or required, all piping and fitting shall be threaded. Fittings shall conform to ANSI B16.3, 300 pound class and shall be of the black malleable iron screw type. All threaded joints shall be made tight with an oil and graphite paste or Teflon thread tape applied to the male threads only. All pipe 1-1/2 inches and smaller shall be reamed to removed scale and dirt. Pipe to be galvanized shall have a deep galvanized coating applied in full accordance with ASTM A123.

PART 3 – EXECUTION

3.01 FIELD WELDING OF STEEL AND STAINLESS STEEL PIPING AND FITTINGS

- A. Contractor shall minimize the amount of field welding of steel and stainless steel piping required. Locations for pipe field welding will be evaluated and allowed on a case-by-case basis upon written approval of the Engineer. All field welding of steel and stainless steel pipe is subject to the following requirements:
 - 1. Welding shall be performed by AWS-certified welders in conformance with AWS 1.6. Submit welder's certification for approval prior to performing any field welding.
 - 2. Piping with wall thickness up to 11 gauge (0.125-inch) shall be welded with the TIG (GTAW) process. Heavier walls shall be properly beveled and have a root pass with the TIG (GTAW) process followed by subsequent passes with the TIG (GTAW) or MIG (GMAW) process. Filler wire of ELC grades only shall be added to all welds to provide a cross-section at the weld equal to or greater than the parent metal. Weld deposit shall be greater than the parent metal. Weld deposit shall be smooth and evenly distributed and have a crown of no more than 1/16 inch on the I.D. and 3/32 inch on the O.D. of the piping or fittings. Concavity, undercut, cracks, or crevices shall not be allowed. Butt-welds shall have full penetration to the interior surface. Excessive weld deposits, slag, spatter, and projections shall be removed by grinding.
 - 3. Jigs shall be utilized to align adjacent sections of piping.
- B. Post-Weld Treatment

1. All field welds shall be wire brushed utilizing steel or stainless steel wire brushes to remove slag and spatter. Stainless steel brushes shall be used on stainless steel pipe.
 2. The weld and the heat affected area shall be pickled with a brush-on pickling gel in accordance with ASTM A380 to remove all weld residue, oxide, and heat stain from the field weld and affected areas.
 3. Pickling of stainless steel pipe shall be done in accordance with pickling paste manufacturer's directions, and areas being pickled shall be protected from direct sunlight. After pickling period is complete, neutralize pickling gel in accordance with directions and rinse area clean.
- C. Where field welding of steel (carbon or stainless) piping is approved by the Engineer, all field welds shall be visually inspected and tested by an approved quality assurance testing firm in accordance with ASME B31.1 and B31.3. The Contractor shall be responsible for contracting with an approved testing firm. Nondestructive testing methods shall be used unless otherwise approved by the Engineer.

3.02 FLUSHING AND TESTING

- A. Flushing and testing of all installed low pressure air piping shall be performed as specified in Section 40 05 00 – Basic Mechanical Requirements. The field testing procedure for process air piping shall use air pressure only.

END OF SECTION

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SECTION 40 05 31

PVC/CPVC PIPE

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. Reference Section 40 05 00 – Basic Mechanical Requirements.

PART 2 – PRODUCTS

2.01 POLYVINYL CHLORIDE (PVC) PIPE AND FITTINGS

- A. PVC pipe and fittings shall be manufactured in accordance with ASTM D1785, D1784 and F441, "normal impact" pipe, Schedule 40 or 80 as specified.
- B. Fittings used with this pipe shall be socket type or flanged type as specified herein, in Section 40 06 20 – Process Pipe, Valve, and Gate Schedules, or indicated on the Drawings. Plastic piping shall be installed in full accordance with the manufacturer's recommendations for the specific installation. No field bending or distortion of the pipe will be permitted.
- C. PVC pipe shall be Type 1 Grade 1 conforming to ASTM D1784 and D1785. Fittings shall conform to the following standard specifications:
1. Socket Type: (Schedule 40); ASTM D2466
 2. Socket Type: (Schedule 80); ASTM D2467
- D. Provide flanged fittings of the same material as the specified pipe and material conforming to ANSI B16.5 at all valves and equipment except at true (double) union valves. Flange gaskets shall be natural rubber or other material fully compatible with the fluid being conveyed. Where flanged piping is used with chemical systems, the gasket material shall conform to the requirements of the following table. Flange bolts shall be type 316 stainless steel minimum, with higher grade materials used where necessary for fluid (chemical) compatibility.

Chemical	Elastomer Material
Hydrofluosilicic Acid	FKM
Sodium Hypochlorite	FKM
Zinc Orthophosphate	EPDM, FKM

- E. Acceptable materials of construction of elastomers for non-chemical service shall be as follows:

Non-Chemical Service	Elastomer Material
Non-Potable Water	EPDM
Process Drain (Gravity)	EPDM, FKM
Process Drain (Pressure)	EPDM, FKM
Potable Water	EPDM
Reclaimed Water	EPDM, FKM
Sample	EPDM, FKM
Sump Pump Discharge	EPDM, FKM

F. Solvent Cement

1. Solvent cement for socket type joints shall conform to ASTM D2564 for PVC pipe and fittings, unless used in chemical service applications.
2. Solvent cement for PVC socket type joints in chemical service applications shall be Weld-On 724 as manufactured by IPS Corporation, or equal.
3. Primer shall be used for all Schedule 80 piping. Primer shall be Weld-On P-70 as manufactured by IPS Corporation, or equal.

- G. C900-Class 200 shall be in sizes between 4 inches and 12 inches and shall meet the requirements of AWWA C900 "Poly Vinyl Chloride (PVC) Pressure Pipe" and shall conform to all the requirements of ASTM D1784 and ASTM D2241. The pipe shall be a minimum of DR 14 and shall be capable of withstanding the overburden pressures determined by the depth of burial in the field.

1. Pipe material shall be made from clean, virgin, NSF approved Class 12454-A PVC compound conforming to resin specification ASTM D1784. Standard laying lengths shall be 20-feet (± 1 inch). Random lengths of not more than 15% of the total footage of each size may be shipped in lieu of the standard lengths. Reruns of reclaimed material shall not be accepted.
2. The pipe shall have bell and spigot ends with push-on, O-ring rubber gasket, compression type joints conforming to the requirements of ASTM D2672. Elastomeric gaskets shall conform to the requirements of ASTM F477.
3. Minimum pipe stiffness (F/dY) at 5% deflection shall be 914 psi for all sizes when tested in accordance with D2241.

4. The pipe shall be designed to pass a quick burst test pressure of 985 psi applied in 60 to 70 seconds when tested in accordance with ASTM D1599, as referenced in ASTM D2241.
 5. Fittings for C900-Class 200, DR 14 shall be ductile iron, bolted mechanical joint.
- H. C900-Class 150 shall be in sizes between 4 inches and 12 inches and shall meet the requirements of AWWA C900 "Poly Vinyl Chlorine (PVC) Pressure Pipe" and shall conform to all the requirements of ASTM D1784 and ASTM D2241. The pipe shall be a minimum of DR 18 and shall be capable of withstanding the overburden pressures determined by the depth of burial in the field.
1. Pipe material shall be made from clean, virgin, NSF approved Class 12454-A PVC compound conforming to resin specification ASTM D1784. Standard laying lengths shall be 20-feet (± 1 inch). Random lengths of not more than 15% of the total footage of each size may be shipped in lieu of the standard lengths. Reruns of reclaimed material shall not be accepted.
 2. The pipe shall have bell and spigot ends with push-on, O-ring rubber gasket, compression type joints conforming to the requirements of ASTM D2672. Elastomeric gaskets shall conform to the requirements of ASTM F477.
 3. Minimum pipe stiffness (F/dY) at 5% deflection shall be 435 psi for all sizes when tested in accordance with D2241.
 4. The pipe shall be designed to pass a quick burst test pressure of 755 psi applied in 60 to 70 seconds when tested in accordance with ASTM D1599, as referenced in ASTM D2241.
 5. Fittings for C900-Class 150, DR 18 shall be ductile iron, bolted mechanical joint.
- I. PVC pressure rated pipe (PR 160) shall be in sizes between 1 1/2 inches and 12 inches and shall conform to all the requirements of ASTM D1784 and ASTM D2241 and shall be a minimum of SDR 26 and shall be capable of withstanding the overburden pressures determined by the depth of burial in the field.
1. Pipe material shall be made from clean, virgin, NSF approved Class 12454-A PVC compound conforming to resin specification ASTM D1784. Standard laying lengths shall be 20-feet ($1\pm$ inch). Random lengths of not more than 15% of the total footage of each size may be shipped in lieu of the standard lengths. Reruns of reclaimed materials shall not be accepted.
 2. The pipe shall have bell and spigot ends with push-on, O-ring rubber gasket, compression type joints conforming to the requirements of ASTM D2672. Elastomeric gaskets shall conform to the requirements of ASTM F477.

3. Minimum pipe stiffness (F/dY) at 5% deflection shall be 135 psi for all sizes when tested in accordance with ASTM D2241.
 4. The pipe shall be designed to pass a quick burst test pressure of 500 psi applied in 60 to 70 seconds when tested in accordance with ASTM D1599, as referenced in ASTM D2241.
 5. The pipe shall be designed to pass for 1000 hours a sustained test pressure of 340 psi when tested in accordance with ASTM D1598, as referenced in ASTM D2241.
- J. Fittings for PR 160, SDR 26 shall be PVC and designed for the pipe being supplied.
- K. Acrylonitrile-butadiene-styrene (ABS) shall conform to the requirements of ASTM D2661. Pipe and fittings shall have socket type couplings with solvent cement joints. Solvent cement shall conform to ASTM D2235.
- L. Type PSM polyvinyl chloride (PVC) pipe and fittings shall conform to the requirements of ASTM D3034 with a maximum SDR of 35. Pipe and fittings shall have bell and spigot ends with O-ring rubber gasketed, compression type joints. Joints shall conform to the requirements of ASTM Specification D3212. Reruns of reclaimed materials shall not be accepted. Unless indicated otherwise, PVC wall pipes shall be provided for all piping passing through exterior walls. Wall pipes shall have a water stop solvent-welded to the pipe. Each wall pipe shall be of the same class and type as the piping to which it is joined.
- M. Perforated and closed drainage pipe and fittings shall be rigid PVC pipe, Schedule 40 unless otherwise shown or specified with solvent welded type joints, or approved equal. Pipe shall be slotted or have two rows of 1/4-inch diameter holes spaced 4-inches apart along the circumference of the pipe. Longitudinal spacing of holes shall be 5-inches maximum.
- N. PTFE (TEFLON) THREAD TAPE SHALL NOT BE USED ON SAMPLE LINE APPLICATIONS.

2.02 CHLORINATED POLYVINYL CHLORIDE (CPVC) PIPE AND FITTINGS

- A. CPVC shall be manufactured in accordance with ASTM D1785, D1784 and F441, "normal impact" pipe, Schedule 40 or 80 as specified.
- B. Fittings used with this pipe shall be socket type or flanged type as specified herein or indicated on the Drawings. Plastic piping shall be installed in full accordance with the manufacturer's recommendations for the specific installation. No field bending or distortion of the pipe will be permitted.

- C. CPVC pipe shall be Type 4, Grade 1, Schedule 80, conforming to ASTM D1784 and ASTM F441. CPVC fittings shall be socket type conforming to ASTM F439.
- D. Solvent Cement
 - 1. Solvent cement for socket type joints shall conform to ASTM F493 for CPVC pipe and fittings.
 - 2. Solvent cement for CPVC socket type joints in chemical service applications shall be Weld-On 724 as manufactured by IPS Corporation, or equal.
 - 3. Primer shall be used for all Schedule 80 piping. Primer shall be Weld-On P-70 as manufactured by IPS Corporation, or equal.

2.03 REINFORCED THERMOPLASTIC HOSE AND FITTINGS

- A. Reinforced thermoplastic hose shall be clear type, reinforced with polyester yarn. Hose material shall be PVC, EVA (Ethyl Vinyl Acetate), or Low-Density Polyethylene, depending on the application, as indicated in Section 40 06 20 – Process Pipe, Valve, and Gate Schedules. Hose shall be rated for the following working pressures:

Internal Diameter	Minimum Working Pressure (at 68°F)
½"	200 psi (75 psi at 150°F)
1"	125 psi (50 psi at 150°F)
1-½"	100 psi
2"	75 psi

- B. Hoses shall be continuous from the source to the discharge unless shown otherwise on the drawings. Splices shall not be allowed unless approved in writing by the Engineer. If allowed, splices shall occur only in handholes or manholes. Connections and splices, if allowed, shall be barb and clamp type using materials that are compatible with the chemical being conveyed.
- C. Reinforced thermoplastic hose shall be a manufactured product of Parker Nexgen or equal.
- D. Wetted materials shall be completely resistant to corrosion by the specified chemicals. Hose manufacturer shall guarantee that the hose is suitable for the intended service.

PART 3 – EXECUTION

3.01 INSTALLATION

- A. Polyvinyl chloride (PVC), chlorinated polyvinyl chloride (CPVC) and High Density Polyethylene (HDPE) pipe shall be laid and joints assembled according to the respective manufacturer's recommendation. PVC pipe installation shall comply with applicable sections of the Uni-Bell PVC Pipe Association Recommended Standard Specifications.
- B. Plastic piping shall not be installed when the temperature is less than 60 degrees F except as otherwise recommended by the manufacturer and approved by the Engineer.

END OF SECTION

SECTION 40 05 51
VALVES, GENERAL

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. The Contractor shall furnish and install, complete with all assemblies and accessories, all valves shown on the Drawings and specified herein including all fittings, appurtenances and transition pieces required for a complete and operable installation.
- B. All valves shall be constructed of first quality materials which have strength, wearing, and corrosion resistance characteristics entirely suitable for the types of service for which the individual valves are designated. Except where noted otherwise, valves designated for water service shall conform to pertinent sections of the latest revision of AWWA C500 Specifications. Cast iron valve bodies and parts shall meet the requirements of the latest revision of ASTM Designation A-126, "Standard Specifications for Gray Iron Castings for Valves, Flanges, and Pipe Fittings, Class B."
- C. All valve body castings shall be clean, sound, and without defects of any kind. No plugging, welding, or repairing of defects will be allowed.
- D. Valves shall have flanged ends for exposed service and mechanical joint ends for buried service, unless otherwise shown on the Drawings or specified herein. Flanged ends shall be flat-faced, 125 lb. American Standard unless otherwise shown or specified in accordance with ANSI B16.1. All bolt heads and nuts shall be hexagonal of American Standard size. The Contractor shall be responsible for coordinating connecting piping. Valves with screwed ends shall be made tight with Teflon tape. Unions are required at all screwed joint valves.

1.02 SUBMITTALS

- A. The following items shall be submitted in accordance with, or in addition to the submittal requirements specified in Section 01 33 00 – Submittal Procedures and Section 46 00 00 – Equipment General Provisions:
 - 1. Performance tests shall be conducted in accordance with the latest revision of AWWA C500.
 - 2. Shop Drawings conforming to the requirements of Section 01 33 00 – Submittal Procedures, are required for all valves, and accessories. Submittals shall include all layout dimensions, size and materials of construction for all components, information on support and anchoring where necessary, pneumatic and hydraulic characteristics and complete descriptive information to demonstrate full

compliance with the Documents. Shop Drawings for electrically operated/controlled valves shall include all details, notes, and diagrams which clearly identify required coordination with the electrical power supply and remote status and alarm indicating devices. Electrical control schematic diagrams shall be submitted with the Shop Drawings for all electrical controls. Diagrams shall be drawn using a ladder-type format in accordance with JIC standards. Shop Drawings for pneumatically operated/controlled valves shall include all details, notes, and diagrams which clearly identify required coordination with the compressed air (service air) system and electrical controls.

3. Operation and maintenance manuals and installation instructions shall be submitted for all valves and accessories in accordance with the Specifications. The manufacturer(s) shall delete all information which does not apply to the equipment being furnished.

1.03 CONTRACTOR'S RESPONSIBILITIES

- A. The Contractor shall provide the services of a qualified representative of the manufacturer(s) of the equipment named below to check out and certify the installation(s), to supervise the initial operation, and to instruct the Owner's operating personnel in proper operation and maintenance procedures in accordance with the following schedule:

Item	Valve/Operator Type	Minimum On-Site Time Requirements
1	Automatic Control Check Valve	One (1) 8-hour day
2	Surge Anticipators	One (1) 8-hour day
3	Motor Operated Modulating Valves	One (1) 8-hour day
4	Motor Operated Open-Close Valves (required only if manufacturer is other than for Item 3 above)	One (1) 8-hour day
5	Pneumatic Hydraulic Cylinder Operated Valves	One (1) 8-hour day

- B. Any additional time required to achieve successful installation and operation shall be at the expense of the Contractor. The manufacturer's representative shall sign in and out at the office of the Engineer's Resident Project Representative on each day they are at the project.
- C. A written report covering the representative's findings and installation approval shall be mailed directly to the Engineer covering all inspection and outlining in detail any deficiencies notes.

- D. The times specified are exclusive of travel time to and from the facility and shall not be construed as to relieve the manufacturer of any additional visits to provide sufficient service to place the equipment in satisfactory operation.

PART 2 – PRODUCTS

2.01 FLOW INDICATORS

- A. Flow indicators shall be the Akron ball-type as manufactured by Brooks Instrument Co., Fischer and Porter, or equal, and shall have bronze bodies, glass dome, and plastic ball.

2.02 CORPORATION STOPS

- A. Corporation stops shall be of bronze with tapered male iron pipe threads on inlets and outlets. Terminal outlets shall have screwed bronze hex head dust plugs or caps. Unions shall be used on all corporation stop outlets with connecting piping. Corporation stops shall have a minimum working pressure rating of 250 psi and shall be as manufactured by Mueller Co., Hays Mfg. Div. of Zurn Industries, or equal.

2.03 FLOOR BOXES

- A. Floor boxes shall be provided for all nut operated or floor accessed valves. Floor boxes shall be of the adjustable, sliding type, cast iron, suitable to withstand heavy traffic, as manufactured by James B. Clow & Sons, Kennedy Valve Mfg. Co., or equal. The covers shall be marked with appropriate designations of piping contents (i.e.: water, sewer) and bases shall be the round type. All nut operated valves in this Section shall be clearly identified by stainless steel or laminated plastic identification tags. The tags shall be permanently affixed to the inside of the floor boxes, under grating, etc. and shall bear the embossed letters which clearly identify each valve by its appropriate designation.
- B. Two (2) valve operating wrenches shall be supplied in 4-foot lengths with tee handles for each size nut supplied. Valve wrenches shall be Model No. F-2520 as manufactured by James B. Clow & Sons, Kennedy Valve Mfg. Co., Figure No. 122, or equal.

2.04 VALVE BOXES

- A. The Contractor shall furnish and install valve boxes as shown on the Drawings and specified herein.
- B. All valve boxes shall be placed so as not to transmit shock or stress to the valve and shall be centered and plumb over the operating nut of the valve. The ground in the trench upon which the valve boxes rest shall be thoroughly compacted to prevent settlement. The boxes shall be fitted together securely and set so that the cover is flush with the finished grade of the adjacent surface. A concrete pad as detailed on the Drawings shall be provided around the valve box, sloped outwards.

- C. All valve boxes shall be 2-piece cast iron, sliding type, 5-1/4" shaft, with heavy duty traffic weight collar and the lid marked with the appropriate carrier product (i.e.: WATER). Boxes shall be as manufactured by James B. Clow & Sons, Kennedy Valve Mfg. Co., Charlotte Pipe and Foundry Company, or equal.

2.05 STRAINERS

- A. Y-Strainers shall be Y-pattern cast iron body, flanged or screwed ends with stainless steel or Monel, 20 mesh strainers. Strainers shall be 200 psi, cold-water service strainers, as manufactured by WATTS, Crane Co., Zurn, or equal.
- B. Caustic service Y-strainers shall be provided as shown on the drawings. Strainers shall be full port-full flow design manufactured of 304 or 316 stainless steel body. Y-strainers shall be furnished with flanged ends. The strainer screen shall be 1/32-inch perforation, easily removable, manufactured of the same material as the valve body.
- C. Stainless steel Y-strainers shall be provided as shown on the drawings. Strainers shall be full port-full flow design manufactured of 304 or 316 stainless steel body. Y-strainers shall be furnished with flanged ends. The strainer screen shall be 1/32-inch perforation, easily removable, manufactured of the same material as the valve body.
- D. PVC and CPVC y-strainers shall be provided in PVC and CPVC piping and as shown on the Drawings. Strainer shall be provided with PVC or CPVC body and end cap, EPDM or Viton seal as required for the chemical service, and 20 mesh screen. Temperature rating shall be 30°F to 140°F, and pressure rating shall be 150 psi @ 70°F, non-shock. PVC and CPVC y-Strainers shall be as manufactured by Asahi/America, Hayward, or equal.
- E. Manually cleaned strainers shall be the duplex basket tapered plug type.
 - 1. Strainers 3-inches in diameter and larger shall have flanged ends conforming to ANSI B16.1-125/150-pound standard.
 - 2. Strainers less than 3-inches in diameter shall have screwed end connectors, unless otherwise shown on the Drawings.
 - 3. Strainers shall be constructed with an ASTM A48, Class 30 cast iron body, ductile iron trim, removable 0.045-inch staggered hole perforation, 304 stainless steel filter baskets and gauges on the inlet and outlet.
 - 4. All strainers shall be suitable for 125 psi service.
 - 5. Switching flow from one basket to the other shall be accomplished by moving the handle through a 180° arc. The switching operation shall not stop flow through the strainer and shall provide for on-line removal of either basket with the other basket functional. The plug shall be automatically positioned with integral stops and shall be easily lifted and reseated under pressure.

6. The strainer shall be designed to minimize the possibility of material bypassing the plug while being rotated and to prevent debris from building up under the plug. The strainer covers shall be designed for quick opening with swing away yoke.
 7. Each basket compartment shall have a side drain outlet.
 8. All strainers shall be provided with support legs.
 9. Duplex basket strainers shall be similar to the Model 53BTX as manufactured by Hayward, or equal.
- F. PVC and CPVC simplex basket strainers shall be provided in PVC and CPVC piping as shown on the Drawings. 1/2"-4" strainers shall be one-piece molded body with (3) ports to facilitate straight-thru flow pattern or u-shape flow pattern as required. Connections shall be true union type to ease installation/future maintenance. The cover, vent plug, and drain plug shall all be hand-removable, requiring no tools. EPDM or Viton seals shall be used as required for chemical service, and internal baskets shall be 1/32" perforation (20-mesh) for 1/2"-1" sizes, and 1/8" perforation for 1-1/2"-8" sizes. 6" and 8" strainers shall be fabricated construction and shall contain flanged connections as standard. The pressure rating for 1/2"-8" sizes shall be 150 psi @ 70°F, non-shock. Strainers shall be manufactured by Hayward Industrial Products, or equal.

2.06 QUICK DISCONNECT COUPLINGS

- A. Quick disconnect type coupling for compressed/service air shall be provided where indicated on the Drawings. Coupling shall provide for instantaneous shutoff in socket end when lines are disconnected. Couplings shall be constructed of 316 stainless steel with a BUNA-N O-ring and integral safety lock. Couplings shall comply with Military Specification 4109 (interchangeable with standard plug of the same size).

2.07 BACKFLOW PREVENTERS

- A. Backflow preventer shall be the size shown on the Drawings and shall be of the double check valve principle. Backflow preventer installation shall include isolation valves and four test cocks, furnished as an assembly. For backflow preventers less than 2-1/2", the installation assembly also shall include a strainer. Isolation valves for backflow preventers shall be ball valves, except for size 2-1/2" and larger which shall be resilient seat gate valves. Test cocks shall be located as recommended by the manufacturer to facilitate functional testing of the assembly. The backflow preventer shall be a WATTS 709, or equal.
- B. Reduced Pressure Backflow Preventer shall be of the size shown on the Drawings and shall be of the reduced pressure principle type in accordance with AWWA Standards C510 and C511, with two (2) independent operating spring loaded check valves and one (1) spring loaded, diaphragm actuated, differential pressure relief valve shall be installed between the check valves. Backflow preventer shall be bronze body construction, with

EPT rubber discs and Buna-N and nylon diaphragm. Screws and springs shall be of stainless steel. End connections shall be screwed, unless otherwise specified or shown on the Drawings. Reduced pressure backflow preventer installations shall include isolation valves and four test cocks, furnished as an assembly. For reduced pressure backflow preventers less than 2-1/2" the installation assembly also shall include a strainer. Isolation valves for reduced pressure backflow preventers shall be ball valves, except for sizes 2-1/2" and larger which shall be resilient seat gate valves. Test cocks shall be located as recommended by the manufacturer to facilitate functional testing of the assembly. The reduced pressure backflow preventer shall be as manufactured by Beeco Division, Hersey Products Inc., Aergap Model 6CM, WATTS 909, or equal.

PART 3 – EXECUTION

3.01 INSTALLATION

- A. Except where noted otherwise herein, all valves shall be installing and tested in accordance with the latest revision of AWWA C500. Before installation, all valves shall be lubricated, manually opened and closed to check their operation and the interior of the valves shall be thoroughly cleaned. Valves shall be placed in the positions shown on the Drawings. Joints shall be made as directed under the Piping Specifications. The valves shall be so located that they are easily accessible for operating purposes and shall bear no stresses due to loads from the adjacent pipe. The Contractor shall be responsible for coordinating connecting piping.
- B. All valves shall be tested at the operating pressures at which the particular line will be used. Any leakage or "sweating" of joints shall be stopped, and all joints shall be tight. All motor operated and cylinder operated valves shall be tested for control operation as directed by the Engineer.
- C. Provide valves in quantity, size, and type with all required accessories as shown on the Drawings.
- D. Install all valves and appurtenances in accordance with manufacturer's instructions. Install suitable corporation stops at all points shown or required where air binding of pipe lines might occur. Install all valves so that operating handwheels or wrenches may be conveniently turned from operating floor but without interfering with access, and as approved by Engineer. Unless otherwise approved, install all valves plumb and level. Valves shall be installed free from distortion and strain caused by misaligned piping, equipment or other causes.
- E. Valve boxes shall be set plumb and centered with the bodies directly over the valves so that traffic loads are not transmitted to the valve. Earth fill shall be carefully tamped around each valve box to a distance of 4 feet on all sides of the box, or to the undisturbed trench face, if less than 4 feet.

- F. All buried valves with flanged connections shall be installed with a minimum of 12" stone bedding.

3.02 SHOP AND FIELD TESTING

- A. Shop and field testing of valves shall be as follows:
 - 1. Certified factory testing shall be provided for all components of the valve and operator system. Valves and operators shall be shop tested in accordance with the requirements in the latest revision of AWWA C500, including performance tests, leakage test, hydrostatic tests, and proof-of-design tests. The manufacturer through the Contractor shall submit certified copies of the reports covering the test for acceptance by the Engineer.
 - 2. Shop testing shall be provided for the operators consisting of a complete functional check of each unit. Any deficiencies found in shop testing shall be corrected prior to shipment. The system supplier through the Contractor shall submit written certification that shop tests for the electrical/pneumatic system and all controls were successfully conducted and that these components provide the functions specified and required for proper operation of the valve operator system.
 - 3. The Contractor shall conduct field tests to check and adjust system components, and to test and adjust operation of the overall system. Preliminary field tests shall be conducted prior to start-up with final field tests conducted during start-up. The factory service representative shall assist the Contractor during all field testing and prepare a written report describing test methods, and changes made during the testing, and summarizing test results. The service representative shall certify proper operation of the valve operator system upon successful completion of the final acceptance field testing.
 - 4. Preliminary and final field tests shall be conducted at a time approved by the Engineer. The Engineer shall witness all field testing.
 - 5. All costs in connection with field testing of equipment such as energy, light, lubricants, water, instruments, labor, equipment, temporary facilities for test purposes, etc. shall be borne by the Contractor. The Contractor shall be fully responsible for the proper operation of equipment during tests and instruction periods and shall neither have nor make any claim for damage which may occur to equipment prior to the time when the Owner formally takes over the operation thereof.
 - 6. Preliminary field tests shall be conducted prior to start-up and shall include a functional check of the entire valve operator system and all system components. Preliminary field tests shall demonstrate that the valve operator system performs according to specifications and that all equipment, valves, controls, alarms, interlocks, etc., function properly. The preliminary field test report must be

approved by the Engineer prior to conducting final field acceptance tests. Based on results of preliminary field tests, the Contractor shall make any adjustments required to settings, etc., to achieve the required valve closing time and operation specified or otherwise directed by the Engineer.

7. Final field acceptance tests shall be conducted simultaneously with the start-up and field testing of the pumps, air compressors, process air blowers, etc. Field tests shall be conducted for the full range of operating modes and conditions specified and as directed by the Engineer. Each of the valves shall be tested at minimum, maximum, and normal head/flow conditions, and under all specified conditions of opening and closing. Performance of pneumatic valves and compressed air system under normal operating conditions and during simulated power failures shall be checked.
8. Field testing shall include optimization of opening and closing times of the valves. The Contractor shall provide the means for accurate measurement of pipeline pressures as directed by the Engineer. Valve opening and closing times shall be adjusted based on process requirements to optimize operation of the valves. Final valve opening and closing times as determined by field tests shall be approved by the Engineer prior to final acceptance of the system.

END OF SECTION

SECTION 40 05 57
VALVE OPERATORS AND ELECTRIC VALVE ACTUATORS

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. Equipment shall be provided in accordance with the requirements of Section 46 00 00 – Equipment General Provisions and Section 40 05 00 – Basic Mechanical Requirements.
- B. Reference Section 40 06 20 – Process Pipe, Valve, and Gate Schedules for additional information on valves and operators/actuators.
- C. The electric valve actuators shall meet the signal requirements described in Section 40 61 23 – Signal Coordination, Section 40 61 93 – Process Control System Input/Output List, and Section 40 61 96 – Process Control Descriptions.
- D. Valve operators and electric valve actuators shall be designed to unseat, open or close, and seat the valve under the most adverse operating condition to which the valves will be subjected.
- E. Operator mounting arrangements shall be as indicated on the Drawings or as directed by the manufacturer and/or Engineer. There shall be no mounting restrictions on the electric valve actuator.
- F. The valve operators and electric actuators shall be the full and undivided responsibility of the valve manufacturer in order to ensure complete coordination of the components and to provide unit responsibility.

1.02 SUBMITTALS

- A. The following items shall be submitted in accordance with, or in addition to the submittal requirements specified in Section 01 33 00 – Submittal Procedures and Section 46 00 00 – Equipment General Provisions:
 - 1. Shop Drawings
 - 2. O&M Manuals
 - 3. Certification that the force required to operate all valves is as specified herein.

PART 2 – PRODUCTS

2.01 GENERAL

- A. Electric actuators shall be provided where specified in the Valve Schedule in Section 40 06 20 – Process Pipe, Valve, and Gate Schedules.
- B. Manual operators shall be provided on all valves which do not receive electric actuators. Manual operator type shall be as specified herein and as shown on the Drawings.
- C. Quarter turn valves 8" and greater in size shall have geared operators. Gate valves 14" and greater in size shall have geared operators.
- D. Operators/actuators shall be furnished with conservatively sized extension bonnets, extension stems, or torque tubes, and all required appurtenances required for a complete installation, including valve stem supports, except in roadways, where a standard valve box with nut shall be provided. Operators furnished with extension bonnets shall include stainless steel extension stems, or stainless steel torque tubes. Contractor shall coordinate quantity and design of valve stem supports with Manufacturer to accommodate anticipated operating conditions per Section 40 06 20 – Process Pipe, Valve, and Gate Schedules.

2.02 MANUAL OPERATORS

- A. Unless otherwise specified or shown on the Drawings, manual operator type shall be as follows:
 - 1. Buried valves shall be equipped with nut operators, extended stems, and valve boxes. Where the depth of the operating nut is more than 4 feet below finish grade, a valve operator extension shall be provided to bring the operating nut to within 18-24 inches of the surface.
 - 2. Exposed valves up to 6-inch shall be lever operated (except gate valves).
 - 3. Exposed valves 8-inches and larger shall be handwheel operated.
 - 4. Exposed gate valves shall be handwheel operated.
 - 5. Valves with centerline of operator located more than 6-feet above the floor or platform from which it is to be operated shall have a chainwheel operator unless otherwise indicated on the Drawings.
- B. Manual operators shall be rigidly attached to the valve body unless otherwise specified or shown on the Drawings.
- C. All operators shall turn counter-clockwise to open and shall have the open direction clearly and permanently marked.

- D. Valve operators shall be designed so that the force required to operate the handwheel, lever, or chain (including breakaway torque requirements) does not exceed 80 pounds applied at the extremity of handwheel or chainwheel operator. Design pressures for sizing of valve operators shall be the piping test pressure for the piping in which the valve is to be installed as shown in the Piping Schedule in Section 40 06 20 – Process Pipe, Valve, and Gate Schedules.
- E. Handwheels for valves operators shall not be less than 12 inches in diameter. The maximum diameter of any handwheel shall not exceed 24”.
- F. Nut operators shall have standard 2-inch square AWWA operating nuts designed in accordance with AWWA C504-94.
- G. Geared manual operators shall be of the worm gear, traveling nut or scotch yolk type except manual operators for butterfly valves 18-inch in diameter or larger which shall be worm gear, unless otherwise indicated in the individual valve specification. Gear operators shall be of the worm gear or bevel gear type. Gear box designs incorporating end of travel stops in the housing shall be equipped with AWWA input stops. Each gearbox shall require a minimum of 10 turns for 90 degree rotation or full valve stem travel and shall be equipped with a mechanical valve position indicator.
- H. Manual operators on below grade (and vault installed) valves shall be permanently lubricated and watertight under an external water pressure of 10 psi.

2.03 ELECTRIC VALVE ACTUATORS

- A. Electric Actuators shall be open/close service or modulating service as specified in the Valve Schedule in Section 40 06 20 – Process Pipe, Valve, and Gate Schedules.
 - 1. Open/Close (non-modulating) valve actuators shall be IQ series as manufactured by Rotork, SA series as manufactured by AUMA, or M2CP series as manufactured by Bettis (Emerson).
 - 2. Modulating valve actuators shall be Type IQM as manufactured by Rotork, Type SAR as manufactured by AUMA, or M2CP series as manufactured by Bettis (Emerson).
 - 3. Actuators for the Emergency Bypass Valves (MOV-35121 at the P.O. Hoffer WTF and MOV-35121 at the Glenville Lake WTF) shall be EHO series as manufactured by Bettis (Emerson) or equal.
- B. Performance Requirements
 - 1. The actuators shall be designed for indoor and outdoor service and shall be capable of mounting in any position.
 - 2. Torque capacity of the actuators shall be sufficient to operate the valves with the maximum pressure differential, as indicated in the Valve Schedule in Section 40

06 20 – Process Pipe, Valve, and Gate Schedules, with a safety factor of 1.5. Actuators in modulating service will be selected such that the required dynamic valve torque is no more than 60% of the electric actuator's maximum rated breakaway of torque.

3. Operating time for full limits of travel shall be not more than 2 seconds per inch diameter of the valve, +/- 50 percent through 20 inches; +/- 30 percent for valves 24 inches and larger. Operating time shall not be less than 60 seconds for all modulating valves.
 4. Actuators shall be capable of operating in ambient temperatures ranging from 0 degrees F – 160 degrees F.
 5. For open/close (non-modulating) actuators, the gearing, motor and contactor shall be capable of 60 starts per hour without overheating.
 6. For modulating actuators, the gearing, motor and contactor shall be capable of 1200 starts per hour without overheating.
- C. The actuators shall include, in one integral housing, individual compartments for the motor, gearing, wiring terminals, and control circuits. The terminal compartment shall be separated from the inner electrical components of the actuator by means of a watertight seal. The inner seal shall protect the motor and all other internal electrical elements of the actuator from entrance of moisture and dust when the terminal cover is removed. Double cartridge shaft seals shall be provided on the hand wheel and output shafts for weatherproof protection. All external fasteners shall be stainless steel. Compartments shall be provided with moisture and dust-proof rigid cast covers meeting NEMA 6, certified to submergence in 6 ft of water for 30 minutes. Actuators located in classified areas shall be suitable for use in Class 1, Division 1, Group D environments.
- D. The actuators shall be provided with externally operable and lockable 480VAC circuit breakers integral to the control housing
- E. All gearing shall be hardened alloy steel or bronze and shall be rated at twice the output torque of the operator and shall be designed to withstand the stall torque of the motor without failure. Output drive gearing shall consist of a worm shaft and worm gear pinion operating in an oil bath. The worm gear pinion shall be alloy bronze. Worm gear drive shall be self-locking to prevent creeping of the valve disc in an intermediate position. Heavy-duty grease shall protect gearing and sealed ball bearings of the main shaft for five years without changing. Motor reduction gearing shall be spur or planetary gearing and shall allow for field repair and change in gear ratio. For quarter turn applications, overtravel of the operator shall be prevented by internal mechanical stops cast into the actuator.
- F. A mechanical dial position indicator shall be furnished to continuously indicate the position of the valve at and between the fully open and fully closed positions. The indicator shall be driven by gearing driven off of the main worm gear pinion and shall operate when the actuator is in either the electrical mode or manual mode.

- G. A handwheel shall be permanently attached for manual operation. A gear assembly shall be provided between the handwheel and the worm shaft if required to reduce the force necessary to operate the handwheel to less than 40 pounds. A positive declutch mechanism shall engage the handwheel when required. When the actuator is set in the declutched position for handwheel operation, it shall return automatically to electric operation when actuator motor is energized. The handwheel shall not rotate during electric operation nor shall a fused motor prevent handwheel operation.
- H. The drive motor shall be specifically designed for actuator service and shall be characterized by high starting torque and low inertia. Motors shall be 460 volts, three phase, 60 Hz AC reversible squirrel cage induction type motors and shall be specifically designed for modulating service where indicated on the Valve Schedule in Section 40 06 20 – Process Pipe, Valve, and Gate Schedules. Motors shall be totally enclosed, non-ventilated, with NEMA Class F insulation minimum (Class H for modulating actuators) and a maximum continuous temperature rating of 120 degree C (rise plus ambient). A space heater shall be provided in the motor compartment. The electric motor shall have a time rating of at least 15 minutes at 104°F (40°C) or twice the valve stroking time, whichever is longer, at an average load of at least 33% of maximum valve torque. Motor bearings shall be permanently lubricated by premium lubricant. The motor shall have plug and socket electrical connection to facilitate easy removal and replacement. The actuator shall include a device to ensure that the motor runs with the correct rotation for the required direction of valve travel with either phase sequence of the three-phase power supply connected to the actuator. The motor shall include single phase protection. A suitable thermal protection device shall be incorporated in the motor or motor starter circuits, connected to a tripping device. Fast acting fuses shall be provided to protect solid state components. The motor shall be capable of starting against the rated load in either the open or close direction when voltage to the motor terminals is plus or minus ten (10) percent of nameplate rating.
1. Open/Close actuators shall be furnished with electro-mechanical reversing starters.
 2. Modulating actuators shall be furnished with solid state reversing starters utilizing thyristors.
- I. Leads from the motor shall be brought to the control circuit (limit switch) compartment without external piping or conduit box. An adequately sized space heater shall be installed in the control circuit compartment to aid in the prevention of damage resulting in from condensation. The following items shall be located in the control circuit compartment.
1. Torque limit switches shall be provided to de-energize the motor control circuit in the event of a stall when attempting to unseat a jammed valve and when torque is exceeded during valve travel. Each actuator shall have an open direction torque switch and a close direction torque switch. The torque switches shall be mechanically operated and able to be set in torque units. Torque switches shall be calibrated prior to the actuator's assembly to the valve.

2. Travel limit switches shall be provided to de-energize the motor control circuit when the actuator reaches the limits of travel in the open and close directions. The limit switch drive shall be of the counter gear type and “in step” with the actuator output drive at all times in either the electrical or manual mode of operation. A minimum of six (6) contacts, three (3) normally open and three (3) normally closed, shall be supplied at each end of valve travel. Four (4) additional contacts shall be provided to report end of travel or any desired position between ends of travel.
- J. Modulating actuators shall have a position feedback potentiometer mounted directly to the valve actuator gearing inside the gearing compartment. The potentiometer shall provide a 4-20 mA signal corresponding to valve position. Modulating valve actuators shall be designed to respond to either a 4-20mADC analog signal or a digital pulse signal as specified herein or as required to coordinate with the requirements of Division 40.
1. Modulating valve actuators designed to respond to a 4-20mADC signal shall be provided with a valve positioner which shall position the valve proportional to an externally generated 4-20mADC signal. The valve positioning control circuitry shall position the valve by comparing the command signal with the present valve position as indicated by the feedback potentiometer. The positioner shall be field adjustable to fail to the “open,” “closed,” or “last” position on loss of 4-20 mADC command signal.
 2. Modulating valve actuators designed to respond to “pulse” open/close signals shall operate the valve during the time the open or close pulse signal is high. Modulating actuators designed to respond to “pulse” open/close signals shall have the latching circuitry described above for open/close actuators disabled.
- K. The electrical terminals shall be housed in a double sealed terminal compartment isolated from the rest of the actuator components. The actuators shall be designed to operate from a single 480VAC, 3-phase source. The actuators shall be furnished with fuses inside of the terminal compartment. A quantity of two – ¾ inch NPT conduit entries shall be furnished.
- L. Actuators shall contain wiring and terminals for the following control functions. All dry contacts shall be rated for 5A at 250VAC.
1. Open, Close, and Stop commands from external dry contacts (utilizing internal 24VDC power supply) and/or from an external signal of 12V to 120V. The inputs for the open, close, stop signals shall be field selectable to be respond to either maintained or momentary remote signals. In momentary mode, the actuator shall have internal latching circuitry that causes the operator to drive the valve to its limit of travel upon receipt of the momentary contact signal unless a stop signal is received.

2. Emergency override input from a normally closed or normally open contact. The actuator shall either open or close (field selectable) upon receiving the emergency override input.
3. Remote Local-Off-Remote selector switch, Open/Close pushbuttons, and Open/Closed pilot lights for a remote manual control station (see below). The remote Local-Off-Remote selector switch and Open/Close pushbuttons shall be a dry contact input to the actuator control circuitry. The Open/Closed pilot lights shall be powered from the valve actuator control power.
4. Four (4) unpowered contacts shall be provided which can be selected to indicate valve "Opened" and "Closed" position, "Remote" status of the actuator, and fail status of the actuator. The fail status contacts shall activate upon motor overtemperature and actuator overtorque as a minimum.
5. Terminals for 4-20mADC position command and 4-20mADC position feedback as described above for modulating actuators.

M. Local Controls

1. Actuators shall be furnished with a Local-Off-Remote selector switch; Open, Close, and Stop pushbuttons for local control; a red lamp indicating closed and a green lamp indicating open. L-O-R switch shall be padlockable in any of the three positions.
 - a. When the LOR is in the "Local" position, open/close control shall be by the open and close pushbuttons on the actuator. The stop push button shall stop the actuator travel.
 - b. When the LOR is in the "Off" position, the actuator shall not operate.
 - c. When the LOR is in the "Remote" position, the actuator shall be controlled by remote inputs from the PLC or from the remote manual controls station.
2. The local controls shall be arranged so that the direction of travel can be reversed without the necessity of stopping the actuator.

2.04 ELECTRIC OPERATORS FOR PVC/CPVC THERMOPLASTIC VALVES (NOT USED)

2.05 PNEUMATIC CYLINDER OPERATORS FOR OPEN-CLOSE TYPE VALVES (NOT USED)

2.06 SPARE PARTS

- A. Spare parts shall be provided in accordance with Section 46 00 00 – Equipment General Provisions.

PART 3 – EXECUTION

3.01 MANUFACTURER'S FIELD SERVICES

- A. The services of a qualified manufacturer's technical representative shall be provided in accordance with Section 46 00 00 – Equipment General Provisions and shall include the following site visits for electric actuators:

Service	Number of Trips	Number of Days/Trip
Installation and Testing	2*	2
Startup and Training	2*	2
Services after Startup	2*	2

**One trip per WTF*

3.02 INSTALLATION

- A. All valve actuators shall be installed in accordance with the manufacturer's published recommendations and the applicable Specification Sections for valves and motor controls.
- B. Valve actuators shall be factory coated in accordance with the manufacturer's standard paint system.

3.03 SHOP TESTING

- A. Shop testing shall be in accordance with Section 46 00 00 – Equipment General Provisions and with the following additional requirements:
1. Conduct a complete functional check of each unit. Correct any deficiencies found in shop testing prior to shipment.
 2. Submit written certification that:
 - a. Shop tests for the electrical system and all controls were successfully conducted;
 - b. Electrical system and all controls provide the functions specified and required for proper operation of the valve operator system.
 3. Each actuator shall be performance tested and individual test certificates shall be supplied free of charge. The test equipment shall simulate each typical valve load and the following parameters should be recorded:
 - a. Current at maximum torque setting

- b. Torque at maximum torque setting
- c. Flash Test Voltage
- d. Actuator Output Speed or Operating Time
- e. In addition, the test certificate should record details of specification, such as gear ratios for both manual and automatic drive, closing direction, and wiring diagram code number.
- f. Verification of actuator torque rating with valve.

3.04 FIELD TESTS

- A. Field testing shall be in accordance with Section 46 00 00 – Equipment General Provisions and with the following additional requirements:
 - 1. Valve actuators shall be field-tested together with the associated valves.
 - 2. Test all valves at the operating pressures at which the particular line will be used.
 - 3. Test all valves for control operation as directed.
 - 4. Field testing shall include optimization of opening and closing times of the valves. Valve opening and closing times shall be adjusted based on process requirements to optimize operation of the valves. Final valve opening and closing times as determined by field tests shall be approved by the Engineer prior to final acceptance of the system.
- B. Preliminary Field Tests
 - 1. General: Preliminary field tests shall be conducted prior to start-up and shall include a functional check of the entire valve operator system and all system components.
 - 2. Scope: Preliminary field tests shall demonstrate that the valve operator system performs according to specifications and that all equipment, valves, controls, alarms, interlocks, etc., function properly.
 - 3. Based on results of preliminary field tests, the Contractor shall make any adjustments required to settings, etc., to achieve the required valve closing time and operation, as specified or otherwise directed.
- C. Final Field Tests
 - 1. Final field tests shall be conducted in accordance with the latest revision of AWWA C500.

2. Final field tests shall be conducted simultaneously with the start-up and field testing of the pumps.
3. Final field tests shall be conducted for the full range of operating modes and conditions specified and as directed by the Engineer. Each of the valves shall be tested at minimum, maximum, and normal head/flow conditions, and under all specified conditions of opening and closing.
4. Certification of Equipment Compliance: After the final field tests are completed and passed, submit affidavit according to Section 46 00 00 – Equipment and General Provisions.

END OF SECTION

SECTION 40 05 59
STOP PLATES AND STOP LOGS

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. The Contractor shall furnish and install all stop plates and stop logs complete with all accessories, special tools, spare parts, mountings, anchor bolts and other appurtenances as specified herein, as shown on the Drawings, and as required for a complete and operating installation.
- B. Equipment shall be provided in accordance with the requirements of Section 46 00 00 – Equipment General Provisions and Section 40 05 00 – Basic Mechanical Requirements.
- C. Locations, dimensions, design criteria, number required, etc. for stop plates and stop logs are indicated in the appropriate Schedule in Section 40 06 20 – Process Pipe, Valve, and Gate Schedules.

PART 2 – PRODUCTS

2.01 GENERAL

- A. Subject to compliance with the Specifications provide products manufactured by Rodney Hunt Company, Washington Aluminum, or equal.
- B. Liberal safety factors shall be used in the design of all of the equipment. Working stresses shall not exceed the lower value of: One-third of the yield strength, or one-fifth of the ultimate strength of the material. The plates and appurtenances shall be designed for installation in the structures shown on the Drawings.

2.02 STOP PLATES (NOT USED)

2.03 STOP PLANKS (NOT USED)

2.04 STOP LOGS

- A. Stop logs shall be fabricated 304 stainless steel with thickness and reinforcement as required for the head conditions in the stop log schedule. The stop log supplier shall be responsible for sizing the stop logs and the stop log frames.
- B. The stop log frames shall be of extruded 304 stainless steel surface mount or embedded design with construction similar to aluminum stop plate frames. Each stop log section

shall be sized for ease of handling and be fitted with a resilient seal along the bottom to make a tight seal between stop logs and between stop log and bottom of channel.

- C. The stop log frame shall have resilient seals on each side to make a tight seal between the stop log and frame. The stop log and frame design shall accommodate head on either side of the stop logs when placed in the channel. Stop logs shall be placed and removed by means of a stop log lifter which fits into the same frame guides. A latching device on the lifter shall be provided for engaging and disengaging the stop logs. Latching device shall be operable from top slab position.
- D. Provide stainless steel cable of sufficient length to facilitate installation and removal of all stop logs.
- E. The stop log system shall be as manufactured by Rodney-Hunt, or equal. Contractor shall provide stop log frames at all locations as indicated on the Drawings. Provide one stop log lifter and cables for each channel configuration indicated (but no less than 3 lifters).

PART 3 – EXECUTION

3.01 MANUFACTURER’S FIELD SERVICES

- A. The services of a qualified manufacturer’s technical representative shall be provided in accordance with Section 46 00 00 – Equipment General Provisions and shall include the following site visits for electric actuators:

Service	Number of Trips	Number of Days/Trip
Installation, Testing, Startup, and Training	1	2
Services after Startup	1	1

3.02 INSTALLATION AND TESTING

- A. The completely assembled stop plates, in vertical position, shall be inspected for proper seating. The plate discs shall be fully installed and removed in its guide system to ensure that it operates freely and to demonstrate operation of the plate lifter. The stop plates shall be checked for leakage.
- B. Stop logs shall be fully installed and removed in each stop log frame to ensure that they operate freely and to demonstrate operation of the stop log lifter. The stop logs shall be checked for leakage.

- C. All stop plates shall be certified that at the operating head conditions indicated in Section 40 06 20 – Process Pipe, Valve, and Gate Schedules, leakage shall not exceed 0.1 gallon per minute per linear feet of gate perimeter at the design operating head.

END OF SECTION

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SECTION 40 05 63

BALL VALVES

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. Reference Section 40 05 00 – Basic Mechanical Requirements.
- B. Valves required for chemical service shall be constructed of materials suitable for the intended service.

PART 2 – PRODUCTS

2.01 BALL VALVES (WATER SERVICE) (BLV-MS)

- A. Ball valves (water service) shall be of the full port, single seated, metal to metal seated, tight-closing type conforming to the latest revision of AWWA C507 Specifications. The manufacturer shall have a minimum of 5 years of experience in manufacturing ball valves of the sizes required in accordance with AWWA C507 Specifications. All ball valves shall be the product of one manufacturer. Ball valves shall be as manufactured by Willamette Valve, Inc., or equal.
- B. Each valve shall be performance and leak tested as specified in AWWA C507 revised as follows: In addition to the testing requirements of AWWA C507, each ball valve shall be thoroughly cleaned and opened and closed at least three (3) times prior to testing. Certified copies of the test results shall be submitted to the Engineer for approval prior to shipment of the valve.
- C. Ball valves shall be AWWA Class 150, unless otherwise indicated in the valve schedules, design with flanged ends, and installed as shown on the Drawings.
- D. The valve body shall be constructed of epoxy coated cast iron conforming to ASTM A 48, Class 35, with a full, unrestricted circular inlet and outlet, with nominal opening diameter equal to the rated size of the valve. Each valve body shall be provided with flanged ends conforming in diameter and drilling to ANSI B16.1, Class 125. All flanges shall be flat faced and finished to true plan surfaces within a tolerance limit of 0.005 inch. Each flange face shall be perpendicular to the longitudinal axis of the valve within a maximum angular variation tolerance of 0.002 inch per foot of flange diameter. Flange faces shall have concentric or spiral serrated finish. The body trunnions shall be fitted with ample sized bronze bearings of sufficient difference in hardness from the plug bearings to eliminate seizing and galling. Bearing pressure shall not exceed 1500 psi at full differential pressure of 150 psi. Valve designs employing teflon coated or other

non-metallic material will not be acceptable. Bearings shall be machined in accurate alignment for reception of the plug trunnions.

- E. The body shall provide rigid means for supporting the valve operating mechanism without the necessity of additional supports and shall be of such design that it shall be capable of receiving the complete plug sub assembly. The valve body shall have integral hubs for housing shaft bearings and seals.
- F. The body shall have a rigidly attached metal seat. The body seat shall be Monel (Alloy 400) and shall be machined, ground, and polished for contact with the stainless steel seat mounted on the plug.
- G. There shall be two (2) pipe connections, one for an air vent and the other for drain.
- H. The plug shall be constructed of epoxy coated cast iron conforming to ASTM A48, Class 35, with a full unobstructed, circular waterway with a diameter equal to the rated size of the valve. It shall have trunnion supports cast integral on the axis of rotation. An extension of one trunnion, called the operating shaft, shall pass through a shaft seal chamber, and connect to the valve operation mechanism.
- I. The plug shall have a stainless steel seat conforming to ASTM A276, Type 304, mounted thereon which shall properly align with the body seat when the valve is in the closed position. The surfaces of the seat ring shall be spherically generated and shall be machined, ground, and polished for contact with the body seat.
- J. The plug trunnions shall be fitted with bronze bearings of sufficient difference in hardness from the body bushings to eliminate seizing and galling.
- K. Bearing pressure shall not exceed 1500 psi at full differential pressure of 150 psi. Valve designs employing Teflon coated or other non-metallic bearing material will not be acceptable.
- L. Valve shafts shall be integral with the plug and shall connect the plug to the torque unit. The shaft shall be of chrome Molybdenum Steel (ASTM A 322 Grade 4140) with hard chrome plate through the seal chamber suitably sized to transmit the torques required to operate the valves under the conditions listed in the valve schedule with appropriate safety factor. Shafts shall be securely attached to valve plug by means of conservatively sized corrosion-resistant taper pins, threaded at one end and secured with lockwashers and nuts (i.e.: mechanically attached). Provide O-ring seal on taper pin if required to prevent leakage. Shaft key shall be constructed of corrosion-resistant material.
- M. Shaft bearings shall be contained in the integral hubs of the valve body and shall be the permanently self-lubricated, corrosion resistant, sleeve type of heavy-duty bronze. The valve assembly shall be furnished with a factory set thrust bearing designed to center the valve plug in the valve seat at all times. End cover bolts shall be of stainless steel construction.

- N. A shaft seal shall be provided of the type utilizing a plug shaft stuffing box, four (4) "O" ring seals, a bronze retainer, and a corrosion resistant steel lock ring. The "O" ring material shall be BUNA-N rubber, as intended for use with potable water or wastewater.
- O. Manual operators for ball valves 18-inches in diameter or larger shall be the worm gear or travelling nut type conforming to AWWA C507. Manual operators for ball valves mounted above 6 feet from the operating floor shall be equipped with worm gear chainwheel actuators. Operators shall be equipped with adjustable AWWA limit stops and shall require a minimum of 15 turns for 90 degrees or full stem valve travel. The capacity of the manual operator shall be adequate to drive the valve under the differential pressure of 150 psi and maximum anticipated flow, unless otherwise indicated in the appropriate valve schedule. Electric motor operators shall be as specified elsewhere in this Section.
- P. The torque unit (valve operating mechanism) shall be of the traveling-nut type and shall be the product of the valve manufacturer. The assembly shall be mounted and attached to the valve body. The torque unit shall be designed to accept a manual, cylinder, or electric motor actuator. The torque unit housing shall employ the following:
1. A traveling crosshead to impart positive rotary movement to the plug which will move transversely to the valve shaft.
 2. A cylinder piston rod or stainless steel Type 416 threaded leadscrew (reach rod or stem) with the crosshead directly attached thereto.
 3. A rotator lever (of cast steel construction).
 4. A matched set of interconnecting links (of cast steel construction) connecting the traveling crosshead to the rotator lever.
- Q. The traveling crosshead shall be confined to permit linear motion only and to prevent it from any tendency to rotate due to linkage reaction. A plug shaft support bearing shall be supplied on the cover.
- R. The torque unit shall be so designed that during the first 50 percent of stroke in closing the flow area is reduced by approximately 81 percent. The remaining 19 percent of flow area shall be gradually reduced to a complete shutoff throughout the last 50 percent of the closing stroke.
- S. The torque unit shall be totally enclosed in a suitable housing with a removable cover and shall be capable of being inspected, lubricated, adjusted, and repaired without interfering with or removing the valve from the line and shall be permanently lubricated. All parts shall be of first class workmanship, easily replaceable and manufactured of the best materials suited for the purpose. All parts subject to rubbing shall be of significantly different hardness to prevent galling and shall be sized to result in a maximum bearing

stress at full load of 2,000 psi. The main shaft shall be replaceable without removing the torque unit housing and while the valve is in the line under pressure.

- T. The manufacturer shall certify that the ball valves are capable of operating in continuous duty service under these pressures and flow conditions.
- U. Each valve shall be hydrostatically tested and tested for bubble tightness after the operator has been mounted and adjusted. Copies of the hydrostatic and leakage test certification and certification of conformance shall be submitted to the Engineer prior to shipment.
- V. All internal and external ferrous components and surfaces of the valves, with the exception of stainless steel and finished or bearing surfaces, shall be shop painted with two coats (10 mils min. dry film thickness) of the manufacturer's premium epoxy for corrosion resistance. Damaged surfaces shall be repaired in accordance with the manufacturer's recommendations.

2.02 BALL VALVES (SERVICE AIR) (BLV-SA)

- A. Ball valves (service air) shall be manufactured by Apollo Ball Valve Division of Conbraco Industries, Inc., Pageland, SC., or equal. The body materials shall be cast bronze rated at 600 psi WOG, 150 psi saturated steam. Valves shall be tested by the manufacturer to MSS SP-72, 100 psi air under water, in the opened and closed position. The valve shall provide a port diameter equal to or exceeding the mating pipe size. Valves 2-1/2 inches in diameter and smaller shall have lever operators, unless otherwise specified herein or noted on the Drawings. Levers shall be cadmium plated steel covered with a vinyl grip and attached with a nut and have a hole for tagging purposes. The stem gland shall be adjustable and independent of the lever to compensate for wear. Bottom loaded stems shall be designed to be blow-out proof. The stuffing box seals and ball seats shall be composed of glass-reinforced TFE. The ball and stem shall be 316 stainless. Ball valves shall have NPT ends.

2.03 BALL VALVES (THREADED STAINLESS STEEL)

- A. Two-Piece Stainless Steel Body (BLV-2S)
 - 1. 3-Inch and Smaller
 - a. Threaded ends, 2-piece, full port, stainless steel design manufactured to MSS SP-110.
 - b. Blow-out proof stem, RPTFE stem bearing, two position locking vinyl grip stainless steel lever operator, compression controlled RPTFE body seals, and adjustable multi-piece PTFE "V" style packing.
 - c. Rated for 1000 psi CWP.

- d. Manufacturer: Apollo 76F-100 Series or Approved Equal.

B. Three-Piece Stainless Steel Body (BLV-3S)

1. 2-Inch and Smaller

- a. Threaded ends, 3-piece, full port, stainless steel design manufactured to MSS SP-110.b. Blow-out proof stem, two position locking vinyl grip stainless steel lever operator, compression controlled RPTFE gaskets, and adjustable multi-piece PTFE "V" style packing.
- b. Rated for 1500 psi CWP.
- c. Manufacturer: Apollo 86A-100 Series or Approved Equal.

2.04 BALL VALVES (FLANGED STAINLESS STEEL)

- A. Flanged stainless steel ball valves 12 inches in diameter and below shall be of the full port, one-piece or two-piece design as manufactured by Bray, American Valve, Sharpe, FNW, Keckley, or equal.
- B. Valves conveying potable water, used in potable water treatment, or conveying chemicals used in potable water treatment, shall be NSF/ANSI 61 and NSF 600 certified, where applicable.
- C. Body
 - 1. Valve body shall be constructed of 316 stainless steel.
 - 2. Valve design shall conform to ASME B16.34. Valves shall be rated for a working pressure of 275 psig at 100°F.
 - 3. Flanges shall conform to ASME B16.5 Class 150.
 - 4. Valve face-to-face dimensions shall conform to ASME B16.10.
 - 5. Valve materials shall comply with NACE MR0175.
- D. Ball
 - 1. Valve ball shall be constructed of 316 stainless steel and precision machined and polished to provide a smooth surface that will allow for bubble tight shut off and low operating torque.
- E. Stem

1. Valve stem shall be constructed of 316 stainless steel and shall be of the one-piece, blowout proof design. The stem shall contain an anti-static device to maintain constant contact with the body and ball to eliminate risk of static discharge.

F. Seat

1. Valve seat shall be PTFE and designed to ensure bidirectional, bubble tight shut off with low operating torque. Seat shall be positively preloaded to ensure low-pressure and vacuum sealing ability.

G. Seals and thrust washer shall be PTFE.

H. Handle, hardware, and trim shall be constructed of 300 series stainless steel.

PART 3 – EXECUTION (NOT USED)

END OF SECTION

SECTION 40 05 64
BUTTERFLY VALVES

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. Reference Section 40 05 00 – Basic Mechanical Requirements.

PART 2 – PRODUCTS

2.01 BUTTERFLY VALVES (WATER SERVICE)

- A. Butterfly valves (water service) shall be of the rubber-seated, tight-closing type conforming to the latest revision of AWWA C504. The manufacturer shall have a minimum of 5 years of experience in manufacturing butterfly valves of the sizes required in accordance with AWWA C504. All butterfly valves shall be the product of one manufacturer. Butterfly valves shall be as manufactured by Pratt, Mueller Co., DeZurik, or GA Industries. Each valve shall be performance and leak tested as specified in AWWA C504 revised as follows: In addition to the testing requirements of AWWA C504, each butterfly valve shall be thoroughly cleaned and opened and closed at least three (3) times prior to testing. Certified copies of the test results shall be submitted to the Engineer for approval prior to shipment of the valve.
- B. Butterfly valves shall be Class 150B, unless otherwise indicated in the valve schedules, and of the short body design with mechanical joint or flanged ends, as shown on the Drawings.
- C. Valve bodies shall be epoxy coated cast iron conforming to ASTM A-126, Grade B, ASTM A-48, Class 40 or Ductile Iron ASTM A536, Grade 65-45-12. Where required to meet design operating conditions, valve bodies shall be manufactured of higher strength materials. Valve bodies shall have integral hubs for housing shaft bearings and seals.
- D. Butterfly valves shall be of the concentric or eccentric shaft types. Valve discs shall be constructed of epoxy coated ductile iron, ASTM A536, Grade 65-45-12. Discs shall provide a full 360 degree seating surface with no external ribs transverse to flow, and shall comply with the latest revision of AWWA C504. The valve manufacturer shall furnish Shop Drawings which include end clearance dimensions when the disc is in the fully open position.
- E. The resilient valve seat shall be synthetic rubber designed to seat against a pressure differential of 150 psi on either side of the valve, unless otherwise indicated. The resilient seat shall be mechanically attached to the valve disc or valve body. Any required seat

attachment hardware shall be stainless steel. The resilient seat shall be capable of being adjusted or replaced in the field without moving the valve disc along the shaft axis or removing the valve from the line. The mating seat surface shall be stainless steel or monel.

1. The seats shall be factory tested as per AWWA C504 at a test pressure of 150 psig, unless otherwise indicated, and post adjusted for differential pressures indicated herein.
- F. Valve shafts shall be one-piece or two-piece units of stainless steel construction suitably sized to transmit the torques required to operate the valves under the conditions listed in the valve schedule with appropriate safety factor. Shafts shall be securely attached to valve disc by means of conservatively sized corrosion-resistant taper pins, threaded at one end and secured with lockwashers and nuts (i.e.: mechanically attached). Provide O-ring seal on taper pin if required to prevent leakage. Shaft key shall be constructed of corrosion-resistant material.
- G. Shaft bearings shall be contained in the integral hubs of the valve body and shall be the permanently self-lubricated, corrosion resistant, sleeve type of teflon or heavy-duty bronze. The valve assembly shall be furnished with a factory set two-way thrust bearing designed to center the valve disc in the valve seat at all times. End cover bolts shall be of stainless steel construction.
- H. The shaft seal shall be either the bronze cartridge type with at least two O-rings, monolithic V-Type, U-Cup Type, or pull down packing type. If monolithic V-Type, U-Cup Type, or pull down packings are utilized, it shall be self-adjusting, self-compensating type. Packing shall be as manufactured by Chevron, or equal. Butterfly valves with pull down packings shall be designed with an extension bonnet so that repacking can be done without removal of the actuator. For buried valves with pull down packing the packing gland cover assembly shall be heavy duty, soil and water resistant. Stuffing boxes for pull down packing shall have a depth sufficient to accept at least four rings of self-compensating type packing specifically selected for the operating pressures to be encountered. Stuffing box bolts, studs and nuts shall be stainless steel.
- I. The "O" ring type shaft seal shall be contained in a removable bronze cartridge. The bronze cartridge shall be manufactured from ASTM B505 copper alloy UNS #C93200 and shall meet the requirements of AWWA C504 for bronze, Grade E. The "O" ring material shall be nitrile, BUNA-N rubber, as intended for use with potable water or wastewater and per ASTM D-2000 with a hardness of 70 Shore A Durometer.
- J. Manual operators for butterfly valves 18-inches in diameter or larger shall be the worm gear type conforming to AWWA C504. Gearboxes shall not be submerged. Submerged butterfly valves shall be oriented with vertical shafts and furnished with extension bonnets/torque tubes and gearboxes located above grade/the maximum water surface as shown on the Drawings. Extension bonnets/torque tubes shall be segmented to

facilitate valve installation and removal as shown on the Drawings. Manual operators for butterfly valves mounted above 6 feet from the operating floor shall be equipped with worm gear chainwheel actuators. Operators shall be equipped with adjustable AWWA limit stops, shall be sized according to Table IV for Class 150B, and shall require a minimum of 15 turns for 90 degrees or full stem valve travel. The capacity of the manual operator shall be adequate to drive the valve under the differential pressure of 150 psi and maximum anticipated flow, unless otherwise indicated in the appropriate valve schedule.

- K. The manufacturer shall certify that the butterfly valves are capable of operating in continuous duty service under these pressures and flow conditions.
- L. Each valve shall be hydrostatically tested and tested for bubble tightness after the operator has been mounted and adjusted. Copies of the hydrostatic and leakage test certification and certification of conformance shall be submitted to the Engineer prior to shipment.
- M. All internal and external ferrous components and surfaces of the valves, with the exception of stainless steel and finished or bearing surfaces, shall be shop painted with two coats (10 mils min. dry film thickness) of the manufacturer's premium epoxy for corrosion resistance. Damaged surfaces shall be repaired in accordance with the manufacturer's recommendations.

2.02 BUTTERFLY VALVES FOR LOW PRESSURE AIR SERVICE (NOT USED)

2.03 RECTANGULAR BUTTERFLY VALVES (NOT USED)

PART 3 – EXECUTION (NOT USED)

END OF SECTION

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SECTION 40 05 65.23

CHECK VALVES

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. Reference Section 40 05 00 – Basic Mechanical Requirements.
- B. Valves intended for chemical service shall be constructed of materials suitable for the intended service.

PART 2 – PRODUCTS

2.01 NOZZLE CHECK VALVES (WATER SERVICE)

- A. Check valves where shown on the Drawings shall be nozzle type, axial or radial guided, annular shaped with two flow ports and rated for a minimum working pressure of 150 psi. The valve shall be non-slam, short stroke, low pressure loss, and be fully open with a flow velocity of 3.3 ft/s. Valves shall be Noreva Model ZB or NB.
- B. Valve closure shall be controlled by internal ring or solid disk, the action of which is cushioned by a helical spring and guide assembly. A flow path around or through the center of the disk shall create minimal pressure drop across the device.
- C. The valve body shall be constructed of ductile iron fully conforming to the latest revision of ASTM A-395. Valve ends shall be integral, flanged, faced, and drilled, in accordance with ANSI B16.5 Class 150.
- D. The valve disk shall be stainless steel ASTM A-351 CF8M. the valve disk shall be spring-loaded guided friction.
- E. Valve seating shall be stainless steel, Type 316 with metal-to-metal sealing, designed for valves to close slam-free and minimize maintenance. No soft seating elastomers shall be used. No external dampening devices shall be used.
- F. The flow diffuser shall be of stainless steel ASTM A-351 CF8M material.
- G. The radial guide and spring shall be of stainless steel, Type 316 material.
- H. All internal hardware shall be stainless steel, Type 316.
- I. With the exception of the valve body and seat, all parts in contact with water shall be manufactured from noncorrosive materials. Internal corrosive surfaces shall be shop

painted with two coats of epoxy for corrosion resistance. Exterior surfaces shall be painted in accordance with the requirements of Section 09 90 00 – Painting.

- J. Valve shall be NSF 61 certified for use in potable water treatment.

PART 3 – EXECUTION (NOT USED)

END OF SECTION

SECTION 40 05 68.13
PVC AND CPVC VALVES

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. Reference Section 40 05 00 – Basic Mechanical Requirements.

PART 2 – PRODUCTS

2.01 MATERIALS OF CONSTRUCTION

- A. Valves shall be constructed of materials suitable for the intended service. PVC valves shall be provided in PVC piping and CPVC valves shall be provided in CPVC piping.
- B. PVC valve bodies shall be constructed of PVC which shall meet or exceed the requirements of cell classification 12454 according to ASTM D1784. CVPC valve bodies shall be constructed of CPVC which shall meet or exceed the requirements of cell classification 23447 according to ASTM D1784.
- C. Materials of construction of other valve components shall be as specified below for the particular type of valve.
- D. Acceptable materials of construction of elastomers for chemical service shall be as follows:

Chemical Service	Elastomer Material
Hydrofluosilicic Acid	FKM
Powdered Activated Carbon Slurry	EPDM, FKM
Sodium Hypochlorite	FKM
Zinc Orthophosphate	EPDM, FKM

- E. Acceptable materials of construction of elastomers for non-chemical service shall be as follows:

Non-Chemical Service	Elastomer Material
Non-Potable Water	EPDM
Process Drain	EPDM, FKM

Non-Chemical Service	Elastomer Material
Potable Water	EPDM
Sample	EPDM, FKM
Sump Pump Discharge	EPDM, FKM

- F. All flanged valves shall be flat face flanged end type conforming to ANSI B16.5 bolt pattern for 150 lb. flanges.
- G. PTFE (TEFLON) THREAD TAPE SHALL NOT BE USED ON SAMPLE LINE APPLICATIONS.

2.02 PVC/CPVC BALL VALVES (BLV-P/BLV-C)

- A. Ball valves shall be true union design with flanged, socket, or threaded ends as required and as specified in Section 40 06 20 – Process Pipe, Valve, and Gate Schedules. All valves shall be full-port design and allow for bi-directional flow. Valve stems shall contain double o-ring seals. Valves shall have removable handles and integrally molded mounting features for actuator installation. Ball valves shall be rated for a minimum pressure of 150 psi at 70°F.
- B. Valve bodies, stems, balls, and unions shall be constructed of PVC or CPVC as specified in 2.01 B. Ball seats shall be made of PTFE, and o-ring seals shall be as specified in 2.01 D and 2.01 E.
- C. Ball valves shall be manufactured by Asahi/America, Nibco/Chemtrol, IPEX, Hayward Flow Control, Plastomatic, or equal.
- D. Ball valves for sodium hypochlorite service shall be vented, with a single hole factory-drilled into the ball to vent in the upstream direction when the ball is in the closed position. Valves shall be color coded or marked to indicate vented ball design.
- E. Where valves are installed in piping to be insulated and jacketed, stem extensions shall be furnished and installed such that the valve can be operated without any interference with these components.

2.03 PVC/CPVC SWING CHECK VALVES (CV-PS/CV-CS)

- A. Swing check valves shall be single-disc design with pivoting swing arm/disc clapper assembly and flanged ends. Valves shall be full flow, gravity operated, and suitable for either horizontal or vertical applications. Valves shall be capable of top entry to facilitate cleaning and repair without removal from the line. Swing check valves shall be pressure rated for 150 psi at 70°F.

- B. Valve bodies, bonnets, swing arms, and discs shall be constructed of PVC or CPVC as specified in 2.01 B. O-ring seals and shutters shall be as specified in 2.01 D and 2.01 E.
- C. Swing check valves shall be manufactured by Asahi/America, IPEX, Hayward Flow Control, or equal.

2.04 PVC/CPVC BALL AND DIAPHRAGM CHECK VALVES (DCV-P/DCV-C)

- A. Ball and diaphragm check valves shall be true union design with flanged, socket, or threaded ends as required and as specified in Section 40 06 20 – Process Pipe, Valve, and Gate Schedules. Primary seat shall be square-cut design to ensure proper seating. Valves shall be suitable for either horizontal or vertical applications. Ball and diaphragm check valves shall be pressure rated for 150 psi at 70°F.
- B. Valve bodies, balls or diaphragms, end connectors, and unions shall be constructed of PVC or CPVC as specified in 2.01 B. O-ring seals shall be as specified in 2.01 D and 2.01 E.
- C. Ball and diaphragm check valves shall be manufactured by Asahi/America, Nibco/Chemtrol, IPEX, Hayward Flow Control, Plastomatic, or equal.

2.05 PVC/CPVC DIAPHRAGM VALVES (DV-P/DV-C)

- A. Diaphragm valves shall be weir-type design with multi-turn handwheel for throttling applications. Diaphragm valves shall have flanged, socket, or threaded ends as specified in Section 40 06 20 – Process Pipe, Valve, and Gate Schedules. Valves shall have a position indicator and adjustable travel stop. Diaphragm valves shall be pressure rated for 150 psi at 70°F.
- B. Valve bodies, bonnets, end connectors, and unions shall be constructed of PVC or CPVC as specified in 2.01 B. Valve diaphragms and o-rings shall be as specified in 2.01 D and 2.01 E. PVDF vapor barrier shall be provided for PTFE diaphragms.
- C. Diaphragm valves shall be manufactured by Asahi/America, IPEX, Hayward Flow Control, Plastomatic, or equal.

2.06 PVC/CPVC BUTTERFLY VALVES (BFV-P/BFV-CP)

- A. Butterfly valves shall be of flanged design. Valves 6" and smaller shall have lever handles, and larger valve shall have gear operators. Valves shall have the ability to mount actuators. Face seals shall completely isolate the valve body from process flow and function as a flange gasket on both sides of the valve. Butterfly valves shall be pressure rated for 150 psi at 70°F.

- B. Valve bodies and discs shall be constructed of PVC or CPVC as specified in 2.01 B. Valve shafts shall be made of 316 stainless steel. Valve disc liners and o-ring seals shall be as specified in 2.01 D and 2.01 E.
- C. Butterfly valves shall be as manufactured by Asahi/America, Nibco/Chemtrol, IPEX, Hayward Flow Control, Plastomatic, or equal.

2.07 PVC/CPVC NEEDLE VALVES (NV-P/NV-C)

- A. Needle valves shall be provided for accurate flow control applications. Valves shall have integrated stem/seat design and have fine pitch stem threads for precise adjustment. Valve ends shall be flanged, socket, or threaded as specified in Section 40 06 20 – Process Pipe, Valve, and Gate Schedules. Needle valves shall be pressure rated for 150 psi at 70°F.
- B. Valve bodies shall be PVC as specified in 2.01 B, seats shall be PTFE, and o-ring seals shall be as specified in 2.01 D and 2.01 E.
- C. Needle valves shall be as manufactured by Nibco/Chemtrol, Hayward Flow Control, or equal.

2.08 PVC/CPVC GLOBE VALVES (GLV-P/GLV-C)

- A. Globe valves shall be provided for flow regulation applications. Valves shall be of union bonnet or outside stem and yolk design. Valve ends shall be flanged, socket, or threaded as specified in Section 40 06 20 – Process Pipe, Valve, and Gate Schedules. Globe valves shall be pressure rated for 150 psi at 70°F.
- B. Valve bodies and discs shall be PVC as specified in 2.01 B, and seals shall be as specified in 2.01 D and 2.01 E.
- C. Globe valves shall be as manufactured by Asahi/America, or equal.

2.09 PVC/CPVC DEGASSING VALVES (DGS-P/DGS-C)

- A. Degassing valves shall be provided to continuously vent gases for a liquid-carrying pipeline or vessel. The float-operated valve will open when liquid level falls (indicating the presence of gas) and close when the gas has been evacuated as the liquid level rises. The valve is to automatically vent gas collected over liquid to a pressure of 100 PSI. The specific gravity of the liquid shall not be less than 0.9. Degassing valves shall be installed vertically, at high points in the piping system where gases collect.
- B. The Valve body shall be PVC or CPVC. The internal float shall be constructed of Natural Polypropylene. Seals shall be EPDM or Viton, as specified above. There shall be a ½" Female NPT process connection and 1/8" Female NPT vent port.

C. Degassing Valves shall be as manufactured by Plastomatic, or equal.

PART 3 – EXECUTION (NOT USED)

END OF SECTION

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SECTION 40 05 68.23
MISCELLANEOUS VALVES

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. Reference Section 40 05 00 – Basic Mechanical Requirements.
- B. Valves intended for chemical service shall be constructed of materials suitable for the intended service.

PART 2 – PRODUCTS

2.01 GLOBE VALVES

- A. Bronze Body (GLV-B)
 - 1. ½-Inch to 3-Inch
 - a. Globe valves for compressed air or water service shall be bronze body and bonnet with brass stem and stainless steel regrindable disc plug. Rising stem and union bonnet through 2-Inch and bolted bonnet to 3-Inch. Valves shall be Jenkins Valve Fig. 2032J, Crane Co., or equal with minimum 300 psi non-shock cold water pressure rating and screwed ends.

2.02 SOLENOID VALVES

- A. Two-Way (SV-2W)
 - 1. Two-way solenoid valves shall be normally closed and shall open when the solenoid is energized, unless otherwise noted. The valve shall be of forged brass-body and bonnet with a BUNA "N" diaphragm and screwed ends. The solenoid's internal parts shall be of 300 and 400 series stainless steel. The valve shall have a safe body working pressure of 125 psi, and shall be as manufactured by ASCO Valves, Automatic Switch Co., or equal, for 120-volt, 60 Hz, single phase operation. Solenoid enclosure shall be NEMA 4 watertight.
- B. Three-Way (SV-3W)
 - 1. Three-way two-position solenoid valves shall be of the two-coil type. Both coils shall be normally closed and each shall open independently when energized. The valve shall be of forged brass-body and bonnet with a Buna "N" diaphragm and screwed ends. The solenoid's internal parts shall be of 300 and 400 series

stainless steel. The valve shall have a safe body working pressure of 125 psi and shall be as manufactured by ASCO Valves, Automatic Switch Co., or equal, for 120V, 60 Hz, single phase operation. Solenoid enclosure shall be NEMA 4 watertight.

C. Four-Way (SV-4W)

1. Four-way two-position solenoid valves shall be of the single coil type and shall be normally closed and shall open when the solenoid is energized (i.e. fail closed). The remainder of the four-way two-position solenoid valves shall be of the two-coil type. Both coils shall be normally closed and each shall open independently when energized. The valve shall be of forged brass-body and bonnet with a Buna "N" diaphragm and screwed ends. The solenoid's internal parts shall be of 300 and 400 series stainless steel. The valve shall have a safe body working pressure of 125 psi and shall be as manufactured by ASCO Valves, Automatic Switch Co. or equal, for 120V, 60 Hz, single phase operation. Solenoid enclosure shall be NEMA 4 watertight. The solenoid valve shall be provided with a manual override.

2.03 BACKFLOW PREVENTION VALVES

A. Double Check Style (BFPV-DC)

1. Backflow preventer shall be the size shown on the Drawings and shall be of the double check valve principle. Backflow preventer installation shall include isolation valves and four test cocks, furnished as an assembly. For backflow preventers less than 2-1/2", the installation assembly also shall include a strainer. Isolation valves for backflow preventers shall be ball valves, except for size 2-1/2" and larger which shall be resilient seat gate valves. Test cocks shall be located as recommended by the manufacturer to facilitate functional testing of the assembly. The backflow preventer shall be as follows.
 - a. Backflow preventers for pipe sizes 1/2" to 2" shall be a WATTS LF007, or equal.
 - b. Backflow preventers for pipe sizes 2 1/2" to 10" shall be a WATTS 709, or equal.
 - c. Backflow preventers for 12" pipe shall be a WATTS 774, or equal.

B. Reduced Pressure Style (BFPV-RP)

1. Reduced Pressure Backflow Preventer shall be of the size shown on the Drawings and shall be of the reduced pressure principle type in accordance with AWWA Standards C510 and C511, with two (2) independent operating spring-loaded check valves and one (1) spring loaded, diaphragm actuated, differential pressure relief valve shall be installed between the check valves. Backflow preventer shall

be bronze body construction, with EPT rubber discs and Buna-N and nylon diaphragm. Screws and springs shall be of stainless steel. End connections shall be screwed, unless otherwise specified or shown on the Drawings. Reduced pressure backflow preventer installations shall include isolation valves and four test cocks, furnished as an assembly. For reduced pressure backflow preventers less than 2-1/2" the installation assembly also shall include a strainer. Isolation valves for reduced pressure backflow preventers shall be ball valves, except for sizes 2-1/2" and larger which shall be resilient seat gate valves. Test cocks shall be located as recommended by the manufacturer to facilitate functional testing of the assembly. The reduced pressure backflow preventer shall be as manufactured by Beeco Division, Hersey Products Inc., Aergap Model 6CM, WATTS 909, or equal.

2.04 PRESSURE RELIEF, REDUCING AND REGULATING VALVES

A. Pressure Relief Valve (PRV)

1. Pressure relief valves 1 inch and under shall have bronze bodies and above 1 inch shall have cast iron bodies, bronze fitted with grey iron diaphragm base and straight chamber and phosphorus bronze diaphragm. The ratio of the diaphragm area to the seat area shall be adequate to overcome sticking. The seat disc shall be of non-corrodible, non-sticking material capable of withstanding extreme temperatures. Valves shall permit dismantling for repairs and cleaning without being removed from the line. Valves shall conform to the ASME Boiler Construction Code as approved by both the Underwriters Lab., and the National Board of Boiler Pressure Vessel Inspectors. All valves shall be designed for a minimum working pressure at least equal to the working pressure of the corresponding pipeline and shall have adjustment over a range of at least 20 percent above or below the required setting pressure of the installation.
2. Pressure relief valves (non-potable water service) shall be diaphragm activated, single seat, pilot operated and shall maintain a constant upstream pressure by relieving excess pressure. The valve shall be normally closed and shall open to maintain the required back pressure when the valve inlet pressure reaches the pilot control set point. The initial pilot control setting shall be 78 psi. The stem shall be stainless steel and shall be guided through the center for 100% of the stem travel. The main valve throttling plug shall be provided with V-port sections to insure precise control at low flow rates. All internal metal parts shall be bronze or stainless steel. The control pilot shall be direct acting, spring loaded, and adjustable with bronze body and stainless steel trim. The diaphragm and seat disc shall be BUNA-N. The valve shall be of the angle or globe pattern as shown on the Drawings and shall be fully repairable in the line. The pressure relief valve shall be the Model 50-01 as manufactured by CLA-VAL, or equal.

B. Pressure Regulating Valve (PRGV)

1. Pressure reducing and regulating valves (water service) 1/2-inch and under shall be bronze and above 1/2-inch shall have cast iron bodies bronze fitted. Valves shall be constructed with full openings and capable of supplying a full flow of water at reduced pressure. Valves shall be so constructed that repairs can be made without removing the valves from the line. The valves shall be equipped with a sedimentation chamber and stainless steel or bronze strainer. Pressure reducing and regulating valves shall be the back pressure sustaining type and shall operate over a range at differential pressures from 5 to 120 psi. Reducing and regulating valves shall meet or exceed the requirements of ASSE 1003 (ANSI A112.26.2) and shall be WATTS model LF25AUB-Z3, Zurn Wilkins model 600XLHTSTSC, or equal.

2.05 HOSE VALVES (HV)

- A. Hose valves shall be 300 lbs. non-shock cold water angle or globe valves, Fig. 112/113 as manufactured by Jenkins Valve Co., or equal. Valves shall be bronze bodied with Buna-N or neoprene disc and bronze bonnet and packing nut. Valve stem, gland, and lock nut shall be brass. Valve shall be provided with 3-inch diameter malleable iron handwheel, cap and chain, and 3/4-inch or 1-inch (or 2-inch near flushing connections) hose connection outlet.

2.06 NEEDLE VALVES (NV)

- A. Needle valves shall be bronze body and spindle with follower gland and shall be 400 psi, non-shock cold water needle valves, Figure 743-G as manufactured by Jenkins Bros., Corp., Crane Co. No. 88, or equal.
- B. Needle valves (service air) shall be bronze body, with stainless steel stem. Valves shall be Jenkins Valve Fig. 741G, Crane Co. or equal and shall have minimum 400 psi non-shock cold water pressure rating and screwed ends.

2.07 PINCH VALVES

- A. Open Pinch Valve (PNV-O)
 1. Pinch valves shall be of the full metal body mechanical pinch type with flanged joint ends on both body and rubber sleeve. Port areas shall be 100% of the full pipe area through the entire valve length. Flanges shall be of one size larger than pipeline size to allow extra thickness of rubber. Mating pipeline flanges shall be standard reducing flange with I.D. to exactly match valve I.D. All internal valve metal parts are to be completely protected by the rubber pinch tube. The rubber pinch tube shall be one piece construction with integral flanges drilled to ANSI 125# standard. The pinch tube shall also be Nylon reinforced with an exterior wrapping of 1/8" thick neoprene. Handwheel closing mechanism shall be double-acting and pinch the sleeve equally from two sides. The stem shall be

non-rising and have a non-rising handwheel. There shall be no cast part in the operating mechanism. Each valve shall have flanges conforming to ANSI B16.1, Class 125 lb. Valves shall be Series "75 DW" as manufactured by Red Valve Co., Inc. or equal.

2.08 MUD VALVES (MDV)

- A. 4-Inch to 24-Inch
 - 1. Mud valves shall be cast iron body and yoke with flanged style frame.
 - 2. Bronze stem, stem nut, disc ring, and seat ring. Non-rising stem.
 - 3. Bolts and nuts shall be 316 stainless steel.
 - 4. Provide 2-inch square operating nut and cast-iron floor box unless shown or specified otherwise.
 - 5. Model F-3075 as manufactured by Clow, or equal.

2.09 TELESCOPING VALVES (TSV)

- A. Telescoping valves shall be of the size shown on the Drawings. The valves shall be rising stem lift with stainless steel tube body material. All connecting bails and hardware shall be stainless steel. Minimum wall thickness for the tube shall be 1/8". At the point where the sliding tube enters the vertical stationary pipe a seal shall be affected by means of a wiper gasket retained by a stainless steel holding flange. The friction seal flange shall have a neoprene or Buna-N wiper gasket. The valves shall have two V-notched weirs located at 180 degrees to each other (maximum travel 36"). The valve lift mechanism shall be ball bearing supported with torque plate, mounted on offset type cast iron pedestal. Provide electric motor operator in weather-tight enclosure to be mounted on valve floorstand. The operator shall be suitable for the intended operation and sized for the telescoping valve that it is used with. The electric operator shall raise and lower the telescoping valve at a rate of 1 FPM. Provide pushbutton station for operation in stainless steel NEMA 4 enclosure. The operator shall have a manual hand crank that does not turn during electric operation. The motor drive shall be a Limitorque valve controller, or equal. Telescoping valves shall be as manufactured by Waterman Industries, Inc., or equal.

END OF SECTION

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SECTION 40 05 78
AIR VALVES FOR WATER AND WASTEWATER SERVICE

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. Reference Section 40 05 00 – Basin Mechanical Requirements.
- B. The Contractor shall furnish and install, complete with all assemblies and accessories, all air valves shown on the Drawings and specified herein including all fittings, appurtenances, drain connections, and transition pieces required for a complete and operable installation.
- C. All valves shall be constructed of materials which have strength, wearing, and corrosion resistance characteristics entirely suitable for the types of service for which the individual valves are designated. Valves shall conform to pertinent sections of the latest edition of their respective governing AWWA standards, except as may be modified to comply with pressure ratings specified herein.
- D. Valves intended for chemical service shall be constructed of materials suitable for the intended use.

1.02 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

- A. Except as otherwise indicated, the current editions of the following standards apply to the work of this section:
 - 1. ANSI/AWWA C512 Air Release, Air/Vacuum, and Combination Air Valves for Water and Wastewater Service
 - 2. NSF-61, NSF-372, All products in contact with potable water shall be
and NSF-600 certified
- B. Reference Section 46 00 00 – Equipment General Provisions for additional requirements.

1.03 CONTRACTOR SUBMITTALS

- A. The following shall be submitted in compliance with Section 01 33 00 – Submittal Procedures:
 - 1. Submit an Affidavit of Compliance for each valve type indicating the valve complies with the latest edition of its governing AWWA Standard.

2. Submit all catalog data information, installation drawings, specifications, layout dimensions, size and materials of construction for all components, pressure ratings, support and anchoring, complete descriptive literature to demonstrate full compliance, and manufacturer's certification that products comply with the indicated requirements.
3. Submit operation and maintenance (O&M) manuals and installation instructions for all valves. O&M manuals shall not include information and/or details which do not apply to the equipment being furnished. O&M manuals shall include:
 - a. Manufacturer's catalog data.
 - b. Manufacturer's installation and operations instructions.
 - c. Manufacturer's maintenance procedures.
 - d. List of special tools.

PART 2 – PRODUCTS

2.01 GENERAL

- A. All valve body castings shall be clean, sound, and without defects of any kind. No plugging, welding, or repairing of defects will be allowed.
- B. Air valves shall be provided with appropriate materials to provide drip tight closure.
- C. Valves 2-inch and smaller shall have NPT threaded inlets and outlets. Valves that are 3-inch shall be either NPT threaded or flanged ANSI B16.5 Class 150. Valves 4-inch and larger shall be flanged ANSI B16.5 Class 150.
- D. Valves shall permit dismantling for repairs and cleaning without being removed from the line. All air valves with connections 3-inches and smaller shall include a ball valve of the same diameter as the nominal valve size located on the inlet side for isolation, unless otherwise detailed or noted on the drawings. All air valves with connections 4-inches and larger shall include a ball or butterfly valve of the same diameter as the nominal valve size located on the inlet side for isolation, unless otherwise detailed or noted on the drawings.
- E. Unless otherwise directed by the Owner, isolation valves shall open counterclockwise.
- F. The exhaust from the valve shall be piped to a suitable disposal point, with the piping firmly supported and installed in such a way as to avoid splashing and wetting of floors. Exhaust piping shall be no smaller than the diameter of the air valve's largest orifice.

- G. For valves where insect screens are required, confirm that the open surface area between the insect screen mesh is no less than the area of the largest air valve orifice so as not to restrict air flow.
- H. All internal and external ferrous components and surfaces of the valves, with the exception of stainless steel and finished or bearing surfaces, shall be shop painted with two coats (10 mils min. dry film thickness) of the manufacturer's premium epoxy for corrosion resistance. Damaged surfaces shall be repaired in accordance with the manufacturer's recommendations.
- I. One spare valve shall be provided for each size and type of valve specified.

2.02 AIR VALVES FOR WATER SERVICE

- A. The valves specified in this section shall be specifically designed for water service.
- B. All air valves for water service 1-inch in diameter and larger shall have a ¼-inch minimum diameter drain plug.
- C. Air Release Valves (ARV): ARVs for water service shall be designed to operate (open) while pressurized allowing entrained air in a water pipeline to escape through the air release orifice. After entrained air escapes through the air release orifice, the valve orifice shall close tightly. The air release orifice will then remain closed until more air accumulates and the opening cycle repeats automatically.
- D. Air/Vacuum Valves (AVV): AVVs for water service shall automatically allow large volumes of air to be released through a large orifice during pipe filling and automatically allow large volumes of air to enter through a large orifice during pipe draining. AVVs shall be designed to react immediately to open when the absolute pressure in the pipeline falls below atmospheric pressure by opening a large orifice.
- E. Combination Air Release and Air/Vacuum Valves (CARV): CARVs for water service shall provide the same function as both ARVs and AVVs listed above. CARVs may be a single body housing specifically designed for use with water mains.
- F. Vacuum Breaker Valves (VBV): VBVs for water service shall open when the internal pressure falls 0.25 psi below atmospheric pressure and close tightly when the internal pressure rises above the opening pressure. VBVs may include an ARV.
- G. Deep Well Valves (DWV): DWVs for water service shall perform the same function as AVVs and are installed at the discharge of vertical turbine pumps to allow pump columns to drain and then exhaust the volume of air displaced as the columns fill again. DWVs shall include an arrestor check / anti-slam device to reduce shock within the valve and pipeline and a throttling device to allow adjustments in the rate of air flow.
- H. Sealing pressure is listed in the Valve Parameters Table below.

- I. Acceptable manufacturers for non-surge air valve applications: Crispin, Golden Anderson, Cla-Val, Valmatic, or equal.

1. Materials of Construction

Component	Material
Body, Cover	Cast Iron ASTM A126 Class B or Ductile Iron ASTM A536 Grade 65-45-12
Float	316 Stainless Steel
Seat	Viton, Buna-N, or PVC ASTM 1784
Trim	304 or 316 Stainless Steel
O-rings	Viton or EPDM
Connection – 2" or smaller	NPT Threaded
Connection – 3"	NPT Threaded or Flanged ANSI B16.5 Class 150
Connection – 4" or larger	Flanged ANSI B16.5 Class 150

- J. Acceptable manufacturers for surge air valve applications: A.R.I., Vent-tech International, Vent-O-Mat, Cla-Val, or equal.

1. Materials of Construction

- a. Valves shall consist of a fabricated or cast tubular shaped body. The assembly shall have an inlet end suitable for connection to the pipeline specified.

Component	Material
Body, Cover	304 Stainless Steel
Float	Ultra-High Molecular Weight Polyethylene (UHMW), Polypropylene, Stainless Steel, or High Density Polyethylene (HDPE)
Seat	EPDM or Buna-N
Trim	304 Stainless Steel
O-rings	Viton or EPDM
Connection – 2" or smaller	NPT Threaded
Connection – 3"	NPT Threaded or Flanged ANSI B16.5 Class 150
Connection – 4" or larger	Flanged ANSI B16.5 Class 150

K. Valve parameters:

Line Designation and Location	Quantity	Model (Indicate if Biased Regulated Anti-Surge Device is required with -B)	Size (in)	Anti-Surge Orifice Size	Normal Operating Pressures (psig) ¹	Min. Air Release Valve Venting Rate (scfm)	Discharge Capacity @ Δ2 psi (scfm)	Intake Capacity @ Δ-5 psi (scfm)	Notes
GLWTF – GWPS	2	DWW	3	Adjustable	15-55	475	N/A	N/A	Insect Screen
GLWTF – IPS	3	DWW	4	Adjustable	15-50	1,300	N/A	N/A	Insect Screen
GLWTF – GWS Pipe, see drawings	4	ARV	1	N/A	15-55	8.5	N/A	N/A	Insect Screen ²
GLWTF – GI Pipe, see drawings	2	ARV	1	N/A	15-50	45	N/A	N/A	Insect Screen
GLWTF – GE Pipe, see drawings	10	ARV	1	N/A	10	6	N/A	N/A	N/A
POHWTF – GWPS	3	DWW	3	Adjustable	5-35	475	N/A	N/A	N/A
POHWTF – IPS	4	DWW	4	Adjustable	5-50	1,300	N/A	N/A	N/A
POHWTF – GE Pipe, see drawings	12	ARV	1	N/A	10	7.5	N/A	N/A	N/A
POHWTF – GWS Pipe, see drawings	4	ARV	1	N/A	5-35	11.0	N/A	N/A	N/A

NOTES: 1) The listed minimum operating pressure is the sealing pressure required to prevent air valve leakage.

2) Insect Screen only required on outdoor ARVs

2.03 AIR VALVES FOR WASTEWATER OR NON-POTABLE WATER SERVICE

- A. The valves specified in this section shall be specifically designed for wastewater service.
- B. All air valves for wastewater and non-potable water service 1-inch diameter and larger shall have a 1-inch min. diameter drain plug.
- C. Air Release Valves (ARV): ARVs for wastewater or non-potable water service shall be designed to operate (open) while pressurized allowing entrained air or other gases in the pipeline to escape through the air release orifice. After entrained air/gas escapes through the air release orifice, the valve orifice shall close tightly. The air release orifice will then remain closed until more air accumulates and the opening cycle repeats automatically.
- D. Air/Vacuum Valves (AVV): AVVs for wastewater or non-potable water service shall automatically allow large volumes of air to be released through a large orifice during pipe filling and automatically allow large volumes of air to enter through a large orifice during pipe draining. AVVs shall be designed to react immediately to open when the absolute pressure in the pipeline falls below atmospheric pressure by opening a large orifice.
- E. Combination Air Release and Air/Vacuum Valves (CARV): CARVs for wastewater or non-potable water service shall provide the same function as both ARVs and AVVs listed above. CARVs may be a single body housing specifically designed for use with sewage force mains and shall be designed not to clog when used on force mains.
- F. Vacuum Breaker Valves (VBV): VBVs for wastewater and non-potable water service shall open when the internal pressure falls 0.25 psi below atmospheric pressure and close tightly when the internal pressure rises above the opening pressure. VBVs may include an ARV.
- G. Deep Well Valves (DWV): DWVs for wastewater and non-potable water service shall perform the same function as AVVs and are installed at the discharge of vertical turbine pumps to allow pump columns to drain and then exhaust the volume of air displaced as the columns fill again. DWVs shall include an arrestor check / anti-slam device to reduce shock within the valve and pipeline and a throttling device to allow adjustment in the rate of air flow.
- H. Air valves for wastewater service shall include backflushing attachments which shall consist of blow-off valves, quick disconnect couplings, and a minimum of 5 feet of rubber hose suitable for backflushing without dismantling the valve.
- I. Sealing pressure is listed in the Valve Parameters Table below.
- J. Acceptable manufacturers for non-surge air valve applications: Crispin, Golden Anderson, Cla-Val, Valmatic, or equal.

1. Materials of Construction

Component	Material
Body, Cover	Cast Iron ASTM A126 Class B, Ductile Iron ASTM A536 Grade 65-45-12, or Stainless Steel ASTM A351
Float	316 Stainless Steel
Seat	Viton, Buna-N or PVC ASTM 1784
Trim	304 or 316 Stainless Steel
O-rings	Viton or EPDM
Connection – 2" or smaller	NPT Threaded
Connection – 3"	NPT Threaded or Flanged ANSI B16.5 Class 150
Connection – 4" or larger	Flanged ANSI B16.5 Class 150

- K. Acceptable manufacturers for surge air valve applications: A.R.I., Vent-tech International, Vent-O-Mat, Cla-Val, or equal.

1. Materials of Construction

Valves shall consist of a fabricated or cast tubular shaped body. The assembly shall have an inlet end suitable for connection to the pipeline specified.

Component	Material
Body, Cover	316 Stainless Steel
Float	Ultra-High Molecular Weight Polyethylene (UHMW), Polypropylene, Stainless Steel, or High Density Polyethylene (HDPE)
Seat	EPDM or Buna-N
Trim	316 Stainless Steel
O-rings	Viton or EPDM
Connection – 2" or smaller	NPT Threaded
Connection – 3"	NPT Threaded or Flanged ANSI B16.5 Class 150
Connection – 4" or larger	Flanged ANSI B16.5 Class 150

L. Valve Parameters:

Line Designation and Location	Quantity	Model (Indicate if Biased Regulated Anti-Surge Device is required with -B)	Size (in)	Anti-Surge Orifice Size	Normal Operating Pressures (psig) ¹	Air Release Valve Venting Rate (scfm)	Discharge Capacity @ Δ2 psi (scfm)	Intake Capacity @ Δ-5 psi (scfm)	Notes
GLWTF – NPW, see drawings	1	ARV	1	N/A	75	1.0	N/A	N/A	N/A
POHWTF – NPW, see drawings	1	ARV	1	N/A	75	1.0	N/A	N/A	N/A

NOTES: 1) The listed minimum operating pressure is the sealing pressure required to prevent air valve leakage.

PART 3 – EXECUTION

3.01 TESTING

- A. Testing shall be performed in accordance with the latest revision of AWWA C512.
- B. Minimum test pressure - air valves for water and wastewater service shall be tested at 20 psig or the minimum operating pressure, whichever is lower.
- C. Maximum test pressure - air valves for water and wastewater service shall be tested at 150% of the maximum design pressure.
- D. Before installation, all valves shall be lubricated, manually opened and closed to check their operation and the interior of the valves shall be thoroughly cleaned.

3.02 SHIPMENT

- A. Valves shall be complete in all details when shipped. Cavities shall be drained of water to protect from freezing. The openings shall be covered to prevent entry of foreign material, and the threads shall be protected. The manufacturer shall carefully prepare the valves for shipment. Valves shall be fully packaged or attached to pallets at the manufacturer's option.

3.03 INSTALLATION

- A. Install all air valves in accordance with the manufacturer's recommendations.

END OF SECTION

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SECTION 40 05 81
FIRE, WALL AND YARD HYDRANTS

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. Reference Section 40 05 00 – Basic Mechanical Requirements.

PART 2 – PRODUCTS

2.01 FIRE HYDRANTS

- A. All fire hydrants shall be dry barrel, traffic type and conform to the latest revision of AWWA Specification C-502 except as listed below or as otherwise directed by the Public Works Commission. All working parts shall be bronzed. The size of the fire hydrants (designated by the nominal diameter of the valve opening) shall not be less than four and one-half (4 ½) inches. All hydrants shall be able to deliver a minimum of 1,000 gallons per minute with a friction loss of not more than five (5) pounds per square inch (psi) total head loss through the hydrant. Hydrants shall be of compression type (opening shall be of such design that when the barrel is broken off the hydrant valve will remain closed and reasonably tight against leakage). All hydrants shall be mechanical joint to accommodate the spigot end of six (6) inch Pressure Class 150, AWWA Standard, ductile iron pipe. The installation of the fire hydrant shall be in accordance with PWC standard details. Bosses (6") may be substituted for tees in pipe sizes exceeding 24 inches in diameter, with prior approval from PWC. The boss shall be welded to the bottom of the main to provide effective flushing of the system.
- B. All hydrants shall be furnished with two (2) two and one-half (2 ½) inch nozzles and one (1) four and one-half (4 ½) inch pumper nozzle. Outlets shall have American National Standard fire hose coupling thread, in accordance with the City of Fayetteville standard, and shall be provided with nozzle caps securely chained to the body of the hydrant. The base of the hydrant shall have two (2) cast lugs suitable for use in strapping the hydrant to the connecting pipe. The operating nut shall be pentagonal in shape, finished with a slight taper to one and one-half (1 ½) inches from point to flat to conform to the standard wrench used by the Fayetteville Public Works Commission. All hydrants shall open left or counterclockwise. Hydrants shall be suitable for working pressure of 150 psi and a test pressure of twice the working pressure. Fire hydrants shall be specific models manufactured by Mueller Company (Model Centurian 200), Clow Corporation (Medallion), American Darling (Model Mark 73-1) or approved equal. The interior of the hydrant shoe shall be coated with a four (4) mil thickness FDA approved epoxy coating.

2.02 WALL HYDRANTS

- A. Wall hydrants shall be of the non-freeze type, cast-bronze construction with wrought stainless steel self-opening, vandal-proof locking cover box, 3/4-inch N.P.T. outlet, integral vacuum breaker backflow preventer, pressure relief valve, bronze casing, bronze operating parts convertible into service tool, "T" handle key. 3/4-inch female and 1-inch male N.P.T. inlet connection. The wall hydrant shall be Models 7.500 as manufactured by Josam, Z-1305 as manufactured by Zurn, 5509 as manufactured by Smith Company, or equal.

2.03 YARD HYDRANTS

- A. Service water system hydrants shall be of the 2 inch non freeze, self-draining, post yard type. Operating parts must be removable through the top of the hydrant.
- B. The inlet shall be 4" mechanical joint and outlet shall be 1 ½" NST. Hydrants shall have ductile iron casing pipe, stainless steel operating rod and cast-iron top stock. Each hydrant shall be equipped with suitable removable adapters to connect 1 ½-inch and ¾-inch hoses.
- C. Each hydrant shall be supplied with a 10-inch operating hand wheel.
- D. Hydrants shall be Eclipse Model 2 by Kupferle or approved equal.

PART 3 – EXECUTION (NOT USED)

END OF SECTION

SECTION 40 05 97
PIPING AND EQUIPMENT IDENTIFICATION SYSTEMS

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. The Contractor shall furnish and install all components of the system for identification of piping and equipment as specified hereinafter. The system shall include the application of color coding to all new and altered plant piping. The Contractor shall paint the equipment and piping of all Contracts in the colors herein specified, and in accordance with the requirements of Section 09 90 00 – Painting.
- B. In addition to the legends specified herein, the Engineer may order the Contractor to furnish and install additional identification legends and arrows at no additional cost to the Owner. Such additional signs may be requested near completion of the work and shall be limited to no more than five (5) signs for each type specified herein. The legends and color combinations for additional signs shall conform to the requirements specified herein.
- C. The Contractor shall submit a schedule of the colors and designations proposed in accordance with Section 01 33 00 – Submittal Procedures and this Section. A minimum of four (4) color charts with cross-references to the colors listed herein shall be included with the Submittal.
- D. Reference Section 40 05 00 – Basic Mechanical Requirements.

PART 2 – PRODUCTS

2.01 PIPING BAND

- A. All new and altered piping shall receive identification bands. Such bands shall be 6-inches wide, neatly made by masking, and spaced at intervals of 30-inches on centers regardless of the diameter of the pipe being painted. The Contractor may use approved precut and prefinished metal bands on piping, in lieu of the masked and painted bands, where approved by the Engineer.

2.02 PIPING IDENTIFICATION LEGEND

- A. The Contractor shall apply identification legends to all types and sections of piping as shown on the Drawings or as designated by the Engineer. Such legends shall be in the form of plain block lettering giving the name of the pipe content in full or abbreviated form and showing the direction of flow by arrows. All lettering and arrows shall be of the plastic snap-on type, Seton nameplate "setmarks", or equal, or they shall be formed by

stenciling in an approved manner using white or black as directed and shall have an overall height in inches in accordance with the following table:

Diameter of Pipe or Pipe Covering	Height of Lettering
3/4 to 1-1/4 inches	1/2-inches
1-1/2 to 2-inches	3/4-inches
2-1/2 to 6-inches	1-1/4-inches
8 to 10-inches	2-1/2-inches
Over 10-inches	3-1/2-inches

- B. Identification lettering shall be located midway between color coding bands where possible. Identification lettering and arrows shall be placed as directed by the Engineer, but shall generally be located each fifteen (15) feet in pipe length, and shall be properly inclined to the pipe axis to facilitate easy reading. In the event lettering and arrow identifications are required for piping less than 3/4-inch in diameter, the Contractor shall furnish and attach approved color-coded tags where instructed.
- C. The colors referenced in the legend are as manufactured by KOP-COAT. They are used for convenience only.
- D. Suggested Piping and Equipment Identification Table is below. Pipe color and lettering shall match that of the existing process piping. All proposed legends and paint colors of any new piping applications shall be coordinated with the Owner prior to procurement of labels.

Service	Legend	ID
Filtered Water	FLW	Match Existing
GAC Effluent	GE	Coordinate with Owner
GAC Slurry	GS	Coordinate with Owner
GAC to Waste	GTW	Coordinate with Owner
GAC Wash Supply	GWS	Coordinate with Owner
GAC Wash Waste	GWW	Coordinate with Owner
Non-Potable Water	NPW	Match Existing
Overflow	OF	Match Existing
Drain	D (is this for PD and SD)	Match Existing

Service	Legend	ID
Sample	SA	Match Existing
Sump Pump Drainage	SPD	Match Existing
Vent	V	Match Existing
Hydrofluosilicic Acid	HF	Match Existing
Sodium Hypochlorite	SH	Match Existing
Zinc Orthophosphate	ZO	Match Existing

2.03 EXECUTION (NOT USED)

END OF SECTION

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SECTION 40 06 20

PROCESS PIPE, VALVE, AND GATE SCHEDULES

PART 1 - GENERAL

1.01 THE REQUIREMENT

- A. Reference Section 40 05 00 - Basic Mechanical Requirements.

1.02 PIPING SCHEDULES

- A. Piping requirements for this Section are outlined on the Drawings and in the Piping Schedules. In the absence of a specified test pressure, pipe shall be tested at the greater of: 1) 150 percent of working pressure as determined by the Engineer or 2) 10 psig, unless the Schedule indicates no test is required.
- B. If the pipe material is not shown on the Piping Schedule or otherwise specified, the following materials shall be used.

PIPE SIZE	MATERIAL	TYPE OF JOINT	CLASS/DESIGN	TEST PRESSURE
4-IN AND LARGER	DIP	FLANGED (EXPOSED)	CLASS 53	(1)
		RESTRAINED (BURIED)	PRESSURE CLASS 350	
LESS THAN 4-IN	PVC/CPVC (2)	SOCKET	SCH 80	(1)
(1) Test at 150 percent of working pressure or 10 psi, whichever is greater. (2) For all PVC / CPVC designations, if piping is exposed to direct sunlight or if heat tracing is required, CPVC shall be used. Otherwise, PVC shall be used.				

1.03 VALVE SCHEDULES

- A. All valves shall be tagged by the manufacturer according to the control valve designations listed in this Section.
- B. Valves not listed in this Section shall be manually operated, unless otherwise shown on the Drawings.

1.04 GATE SCHEDULES

- A. Gates shall be tagged by the manufacturer according to locations listed in this Section.

11-03-21

WATER TREATMENT PLANT PIPING SCHEDULE										
PIPE DESIGNATIONS		MATERIAL	BURIED PIPING		EXPOSED PIPING		DESIGN PRESSURE (PSI) ¹			
			TYPE OF JOINT	CLASS/ DESIGN	TYPE OF JOINT	CLASS/ DESIGN	WORKING	SURGE	RESTRAINT	FIELD TEST
GWS	GAC BACKWASH SUPPLY	DIP	RESTRAINED	PRESSURE CLASS 250	FLANGED	CLASS 53	25	30	40	35
GWW	GAC BACKWASH WASTE	DIP	RESTRAINED	PRESSURE CLASS 250	FLANGED	CLASS 53	15	N/A	20	15
FLW	FILTERED WATER	DIP	RESTRAINED	PRESSURE CLASS 150	FLANGED	CLASS 53	25	30	40	35
GE	GAC EFFLUENT	< 14" DIP	RESTRAINED	PRESSURE CLASS 350	FLANGED	CLASS 53	25	N/A	40	35
		>= 14" & <24" DIP	RESTRAINED	PRESSURE CLASS 250	FLANGED	CLASS 53				
		>= 24" & <30" DIP	RESTRAINED	PRESSURE CLASS 250	FLANGED	CLASS 53				
		>= 30" DIP	RESTRAINED	PRESSURE CLASS 150	FLANGED	CLASS 53				
GI	GAC INFLUENT (FUTURE)	DIP	RESTRAINED	PRESSURE CLASS 150	FLANGED	CLASS 53	TBD	N/A	TBD	TBD
GS	GAC SLURRY	STAINLESS STEEL	N/A	N/A	WELDED/ FLANGED ⁴	SECTION 40 05 24.43	65	80	110	95
GTW	GAC TO WASTE	DIP	RESTRAINED	PRESSURE CLASS 350	FLANGED	CLASS 53	15	N/A	20	15

WATER TREATMENT PLANT PIPING SCHEDULE										
PIPE DESIGNATIONS		MATERIAL	BURIED PIPING		EXPOSED PIPING		DESIGN PRESSURE (PSI) ¹			
			TYPE OF JOINT	CLASS/ DESIGN	TYPE OF JOINT	CLASS/ DESIGN	WORKING	SURGE	RESTRAINT	FIELD TEST
NPW	NON- POTABLE (SERVICE) WATER	< 4" PVC / CPVC ³	SOCKET	SCH 80	SOCKET/ FLANGED	SCH 80	65	80	110	95
		> = 4" DIP	RESTRAINED	PRESSURE CLASS 350	FLANGED	CLASS 53				
OF	OVERFLOW	< 4" PVC / CPVC ³	SOCKET	SCH 80	SOCKET/ FLANGED	SCH 80	25	N/A	40	35
		> = 4" DIP	RESTRAINED	PRESSURE CLASS 150	FLANGED	CLASS 53				
D	PROCESS DRAIN	< 4" PVC / CPVC ³	SOCKET	SCH 80	SOCKET/ FLANGED	SCH 80	25	N/A	40	35
		> = 4" DIP	RESTRAINED	PRESSURE CLASS 350	FLANGED	CLASS 53				
RD / SRD	ROOF DRAIN / SECONDARY ROOF DRAIN	PVC	SOLVENT WELD	SCH 80	SOLVENT WELD	SCH 80	SEE SPECIFICATION 22 14 13			
SA ⁵	SAMPLE	PVC / CPVC ³	SOCKET	SCH 80	SOCKET/ FLANGED	SCH 80	100	0	100	50
		STAINLESS STEEL TUBING ⁶	N/A	N/A	COMPRESSION	SECTION 40 79 00	100	0	100	50
SD	STORM DRAIN	RCP	PUSH-ON	IV	N/A	N/A	SECTION 33 05 39.23 / 40 05 33 / 22 14 13			
		PVC - INTERIOR	N/A	N/A	SOLVENT WELD	SCH 80				
		HDPE	PUSH-ON	SECTION 40 05 33	N/A	N/A				
TW	TEMPERED WATER	< 4" CPVC ³	SOCKET	SCH 80	SOCKET/ FLANGED	SCH 80	SECTION 22 11 13			
V	VENT	< 4" PVC / CPVC ³	SOCKET	SCH 80	SOCKET/ FLANGED	SCH 80	N/A	N/A	N/A	N/A
		CARBON STEEL ²	N/A	N/A	WELDED/ FLANGED ⁴	SECTION 40 05 24.23				
		> = 4" DIP	RESTRAINED	PRESSURE CLASS 350	FLANGED	CLASS 53				

WATER TREATMENT PLANT PIPING SCHEDULE								
PIPE DESIGNATIONS	MATERIAL	BURIED PIPING		EXPOSED PIPING		DESIGN PRESSURE (PSI) ¹		
		TYPE OF JOINT	CLASS/ DESIGN	TYPE OF JOINT	CLASS/ DESIGN	WORKING	SURGE	RESTRAINT
1) Surge pressure is the maximum pressure in the system during a surge event. Restraint pressure shall be used to determine pipe joint design and if required, the size, number, material, and dimensions of tabs and threaded-rods and thrust blocking for thrust restraint of piping and piping system components specified.								
2) Carbon steel piping will be used to support air release valves per Detail 5 on M504,								
3) For all PVC / CPVC designations, if piping is exposed to direct sunlight or if heat tracing is required, CPVC shall be used. Otherwise, PVC shall be used.								
4) Flanges shall be provided as shown on the drawings or as approved by the Engineer.								
5) PTFE (TEFLON) THREAD TAPE SHALL NOT BE USED ON SAMPLE LINES.								
6) Where shown on Drawings.								

WATER TREATMENT PLANT PIPING SCHEDULE											
PIPE DESIGNATIONS		MATERIAL	BURIED PIPING		EXPOSED PIPING			DESIGN PRESSURE (PSI) ¹			
			TYPE OF JOINT	CLASS/ DESIGN	TYPE OF JOINT	CLASS/ DESIGN	HEAT TRACE ²	WORKING	SURGE	RESTRAINT	FIELD TEST
GWS	GAC BACKWASH SUPPLY	DIP	RESTRAINED	PRESSURE CLASS 250	FLANGED	CLASS 53	NO	30	35	45	40
GWV	GAC BACKWASH WASTE	DIP	RESTRAINED	PRESSURE CLASS 250	FLANGED	CLASS 53	NO	20	N/A	25	20
FLW	FILTERED WATER	DIP	RESTRAINED	PRESSURE CLASS 150	FLANGED	CLASS 53	NO	25	30	45	40
FW	FINISHED WATER	< 14" DIP	RESTRAINED	PRESSURE CLASS 350	FLANGED	CLASS 53	NO	85	110	150	130
		>= 14" & <24" DIP	RESTRAINED	PRESSURE CLASS 250	FLANGED	CLASS 53	NO				
PW	POTABLE WATER	< 4" PVC / CPVC ³	SOCKET	SCH 80	SOCKET/ FLANGED	SCH 80	YES/NO	85	110	150	130
TW	TEPID WATER	< 4" PVC / CPVC ³	SOCKET	SCH 80	SOCKET/ FLANGED	SCH 80	YES/NO	85	110	150	130
GI	GAC INFLUENT (FUTURE)	DIP	RESTRAINED	PRESSURE CLASS 250	FLANGED	CLASS 53	NO	TBD	N/A	TBD	TBD
GE	GAC EFFLUENT	< 14" DIP	RESTRAINED	PRESSURE CLASS 350	FLANGED	CLASS 53	NO	30	N/A	45	40
		>= 14" & <24" DIP	RESTRAINED	PRESSURE CLASS 250	FLANGED	CLASS 53	NO				
		>= 24" & <30" DIP	RESTRAINED	PRESSURE CLASS 250	FLANGED	CLASS 53	NO				
		>= 30" DIP	RESTRAINED	PRESSURE CLASS 150	FLANGED	CLASS 53	NO				

WATER TREATMENT PLANT PIPING SCHEDULE										
PIPE DESIGNATIONS	MATERIAL	BURIED PIPING		EXPOSED PIPING			DESIGN PRESSURE (PSI) ¹			
		TYPE OF JOINT	CLASS/ DESIGN	TYPE OF JOINT	CLASS/ DESIGN	HEAT TRACE ²	WORKING	SURGE	RESTRAINT	FIELD TEST
NPW	NON- POTABLE (SERVICE) WATER	SOCKET	SCH 80	SOCKET/ FLANGED	SCH 80	NO	70	85	120	105
		RESTRAINED	PRESSURE CLASS 350	FLANGED	CLASS 53	NO				
OF	OVERFLOW	SOCKET	SCH 80	SOCKET/ FLANGED	SCH 80	NO	20	N/A	25	20
		RESTRAINED	PRESSURE CLASS 150	FLANGED	CLASS 53	NO				
D	PROCESS DRAIN	SOCKET	SCH 80	SOCKET/ FLANGED	SCH 80	NO	10	N/A	20	15
		RESTRAINED	PRESSURE CLASS 350	FLANGED	CLASS 53	NO				
RD / SRD	ROOF DRAIN / SECONDARY ROOF DRAIN	SOLVENT WELD	SCH 80	SOLVENT WELD	SCH 80	NO	SEE SPECIFICATION 22 14 13			
SA ⁵	SAMPLE	SOCKET	SCH 80	SOCKET/ FLANGED	SCH 80	NO	60	75	135	90
		N/A	N/A	COMPRESSION	SECTION 40 79 00	NO	60	75	135	90
SD	STORM DRAIN	PUSH-ON	IV	N/A	N/A	NO	SECTION 33 05 39.23 / 40 05 33			
		PUSH-ON	SECTION 40 05 33	N/A	N/A	NO				
V	VENT	SOCKET	SCH 80	SOCKET/ FLANGED	SCH 80	NO	N/A	N/A	N/A	N/A

1) Surge pressure is the maximum pressure in the system during a surge event. Restraint pressure shall be used to determine pipe joint design and if required, the size, number, material, and dimensions of tabs and threaded-rods and thrust blocking for thrust restraint of piping and piping system components specified.

2) Carbon steel piping will be used to support air release valves per Detail 5 on M504.

3) For all PVC / CPVC designations, if piping is exposed to direct sunlight or if heat tracing is required, CPVC shall be used. Otherwise, PVC shall be used.

4) Flanges shall be provided as shown on the drawings or as approved by the Engineer.

5) PTFE (TEFLON) THREAD TAPE SHALL NOT BE USED ON SAMPLE LINES.

6) Where shown on Drawings.

CHEMICAL PIPING SCHEDULE							
PIPE DESIGNATIONS	MATERIAL	BURIED PIPING		EXPOSED PIPING		DESIGN PRESSURE (PSI) ¹	
		TYPE OF JOINT	CLASS/DESIGN	TYPE OF JOINT	CLASS/DESIGN	WORKING	RESTRAINT
							FIELD TEST

CHEMICAL PIPING SCHEDULE									
PIPE DESIGNATIONS		MATERIAL	BURIED PIPING		EXPOSED PIPING		DESIGN PRESSURE (PSI) ¹		
			TYPE OF JOINT	CLASS/ DESIGN	TYPE OF JOINT	CLASS/ DESIGN	WORKING	RESTRAINT	FIELD TEST
SH	SODIUM HYPOCHLORITE	< 4" PVC / CPVC ³	N/A	N/A	SOCKET ⁴	SCH 80	70	125	125

CHEMICAL PIPING SCHEDULE							
PIPE DESIGNATIONS	MATERIAL	BURIED PIPING		EXPOSED PIPING		DESIGN PRESSURE (PSI) ¹	
		TYPE OF JOINT	CLASS/ DESIGN	TYPE OF JOINT	CLASS/ DESIGN	WORKING	FIELD TEST
1) Surge pressure is the maximum pressure in the system during a surge event. Restraint pressure shall be used to determine pipe joint design and if required, the size, number, material, and dimensions of tabs and threaded-rods and thrust blocking for thrust restraint of piping and piping system components specified. 2) For all PVC / CPVC designations, if piping is exposed to direct sunlight or if heat tracing is required, CPVC shall be used. Otherwise, PVC shall be used. 3) Flanges shall be provided as shown on the drawings or as approved by the Engineer. 4) Joints shall be socket except for connections to existing piping with socket or threaded joints.							

CHEMICAL PIPING SCHEDULE									
PIPE DESIGNATIONS		MATERIAL	BURIED PIPING		EXPOSED PIPING		DESIGN PRESSURE (PS) ¹		
			TYPE OF JOINT	CLASS/ DESIGN	TYPE OF JOINT	CLASS/ DESIGN	WORKING	RESTRAINT	FIELD TEST
HF	HYDROFLUOSILICIC ACID	< 4"	SOCKET	SCH 80	SOCKET ⁴	SCH 80	50	75	75
		HDPE	FUSION	SDR 11	N/A	N/A			
		PVC HOSE	COMPRESSION	SECTION 40 05 31	N/A	N/A			

CHEMICAL PIPING SCHEDULE									
PIPE DESIGNATIONS	MATERIAL	BURIED PIPING		EXPOSED PIPING		DESIGN PRESSURE (PSI) ¹			
		TYPE OF JOINT	CLASS/ DESIGN	TYPE OF JOINT	CLASS/ DESIGN	WORKING	RESTRAINT	FIELD TEST	
SH SODIUM HYPOCHLORITE	< 4" PVC / CPVC ³	SOCKET	SCH 80	SOCKET ⁴	SCH 80	50	75	75	
	HDPE	FUSION	SDR 11	N/A	N/A				
	PVC HOSE	COMPRESSION	SECTION 40 05 31	N/A	N/A				
ZO ZINC ORTHOPHOSPHATE	< 4" PVC / CPVC ³	SOCKET	SCH 80	SOCKET ⁴	SCH 80	50	75	75	
	HDPE	FUSION	SDR 11	N/A	N/A				
	PVC HOSE	COMPRESSION	SECTION 40 05 31	N/A	N/A				
AA AQUA AMMONIA	< 4" PVC	N/A	N/A	SOCKET ⁴	SCH 80	25	75	75	
	HDPE	FUSION	SDR 11	N/A	N/A				

CHEMICAL PIPING SCHEDULE						
PIPE DESIGNATIONS	MATERIAL	BURIED PIPING		EXPOSED PIPING		DESIGN PRESSURE (PSI) ¹
		TYPE OF JOINT	CLASS/ DESIGN	TYPE OF JOINT	CLASS/ DESIGN	
1) Surge pressure is the maximum pressure in the system during a surge event. Restraint pressure shall be used to determine pipe joint design and if required, the size, number, material, and dimensions of tabs and threaded-rods and thrust blocking for thrust restraint of piping and piping system components specified.						
2) For all PVC / CPVC designations, if piping is exposed to direct sunlight or if heat tracing is required, CPVC shall be used. Otherwise, PVC shall be used.						
3) Flanges shall be provided as shown on the drawings or as approved by the Engineer.						
4) Joints shall be socket end connections to existing piping with socket or threaded joints.						

CHEMICAL PIPING SCHEDULE						
PIPE DESIGNATIONS	MATERIAL	BURIED PIPING		EXPOSED PIPING		DESIGN PRESSURE (PSI) ¹
		TYPE OF JOINT	CLASS/ DESIGN	TYPE OF JOINT	CLASS/ DESIGN	
1) Surge pressure is the maximum pressure in the system during a surge event. Restraint pressure shall be used to determine pipe joint design and if required, the size, number, material, and dimensions of tabs and threaded-rods and thrust blocking for thrust restraint of piping and piping system components specified.						
2) For all PVC / CPVC designations, if piping is exposed to direct sunlight or if heat tracing is required, CPVC shall be used. Otherwise, PVC shall be used.						
3) Flanges shall be provided as shown on the drawings or as approved by the Engineer.						
4) Joints shall be socket end connections to existing piping with socket or threaded joints.						

ELECTRICALLY OPERATED VALVE SCHEDULE								
TAG NO.	VALVE TYPE	OPERATOR TYPE	SIZE (in.)	FLOW (MGD)	MAX DIFFERENTIAL PRESSURE (psi)	CLASS	SERVICE	LOCATION
MOV-33121	BUTTERFLY	OPEN/CLOSE	24	4	5	150	FLW	P.O Hoffer Influent Valve GAC Contactor 1
MOV-33221	BUTTERFLY	OPEN/CLOSE	24	4	5	150	FLW	P.O Hoffer Influent Valve GAC Contactor 2
MOV-33321	BUTTERFLY	OPEN/CLOSE	24	4	5	150	FLW	P.O Hoffer Influent Valve GAC Contactor 3
MOV-33421	BUTTERFLY	OPEN/CLOSE	24	4	5	150	FLW	P.O Hoffer Influent Valve GAC Contactor 4
MOV-33521	BUTTERFLY	OPEN/CLOSE	24	4	5	150	FLW	P.O Hoffer Influent Valve GAC Contactor 5
MOV-33621	BUTTERFLY	OPEN/CLOSE	24	4	5	150	FLW	P.O Hoffer Influent Valve GAC Contactor 6
MOV-33721	BUTTERFLY	OPEN/CLOSE	24	4	5	150	FLW	P.O Hoffer Influent Valve GAC Contactor 7
MOV-33821	BUTTERFLY	OPEN/CLOSE	24	4	5	150	FLW	P.O Hoffer Influent Valve GAC Contactor 8
MOV-33921	BUTTERFLY	OPEN/CLOSE	24	4	5	150	FLW	P.O Hoffer Influent Valve GAC Contactor 9
MOV-34021	BUTTERFLY	OPEN/CLOSE	24	4	5	150	FLW	P.O Hoffer Influent Valve GAC Contactor 10
MOV-34121	BUTTERFLY	OPEN/CLOSE	24	4	5	150	FLW	P.O Hoffer Influent Valve GAC Contactor 11
MOV-34221	BUTTERFLY	OPEN/CLOSE	24	4	5	150	FLW	P.O Hoffer Influent Valve GAC Contactor 12
MOV-33122A	BUTTERFLY	OPEN/CLOSE	24	11.5	60	150	GWS	P.O Hoffer GWS Valve GAC Contactor 1
MOV-33222A	BUTTERFLY	OPEN/CLOSE	24	11.5	60	150	GWS	P.O Hoffer GWS Valve GAC Contactor 2
MOV-33322A	BUTTERFLY	OPEN/CLOSE	24	11.5	60	150	GWS	P.O Hoffer GWS Valve GAC Contactor 3
MOV-33422A	BUTTERFLY	OPEN/CLOSE	24	11.5	60	150	GWS	P.O Hoffer GWS Valve GAC Contactor 4
MOV-33522A	BUTTERFLY	OPEN/CLOSE	24	11.5	60	150	GWS	P.O Hoffer GWS Valve GAC Contactor 5
MOV-33622A	BUTTERFLY	OPEN/CLOSE	24	11.5	60	150	GWS	P.O Hoffer GWS Valve GAC Contactor 6
MOV-33722A	BUTTERFLY	OPEN/CLOSE	24	11.5	60	150	GWS	P.O Hoffer GWS Valve GAC Contactor 7
MOV-33822A	BUTTERFLY	OPEN/CLOSE	24	11.5	60	150	GWS	P.O Hoffer GWS Valve GAC Contactor 8
MOV-33922A	BUTTERFLY	OPEN/CLOSE	24	11.5	60	150	GWS	P.O Hoffer GWS Valve GAC Contactor 9
MOV-34022A	BUTTERFLY	OPEN/CLOSE	24	11.5	60	150	GWS	P.O Hoffer GWS Valve GAC Contactor 10

ELECTRICALLY OPERATED VALVE SCHEDULE								
TAG NO.	VALVE TYPE	OPERATOR TYPE	SIZE (in.)	FLOW (MGD)	MAX DIFFERENTIAL PRESSURE (psi)	CLASS	SERVICE	LOCATION
MOV-34122A	BUTTERFLY	OPEN/CLOSE	24	11.5	60	150	GWS	P.O Hoffer GWS Valve GAC Contactor 11
MOV-34222A	BUTTERFLY	OPEN/CLOSE	24	11.5	60	150	GWS	P.O Hoffer GWS Valve GAC Contactor 12
MOV-33122B	BUTTERFLY	OPEN/CLOSE	24	11.5	5	150	GWV	P.O Hoffer GWW Valve GAC Contactor 1
MOV-33222B	BUTTERFLY	OPEN/CLOSE	24	11.5	5	150	GWV	P.O Hoffer GWW Valve GAC Contactor 2
MOV-33322B	BUTTERFLY	OPEN/CLOSE	24	11.5	5	150	GWV	P.O Hoffer GWW Valve GAC Contactor 3
MOV-33422B	BUTTERFLY	OPEN/CLOSE	24	11.5	5	150	GWV	P.O Hoffer GWW Valve GAC Contactor 4
MOV-33522B	BUTTERFLY	OPEN/CLOSE	24	11.5	5	150	GWV	P.O Hoffer GWW Valve GAC Contactor 5
MOV-33622B	BUTTERFLY	OPEN/CLOSE	24	11.5	5	150	GWV	P.O Hoffer GWW Valve GAC Contactor 6
MOV-33722B	BUTTERFLY	OPEN/CLOSE	24	11.5	5	150	GWV	P.O Hoffer GWW Valve GAC Contactor 7
MOV-33822B	BUTTERFLY	OPEN/CLOSE	24	11.5	5	150	GWV	P.O Hoffer GWW Valve GAC Contactor 8
MOV-33922B	BUTTERFLY	OPEN/CLOSE	24	11.5	5	150	GWV	P.O Hoffer GWW Valve GAC Contactor 9
MOV-34022B	BUTTERFLY	OPEN/CLOSE	24	11.5	5	150	GWV	P.O Hoffer GWW Valve GAC Contactor 10
MOV-34122B	BUTTERFLY	OPEN/CLOSE	24	11.5	5	150	GWV	P.O Hoffer GWW Valve GAC Contactor 11
MOV-34222B	BUTTERFLY	OPEN/CLOSE	24	11.5	5	150	GWV	P.O Hoffer GWW Valve GAC Contactor 12
MOV-33123A	BUTTERFLY	OPEN/CLOSE	10	4	10	150	GE	P.O Hoffer GE Valve GAC Contactor 1
MOV-33223A	BUTTERFLY	OPEN/CLOSE	10	4	10	150	GE	P.O Hoffer GE Valve GAC Contactor 2
MOV-33323A	BUTTERFLY	OPEN/CLOSE	10	4	10	150	GE	P.O Hoffer GE Valve GAC Contactor 3
MOV-33423A	BUTTERFLY	OPEN/CLOSE	10	4	10	150	GE	P.O Hoffer GE Valve GAC Contactor 4
MOV-33523A	BUTTERFLY	OPEN/CLOSE	10	4	10	150	GE	P.O Hoffer GE Valve GAC Contactor 5
MOV-33623A	BUTTERFLY	OPEN/CLOSE	10	4	10	150	GE	P.O Hoffer GE Valve GAC Contactor 6
MOV-33723A	BUTTERFLY	OPEN/CLOSE	10	4	10	150	GE	P.O Hoffer GE Valve GAC Contactor 7
MOV-33823A	BUTTERFLY	OPEN/CLOSE	10	4	10	150	GE	P.O Hoffer GE Valve GAC Contactor 8
MOV-33923A	BUTTERFLY	OPEN/CLOSE	10	4	10	150	GE	P.O Hoffer GE Valve GAC Contactor 9
MOV-34023A	BUTTERFLY	OPEN/CLOSE	10	4	10	150	GE	P.O Hoffer GE Valve GAC Contactor 10
MOV-34123A	BUTTERFLY	OPEN/CLOSE	10	4	10	150	GE	P.O Hoffer GE Valve GAC Contactor 11
MOV-34223A	BUTTERFLY	OPEN/CLOSE	10	4	10	150	GE	P.O Hoffer GE Valve GAC Contactor 12

ELECTRICALLY OPERATED VALVE SCHEDULE								
TAG NO.	VALVE TYPE	OPERATOR TYPE	SIZE (in.)	FLOW (MGD)	MAX DIFFERENTIAL PRESSURE (psi)	CLASS	SERVICE	LOCATION
MOV-33123B	BUTTERFLY	OPEN/CLOSE	10	4	10	150	GTW	P.O Hoffer GTW Valve GAC Contactor 1
MOV-33223B	BUTTERFLY	OPEN/CLOSE	10	4	10	150	GTW	P.O Hoffer GTW Valve GAC Contactor 2
MOV-33323B	BUTTERFLY	OPEN/CLOSE	10	4	10	150	GTW	P.O Hoffer GTW Valve GAC Contactor 3
MOV-33423B	BUTTERFLY	OPEN/CLOSE	10	4	10	150	GTW	P.O Hoffer GTW Valve GAC Contactor 4
MOV-33523B	BUTTERFLY	OPEN/CLOSE	10	4	10	150	GTW	P.O Hoffer GTW Valve GAC Contactor 5
MOV-33623B	BUTTERFLY	OPEN/CLOSE	10	4	10	150	GTW	P.O Hoffer GTW Valve GAC Contactor 6
MOV-33723B	BUTTERFLY	OPEN/CLOSE	10	4	10	150	GTW	P.O Hoffer GTW Valve GAC Contactor 7
MOV-33823B	BUTTERFLY	OPEN/CLOSE	10	4	10	150	GTW	P.O Hoffer GTW Valve GAC Contactor 8
MOV-33923B	BUTTERFLY	OPEN/CLOSE	10	4	10	150	GTW	P.O Hoffer GTW Valve GAC Contactor 9
MOV-34023B	BUTTERFLY	OPEN/CLOSE	10	4	10	150	GTW	P.O Hoffer GTW Valve GAC Contactor 10
MOV-34123B	BUTTERFLY	OPEN/CLOSE	10	4	10	150	GTW	P.O Hoffer GTW Valve GAC Contactor 11
MOV-34223B	BUTTERFLY	OPEN/CLOSE	10	4	10	150	GTW	P.O Hoffer GTW Valve GAC Contactor 12
MOV-33124	BUTTERFLY	MODULATING	10	4	25	150	GE	P.O Hoffer Control Valve GAC Contactor 1
MOV-33224	BUTTERFLY	MODULATING	10	4	25	150	GE	P.O Hoffer Control Valve GAC Contactor 2
MOV-33324	BUTTERFLY	MODULATING	10	4	25	150	GE	P.O Hoffer Control Valve GAC Contactor 3
MOV-33424	BUTTERFLY	MODULATING	10	4	25	150	GE	P.O Hoffer Control Valve GAC Contactor 4
MOV-33524	BUTTERFLY	MODULATING	10	4	25	150	GE	P.O Hoffer Control Valve GAC Contactor 5
MOV-33624	BUTTERFLY	MODULATING	10	4	25	150	GE	P.O Hoffer Control Valve GAC Contactor 6
MOV-33724	BUTTERFLY	MODULATING	10	4	25	150	GE	P.O Hoffer Control Valve GAC Contactor 7
MOV-33824	BUTTERFLY	MODULATING	10	4	25	150	GE	P.O Hoffer Control Valve GAC Contactor 8
MOV-33924	BUTTERFLY	MODULATING	10	4	25	150	GE	P.O Hoffer Control Valve GAC Contactor 9
MOV-34024	BUTTERFLY	MODULATING	10	4	25	150	GE	P.O Hoffer Control Valve GAC Contactor 10
MOV-34124	BUTTERFLY	MODULATING	10	4	25	150	GE	P.O Hoffer Control Valve GAC Contactor 11
MOV-34224	BUTTERFLY	MODULATING	10	4	25	150	GE	P.O Hoffer Control Valve GAC Contactor 12
MOV-35121	BUTTERFLY	OPEN/CLOSE	54	48	5	150	FLW	P.O. Hoffer GAC Bypass Valve
MOV-33121	BUTTERFLY	OPEN/CLOSE	24	2.4	5	150	FLW	Glenville Lake Influent Valve GAC Contactor 1
MOV-33221	BUTTERFLY	OPEN/CLOSE	24	2.4	5	150	FLW	Glenville Lake Influent Valve GAC Contactor 2
MOV-33321	BUTTERFLY	OPEN/CLOSE	24	2.4	5	150	FLW	Glenville Lake Influent Valve GAC Contactor 3

ELECTRICALLY OPERATED VALVE SCHEDULE								
TAG NO.	VALVE TYPE	OPERATOR TYPE	SIZE (in.)	FLOW (MGD)	MAX DIFFERENTIAL PRESSURE (psi)	CLASS	SERVICE	LOCATION
MOV-33421	BUTTERFLY	OPEN/CLOSE	24	2.4	5	150	FLW	Glenville Lake Influent Valve GAC Contactor 4
MOV-33521	BUTTERFLY	OPEN/CLOSE	24	2.4	5	150	FLW	Glenville Lake Influent Valve GAC Contactor 5
MOV-33621	BUTTERFLY	OPEN/CLOSE	24	2.4	5	150	FLW	Glenville Lake Influent Valve GAC Contactor 6
MOV-33721	BUTTERFLY	OPEN/CLOSE	24	2.4	5	150	FLW	Glenville Lake Influent Valve GAC Contactor 7
MOV-33821	BUTTERFLY	OPEN/CLOSE	24	2.4	5	150	FLW	Glenville Lake Influent Valve GAC Contactor 8
MOV-33921	BUTTERFLY	OPEN/CLOSE	24	2.4	5	150	FLW	Glenville Lake Influent Valve GAC Contactor 9
MOV-34021	BUTTERFLY	OPEN/CLOSE	24	2.4	5	150	FLW	Glenville Lake Influent Valve GAC Contactor 10
MOV-33122A	BUTTERFLY	OPEN/CLOSE	16	4.4	55	150	GWS	Glenville Lake GWS Valve GAC Contactor 1
MOV-33222A	BUTTERFLY	OPEN/CLOSE	16	4.4	55	150	GWS	Glenville Lake GWS Valve GAC Contactor 2
MOV-33322A	BUTTERFLY	OPEN/CLOSE	16	4.4	55	150	GWS	Glenville Lake GWS Valve GAC Contactor 3
MOV-33422A	BUTTERFLY	OPEN/CLOSE	16	4.4	55	150	GWS	Glenville Lake GWS Valve GAC Contactor 4
MOV-33522A	BUTTERFLY	OPEN/CLOSE	16	4.4	55	150	GWS	Glenville Lake GWS Valve GAC Contactor 5
MOV-33622A	BUTTERFLY	OPEN/CLOSE	16	4.4	55	150	GWS	Glenville Lake GWS Valve GAC Contactor 6
MOV-33722A	BUTTERFLY	OPEN/CLOSE	16	4.4	55	150	GWS	Glenville Lake GWS Valve GAC Contactor 7
MOV-33822A	BUTTERFLY	OPEN/CLOSE	16	4.4	55	150	GWS	Glenville Lake GWS Valve GAC Contactor 8
MOV-33922A	BUTTERFLY	OPEN/CLOSE	16	4.4	55	150	GWS	Glenville Lake GWS Valve GAC Contactor 9
MOV-34022A	BUTTERFLY	OPEN/CLOSE	16	4.4	55	150	GWS	Glenville Lake GWS Valve GAC Contactor 10
MOV-33122B	BUTTERFLY	OPEN/CLOSE	24	4.4	10	150	GWV	Glenville Lake GWV Valve GAC Contactor 1
MOV-33222B	BUTTERFLY	OPEN/CLOSE	24	4.4	10	150	GWV	Glenville Lake GWV Valve GAC Contactor 2
MOV-33322B	BUTTERFLY	OPEN/CLOSE	24	4.4	10	150	GWV	Glenville Lake GWV Valve GAC Contactor 3
MOV-33422B	BUTTERFLY	OPEN/CLOSE	24	4.4	10	150	GWV	Glenville Lake GWV Valve GAC Contactor 4
MOV-33522B	BUTTERFLY	OPEN/CLOSE	24	4.4	10	150	GWV	Glenville Lake GWV Valve GAC Contactor 5
MOV-33622B	BUTTERFLY	OPEN/CLOSE	24	4.4	10	150	GWV	Glenville Lake GWV Valve GAC Contactor 6
MOV-33722B	BUTTERFLY	OPEN/CLOSE	24	4.4	10	150	GWV	Glenville Lake GWV Valve GAC Contactor 7
MOV-33822B	BUTTERFLY	OPEN/CLOSE	24	4.4	10	150	GWV	Glenville Lake GWV Valve GAC Contactor 8
MOV-33922B	BUTTERFLY	OPEN/CLOSE	24	4.4	10	150	GWV	Glenville Lake GWV Valve GAC Contactor 9

ELECTRICALLY OPERATED VALVE SCHEDULE								
TAG NO.	VALVE TYPE	OPERATOR TYPE	SIZE (in.)	FLOW (MGD)	MAX DIFFERENTIAL PRESSURE (psi)	CLASS	SERVICE	LOCATION
MOV-34022B	BUTTERFLY	OPEN/CLOSE	24	4.4	10	150	GWW	Glenville Lake GWW Valve GAC Contactor 10
MOV-33123A	BUTTERFLY	OPEN/CLOSE	10	2.4	10	150	GE	Glenville Lake GE Control Valve GAC Contactor 1
MOV-33223A	BUTTERFLY	OPEN/CLOSE	10	2.4	10	150	GE	Glenville Lake GE Control Valve GAC Contactor 2
MOV-33323A	BUTTERFLY	OPEN/CLOSE	10	2.4	10	150	GE	Glenville Lake GE Control Valve GAC Contactor 3
MOV-33423A	BUTTERFLY	OPEN/CLOSE	10	2.4	10	150	GE	Glenville Lake GE Control Valve GAC Contactor 4
MOV-33523A	BUTTERFLY	OPEN/CLOSE	10	2.4	10	150	GE	Glenville Lake GE Control Valve GAC Contactor 5
MOV-33623A	BUTTERFLY	OPEN/CLOSE	10	2.4	10	150	GE	Glenville Lake GE Control Valve GAC Contactor 6
MOV-33723A	BUTTERFLY	OPEN/CLOSE	10	2.4	10	150	GE	Glenville Lake GE Control Valve GAC Contactor 7
MOV-33823A	BUTTERFLY	OPEN/CLOSE	10	2.4	10	150	GE	Glenville Lake GE Control Valve GAC Contactor 8
MOV-33923A	BUTTERFLY	OPEN/CLOSE	10	2.4	10	150	GE	Glenville Lake GE Control Valve GAC Contactor 9
MOV-34023A	BUTTERFLY	OPEN/CLOSE	10	2.4	10	150	GE	Glenville Lake GE Control Valve GAC Contactor 10
MOV-33123B	BUTTERFLY	OPEN/CLOSE	10	2.4	5	150	GTW	Glenville Lake GTW Valve GAC Contactor 1
MOV-33223B	BUTTERFLY	OPEN/CLOSE	10	2.4	5	150	GTW	Glenville Lake GTW Valve GAC Contactor 2
MOV-33323B	BUTTERFLY	OPEN/CLOSE	10	2.4	5	150	GTW	Glenville Lake GTW Valve GAC Contactor 3
MOV-33423B	BUTTERFLY	OPEN/CLOSE	10	2.4	5	150	GTW	Glenville Lake GTW Valve GAC Contactor 4
MOV-33523B	BUTTERFLY	OPEN/CLOSE	10	2.4	5	150	GTW	Glenville Lake GTW Valve GAC Contactor 5
MOV-33623B	BUTTERFLY	OPEN/CLOSE	10	2.4	5	150	GTW	Glenville Lake GTW Valve GAC Contactor 6
MOV-33723B	BUTTERFLY	OPEN/CLOSE	10	2.4	5	150	GTW	Glenville Lake GTW Valve GAC Contactor 7
MOV-33823B	BUTTERFLY	OPEN/CLOSE	10	2.4	5	150	GTW	Glenville Lake GTW Valve GAC Contactor 8
MOV-33923B	BUTTERFLY	OPEN/CLOSE	10	2.4	5	150	GTW	Glenville Lake GTW Valve GAC Contactor 9
MOV-34023B	BUTTERFLY	OPEN/CLOSE	10	2.4	5	150	GTW	Glenville Lake GTW Valve GAC Contactor 10
MOV-33124	BUTTERFLY	MODULATING	10	2.4	25	150	GE	Glenville Lake GE Modulating Valve GAC Contactor 1
MOV-33224	BUTTERFLY	MODULATING	10	2.4	25	150	GE	Glenville Lake GE Modulating Valve GAC Contactor 2

ELECTRICALLY OPERATED VALVE SCHEDULE								
TAG NO.	VALVE TYPE	OPERATOR TYPE	SIZE (in.)	FLOW (MGD)	MAX DIFFERENTIAL PRESSURE (psi)	CLASS	SERVICE	LOCATION
MOV-33324	BUTTERFLY	MODULATING	10	2.4	25	150	GE	Glenville Lake GE Modulating Valve GAC Contactor 3
MOV-33424	BUTTERFLY	MODULATING	10	2.4	25	150	GE	Glenville Lake GE Modulating Valve GAC Contactor 4
MOV-33524	BUTTERFLY	MODULATING	10	2.4	25	150	GE	Glenville Lake GE Modulating Valve GAC Contactor 5
MOV-33624	BUTTERFLY	MODULATING	10	2.4	25	150	GE	Glenville Lake GE Modulating Valve GAC Contactor 6
MOV-33724	BUTTERFLY	MODULATING	10	2.4	25	150	GE	Glenville Lake GE Modulating Valve GAC Contactor 7
MOV-33824	BUTTERFLY	MODULATING	10	2.4	25	150	GE	Glenville Lake GE Modulating Valve GAC Contactor 8
MOV-33924	BUTTERFLY	MODULATING	10	2.4	25	150	GE	Glenville Lake GE Modulating Valve GAC Contactor 9
MOV-34024	BUTTERFLY	MODULATING	10	2.4	25	150	GE	Glenville Lake GE Modulating Valve GAC Contactor 10
MOV-33125	BUTTERFLY	OPEN/CLOSE	16	4.4	25	150	GE	Glenville Lake Dualcell A Valve GAC Contactor 1
MOV-33225	BUTTERFLY	OPEN/CLOSE	16	4.4	25	150	GE	Glenville Lake Dualcell A Valve GAC Contactor 2
MOV-33325	BUTTERFLY	OPEN/CLOSE	16	4.4	25	150	GE	Glenville Lake Dualcell A Valve GAC Contactor 3
MOV-33425	BUTTERFLY	OPEN/CLOSE	16	4.4	25	150	GE	Glenville Lake Dualcell A Valve GAC Contactor 4
MOV-33525	BUTTERFLY	OPEN/CLOSE	16	4.4	25	150	GE	Glenville Lake Dualcell A Valve GAC Contactor 5
MOV-33625	BUTTERFLY	OPEN/CLOSE	16	4.4	25	150	GE	Glenville Lake Dualcell A Valve GAC Contactor 6
MOV-33725	BUTTERFLY	OPEN/CLOSE	16	4.4	25	150	GE	Glenville Lake Dualcell A Valve GAC Contactor 7
MOV-33825	BUTTERFLY	OPEN/CLOSE	16	4.4	25	150	GE	Glenville Lake Dualcell A Valve GAC Contactor 8
MOV-33925	BUTTERFLY	OPEN/CLOSE	16	4.4	25	150	GE	Glenville Lake Dualcell A Valve GAC Contactor 9
MOV-34025	BUTTERFLY	OPEN/CLOSE	16	4.4	25	150	GE	Glenville Lake Dualcell A Valve GAC Contactor 10
MOV-33126	BUTTERFLY	OPEN/CLOSE	16	4.4	25	150	GE	Glenville Lake Dualcell B Valve GAC Contactor 1
MOV-33226	BUTTERFLY	OPEN/CLOSE	16	4.4	25	150	GE	Glenville Lake Dualcell B Valve GAC Contactor 2

ELECTRICALLY OPERATED VALVE SCHEDULE								
TAG NO.	VALVE TYPE	OPERATOR TYPE	SIZE (in.)	FLOW (MGD)	MAX DIFFERENTIAL PRESSURE (psi)	CLASS	SERVICE	LOCATION
MOV-33326	BUTTERFLY	OPEN/CLOSE	16	4.4	25	150	GE	Glenville Lake Dualcell B Valve GAC Contactor 3
MOV-33426	BUTTERFLY	OPEN/CLOSE	16	4.4	25	150	GE	Glenville Lake Dualcell B Valve GAC Contactor 4
MOV-33526	BUTTERFLY	OPEN/CLOSE	16	4.4	25	150	GE	Glenville Lake Dualcell B Valve GAC Contactor 5
MOV-33626	BUTTERFLY	OPEN/CLOSE	16	4.4	25	150	GE	Glenville Lake Dualcell B Valve GAC Contactor 6
MOV-33726	BUTTERFLY	OPEN/CLOSE	16	4.4	25	150	GE	Glenville Lake Dualcell B Valve GAC Contactor 7
MOV-33826	BUTTERFLY	OPEN/CLOSE	16	4.4	25	150	GE	Glenville Lake Dualcell B Valve GAC Contactor 8
MOV-33926	BUTTERFLY	OPEN/CLOSE	16	4.4	25	150	GE	Glenville Lake Dualcell B Valve GAC Contactor 9
MOV-34026	BUTTERFLY	OPEN/CLOSE	16	4.4	25	150	GE	Glenville Lake Dualcell B Valve GAC Contactor 10
MOV-35121	BUTTERFLY	OPEN/CLOSE	30	24	5	150	FLW	Glenville Lake GAC Bypass Valve

STOP LOG SCHEDULE							
TAG NO.	DESCRIPTION	SIZE		DESIGN HEAD ¹ (ft.)	CHANNEL INVERT TO OPERATING FLOOR (ft.)	NO. OF STOP LOG FRAMES	NO. OF SETS OF STOP LOGS
		WIDTH (in.)	HEIGHT (in.)				
NA	GAC INFLUENT FLUME- GLWTF	60	133.5	8.34	12.5	2	1
NA	GAC INFLUENT FLUME - POHWTF	60	133.5	8	12.5	2	1
1) Design Head is as measured from the gate invert to the maximum WSEL.							

END OF SECTION

SECTION 40 41 13
HEAT TRACING SYSTEMS

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. The Contractor shall furnish and install heat tracing and insulation systems as shown and required by notes in the drawings or as required by the Section 40 06 20 – Process Pipe, Valve, and Gate Schedules. All heat tracing components shall be supplied by the same manufacturer. The heat tracing and insulation system shall include but shall not be limited to self-regulating heater cables, grommet end termination kits, power connection kits, splice kits, NEMA 4X enclosed thermostats, piping insulation and jacket and installation tape. The intent of this specification is for the contractor to supply all appurtenances needed for a complete and fully operational system at each location that a heat tracing system is required. The heat tracing system supplier shall be completely responsible for the design of the system such that the entire system meets all aspects of this specification and the system functions in the environment where it will be installed. All parameters of the system shall be sized and as recommended by the supplier.
- B. The heat tracing system(s) shall be provided in accordance with the requirements of Section 40 05 00 – Basic Mechanical Requirements.
- C. Piping insulation and jacket shall be supplied with all heat traced piping and shall be in conformance with Section 40 42 13 – Insulation. The thickness of the insulation shall be as stipulated in this specification.
- D. All air release valve piping that will remain constantly wet and that is installed outdoors shall be heat traced. All pressure gauge piping installed outdoors shall be heat traced and insulated.
- E. The minimum design ambient temperature for the heat tracing system design shall be - 10°F.
- F. All the components of the heat tracing system shall be individually Underwriters Laboratory (UL) listed. The system as supplied shall conform to all applicable parts of the following:
 - 1. National Fire Protection Association (NFPA)
 - 2. National Electric Code (NEC)

3. Local and State/Commonwealth Building Codes

1.02 OPERATING CONDITIONS AND PERFORMANCE REQUIREMENTS

- A. Heat tracing system conductors and insulation for METAL piping shall be supplied in conformance with the following table:

Heat Tracing Conductors and Insulation for Metal Piping

Pipe Size (in)	Insulation Thickness (in)	Cable Heat Rating Watts per Foot	
		Design Air Temperature -10°F	Design Air Temperature -40°F
≤3/4	1	3	3
1	1	3	5
1-1/4	1	3	5
1-1/2	1	3	5
2	1	3	5
2-1/2	1	3	5
3	1-1/2	3	5
4	1-1/2	5	8
6	2	5	8
8	2	5	8
10	2	8	10(1)
12	2	8	10(1)

- 1) Two conductors shall be provided and shall be placed on top of and under the pipe.

- B. Heat tracing system conductors and insulation for NONMETALLIC piping shall be supplied in conformance with the following table:

Heat Tracing Conductors and Insulation for Nonmetallic Piping

Pipe Size (in)	Insulation Thickness (in)	Cable Heat Rating Watts per Foot	
		Ambient Air Temperature -10°F	Ambient Air Temperature -40°F
≤3/4	1	3	3

Pipe Size (in)	Insulation Thickness (in)	Cable Heat Rating Watts per Foot	
		Ambient Air Temperature -10°F	Ambient Air Temperature -40°F
1	1	3	5
1-1/4	1	3	5
1-1/2	1	3	5
2	1	3	5
2-1/2	1	5	8
3	1-1/2	3	8
4	1-1/2	5	8
6	2	5	8
8	2	8	10
10	2	8(2)	(1)
12	2	8(2)	(1)

- 1) Consult the heat tracing system manufacturer for the cable rating and the number of passes for each pipe.
- 2) Two conductors shall be provided and shall be placed on top of and under the pipe.

1.03 SUBMITTALS

- A. The following items shall be submitted with the Shop Drawings in accordance with, or in addition to the submittal requirements specified in Section 01 33 00 – Submittal Procedures:
 1. Submittal data on all components of the heat trace system and any other data recommended by the manufacturer
 2. Installation and maintenance instructions
 3. List of replacement parts for the entire system in table format
 4. Bill of materials list of the system as supplied in table format

PART 2 – PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Each heat trace system shall be supplied by Thermon Manufacturing Company, Raychem Corporation or Chromalox. All system components shall be supplied by a single manufacturer.

2.02 MATERIALS

- A. The self-regulating heater cable assembly shall consist of two parallel copper bus wires, minimum size 16 AWG, connected through a semi-conductive heating matrix. This heating element shall be covered with a cross-linked polyolefin insulation jacket. This insulation shall be covered by a tinned copper braid and then covered with a fluoropolymer insulating jacket. All heat cables shall be rated for 120 volt supply voltage.
- B. Each heat tracing circuit shall be supplied with a power connection and end seal kit. Each end seal kit shall include a lighted end termination kit Chromalox model UESL or equal. It shall be the Contractor's responsibility to make sure that no circuit in the system be longer than as recommended by the heat tracing system manufacturer.
- C. All terminations, splices, junctions and tee's in the circuit shall be made using manufacturer recommended and supplied kits. Junction boxes shall be provided where required for access to all circuit appurtenances.
- D. Flexible heater elements shall be provided where indicated on the Drawings to protect pumps & other equipment. The flexible heater shall be 3 inches wide by 40 inches long and shall consist of a heater element encapsulated in silicone rubber. The silicone rubber shall be rated for a temperature range of -80°F to 390°F. The flexible heater shall be designed with eyelets in the ends and edges as required for mounting on the pump using manufacturer supplied silicone straps. The flexible heater shall be rated for 120 Vac and 600 watts of heat output. The flexible heater shall be supplied with a preset thermostat which will energize the flexible heater when the ambient temperature reaches 40°F and shut down the heater when the ambient temperature reaches 50°F. The flexible heater shall be model SL-N as manufactured by Chromalox or equal.

2.03 ELECTRICAL AND CONTROL REQUIREMENTS

- A. A thermostat shall be furnished and installed for each heat trace circuit. The thermostat for each circuit shall be an adjustable ambient sensing thermostat designed for controlling the heating cable to provide freeze protection of pipes. The thermostat shall have an adjustable range of 15°F to 140°F. The enclosure for the thermostat shall be NEMA 4X. The Thermostat shall be rated to match the voltage of the heating cable and shall have a switch rating of 20 amps (minimum). Thermostat shall be suitable for use

in Class 1 (Division 1 and 2) or Class 2 (Division 1 and 2) hazardous locations where thermostat is shown to be installed in hazardous locations.

2.04 SPARE PARTS

- A. Spare parts shall be provided in accordance with Section 46 00 00 – Equipment General Provisions and shall include the following:
1. 100 ft. of self-regulating cable for each cable wattage provided for the system(s)
 2. One (1) spare ambient thermostat controller for each heat tracing system
 3. One (1) spare ambient temperature RTD
 4. Two (2) each of the following: cable termination kits, cable splice kits and cable tee kits

PART 3 – EXECUTION

3.01 MANUFACTURER’S FIELD SERVICES

- A. The services of a qualified manufacturer's technical representative shall be provided in accordance with Section 46 00 00 – Equipment General Provisions and shall include the following site visits:

Service	Number of Trips	Number of Days/Trip
Installation and Testing	1	1
Startup and Training	1	1

3.02 INSTALLATION

- A. The installation of all heat tracing and insulation components shall conform to all instructions and requirements recommended by the heat tracing system manufacturer. All installation and terminations shall conform to the National Electric Code.
- B. All piping shall be pressure tested prior to installation of any heat tracing or insulation components. Thermal insulation shall only be installed when all heat tracing components are in place and satisfactorily tested as indicated herein. Once tested, the insulation shall be installed immediately to prevent damage to the heat tracing system components.

- C. No insulation shall be installed using staples. Insulation jackets shall be installed as recommended by the insulation system supplier such that no damage is done to the heat tracing system components.
- D. The installation of heat tracing cable on nonmetallic pipe shall be done in strict conformance with the heat tracing manufacturer's recommendations. Requirements shall include heat shielding tape or wrap as recommended by the heat tracing manufacturer
- E. Contractor shall install weather proofing for all outdoor piping. The field applied jacket with moisture barrier shall be slipped around pipe into preformed 2-lock position. Butt next jacket section adjacent to previous section leaving 3/8-inch gap. Place preformed 2-inch butt strap with sealant over the seam and secure with ½-inch aluminum band and wing seal. Contractor shall install preformed fittings identical in composition to pipe jacketing at all fittings
- F. The Contractor shall insure that surfaces of pipes, valves, heat tracing, and fittings are clean and dry prior to installation of insulation. Insulation shall be installed so as to make surfaces smooth, even, and substantially flush with the adjacent insulation. The Contractor shall follow the manufacturer's application instructions for the materials used
- G. A label shall be installed on the piping insulation jacket every 15 feet and readily visible from ground level: ELECTRIC HEAT TRACING: CAUTION

3.03 FIELD TESTING

- A. All heating cable shall be tested using a megohmmeter (megger) between the heating cable bus wires and the metallic ground braid. A 2,500 VDC megger test is required and the minimum acceptable resistance value shall be 20 megaohms regardless of the circuit length. Any cables found to be less than this value shall be replaced at no additional cost to the Owner. The megger tests shall be performed as follows:
 - 1. After installation of the cable and all fabrication kits but prior to installing any of the insulation system components.
 - 2. After installation of the insulation system components but prior to energizing the cables.
 - 3. All test reading for each megger test shall be recorded by the installer and submitted with the maintenance instructions.

END OF SECTION

SECTION 40 42 13

INSULATION

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. The Contractor shall furnish and install insulation as shown on the Drawings or otherwise specified. Insulation shall not be installed until piping has been field tested and approved by the Owner. The Contractor shall protect the insulation from moisture at all times.
- B. Reference Section 40 05 00 – Basic Mechanical Requirements.

PART 2 – PRODUCTS

2.01 INSULATED PROCESS/CHEMICAL PIPING

- A. Fiberglass insulation shall be Owens Corning Fiberglass Corp., Fiberglass 25ASJ/SSC; Certain Teed Products Corporation, Certain Teed snap-on ASJ/SSL; or equal. Insulation shall be heavy density sectional pipe insulation with vapor barrier and self-sealing lap. Minimum density insulation density shall be 6 pounds per cubic foot. Contractor shall use manufacturer's recommended adhesives and tape for jointing material. Fittings shall be molded fiberglass. Minimum insulation thickness shall be 1-1/2 inches for 4" diameter pipe and larger, and 1 inch for smaller pipe. Insulation thickness for heat traced pipe is specified in Section 40 41 13 – Heat Tracing Systems.
- B. Weatherproof insulation jacket for process piping shall be Certain Teed Products Corporation; Childers Products Company, Lock On and Slip On; or equal. Jacket shall be smooth embossed aluminum metal jacket with minimum thickness 0.016 inches thick for interior installations and at least 0.031 inches thick for exterior installations. Fastening shall use preformed "2"-lock seam with 2 inch butt strap with sealant. Bonds shall be 1/2 inch aluminum with wing seals. Fittings shall be prefabricated 0.016/0.031 inches thickness aluminum.
 - 1. Contractor shall install weather proofing for outdoor piping. The field applied jacket with moisture barrier shall be slipped around pipe into preformed 2-lock position. Butt next jacket section adjacent to previous section leaving 3/8 inch gap. Place preformed 2 inch butt strap with sealant over the seam and secure with 1/2 inch aluminum band and wing seal. Contractor shall install preformed fittings identical in composition to pipe jacketing at all fittings.

- C. Insulation fitting covers and jacket for chemical piping shall be Zeston 2000 PVC by Manville, or equal. Fitting covers shall fit snugly over fittings, including all elbows and valves, etc. Jacketing shall be high-impact UV-resistant covering for insulated piping and shall match fitting covers. Fitting covers and jackets shall be white and suitable for painting. PVC jacketing shall be 30 mil thick and shall be factory curled to fit snugly. Fitting covers and jacketing shall be secured with tacks.
- D. The Contractor shall ensure that surfaces of pipes, valves, heat tracing, and fittings are clean and dry prior to installation of insulation. Insulation shall be installed so as to make surfaces smooth, even, and substantially flush with the adjacent insulation. The Contractor shall follow the manufacturer's application instructions for the materials used.

2.02 INSULATED AIR PIPING

- A. Fiberglass insulation shall be provided for exposed exterior blower discharge piping as shown on the Drawings and as specified herein. Insulation shall be a roll of semi-rigid fiberglass board insulation. The fibrous insulation is adhered to the ASJ jacket with the end grain of the insulation perpendicular to the jacket surface. Each section of insulation may be secured on the longitudinal seam by using staples and mastic or vapor barrier ASJ pressure sensitive tape. Adjacent sections shall be butted together and sealed with vapor barrier ASJ tape. The insulation shall be 2-1/2 inches thick with a fiberglass density of at least 3 pounds per cubic foot.
- B. Insulation for fittings and flanges shall be mitered segments of nominal 6 pounds per cubic foot density fiberglass pipe covering. Cover with a coat of insulating cement then embed a 20 x 20 weave white glass reinforcing cloth between two 1/16 inch coats of Benjamin Foster 30-36. The glass cloth and second coat shall overlap adjacent covering by two inches. Insulation shall be fiberglass pipe wrap as manufactured by Owens-Corning, Johns Mansfield, or equal.
- C. The insulation shall be covered with a smooth, weatherproof, embossed aluminum jacket with integral Kraft-polyethylene vapor barrier separating the insulation from the metal. The factory applied aluminum jackets shall be at least .016 inches thick for interior installation and at least .031 inches thick for exterior installation. They shall be at least 36" long as measured along the pipe.
- D. Circumferentially, the width of the sheets shall be 1/2" to 2" greater than the circumference of the pipe insulation, with a Pittsburgh locktype on the longitudinal edge.
- E. The metal jackets shall be held in place by .020" thick, 3/4 inch wide, metal bands on 9" centers.
- F. Special care shall be taken to make all exterior insulation jackets completely waterproof by the use of an appropriate silicone base sealant at all joints, etc.

PART 3 – EXECUTION (NOT USED)

END OF SECTION

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SECTION 40 61 13
PROCESS CONTROL SYSTEM GENERAL PROVISIONS

PART 1 – GENERAL

1.01 SCOPE

- A. The Contractor shall provide, through the services of an instrumentation and control system subcontractor, components, system installation services, as well as required and specified ancillary services in connection with the Instrumentation, Control and Information System.
- B. The System includes materials, labor, tools, fees, charges, and documentation required to furnish, install, test and place in operation a complete and operable instrumentation, control and information system.
- C. The system shall include measuring elements, signal converters, transmitters, local control panels, digital hardware and software, operator workstations, remote telemetry units, signal and data transmission systems, interconnecting wiring, and pertinent accessories.
- D. The scope of the work to be performed under this Division includes but is not limited to the following:
 - 1. The Contractor shall retain overall responsibility for the instrumentation and control system as specified herein.
 - 2. Furnish and install process instrumentation and associated taps and supports as scheduled or shown on the Drawings, unless otherwise noted or supplied by equipment vendors.
 - 3. Furnish and install local control panels, field panels and associated cabinets and panels as shown on the Drawings and as specified in Sections 40 60 00 through 40 79 99, inclusive and where included.
 - 4. Furnish and install digital control system hardware and software as specified in Sections 40 60 00 through 40 79 99, inclusive and where included.
 - 5. Final termination and testing of instrumentation and control system signal wiring and power supply wiring at equipment furnished under Sections 40 60 00 through 40 79 99, inclusive and where included.
 - 6. Furnish, install and terminate special cables for devices (e.g., instruments, printers, radios). Furnish and terminate control system communication network cables.

7. Furnish and install surge protection devices for digital equipment, local control panels, remote telemetry units, and instrumentation provided under this Division, including connections to grounding system(s) provided under Division 26.
 8. Coordinate grounding requirements with the electrical subcontractor for digital equipment, local control panels, remote telemetry units, and instrumentation provided under this Division. Terminate grounding system cables at equipment provided under this Division.
 9. Provide system testing, calibration, training and startup services as specified herein and as required to make systems fully operational.
- E. It is the intent of the Contract Documents to construct a complete and working installation. Items of equipment or materials that may reasonably be assumed as necessary to accomplish this end shall be supplied whether or not they are specifically stated herein.

1.02 RELATED ITEMS

- A. Field mounted switches, torque switches, limit switches, gauges, valve and gate operator position transmitters, sump pump controls, and other instrumentation and controls furnished with mechanical or electrical equipment not listed in the instrument schedule shall be furnished, installed, tested, and calibrated as specified under other Divisions unless otherwise indicated.
- B. Additional and related work performed under Division 26 includes the following:
1. Instrument A.C. power source and disconnect switch for process instrumentation, A.C. grounding systems, and A.C. power supplies for equipment, control panels and accessories furnished under Sections 40 60 00 through 40 79 99, inclusive and where included.
 2. Conduit and raceways for instrumentation and control system signal wiring, grounding systems, special cables and communication network cables.
 3. Instrumentation and control system signal wiring.
 4. Install control system communication network cables.
 5. Furnish and install grounding systems for digital equipment, local control panels, remote telemetry units, and instrumentation provided under Sections 40 60 00 through 40 79 99, inclusive and where included. Grounding systems shall be complete to the equipment provided under Sections 40 60 00 through 40 79 99, inclusive, and where included, ready for termination by the instrumentation subcontractor.

6. Termination of instrumentation and control system signal wiring at equipment furnished under other Divisions of the Specifications.
7. Final wiring and termination to A.C. grounding systems and to A.C. power sources (e.g., panelboards, motor control centers, and other sources of electrical power).

1.03 GENERAL INFORMATION AND DESCRIPTION

- A. Where manufacturers are named for a particular item of equipment, it is intended as a guide to acceptable quality and performance and does not exempt such equipment from the requirements of these Specifications or Drawings.
- B. In order to centralize responsibility, it is required that equipment (including field instrumentation and control system hardware and software) offered under this Division shall be furnished and installed by the instrumentation subcontractor, or under the supervision of the instrumentation subcontractor, who shall assume complete responsibility for proper operation of the instrumentation and control system equipment, including that of coordinating signals, and furnishing appurtenant equipment.
- C. The Contractor shall retain total responsibility for the proper detailed design, fabrication, inspection, test, delivery, assembly, installation, activation, checkout, adjustment and operation of the entire instrumentation and control system as well as equipment and controls furnished under other Divisions of the Specifications. The Contractor shall be responsible for the delivery of detailed drawings, manuals and other documentation required for the complete coordination, installation, activation and operation of mechanical equipment, equipment control panels, local control panels, field instrumentation, control systems and related equipment/systems and shall provide for the services of a qualified installation engineer to supervise activities required to place the completed facility in stable operation under full digital control.
- D. The instrumentation and control system shall be capable of simultaneously implementing all real time control and information system functions, and servicing all operator service requests as specified, without degrading the data handling and processing capability of other system components.
- E. Control system inputs and outputs are listed in Section 40 61 93 – Process Control System Input/Output List. This information, together with the functional control descriptions, process and instrumentation diagrams, and electrical control schematics, describes the real time monitoring and control functions to be performed. In addition, the system shall provide various human/machine interface and data reporting functions as specified in the software sections of this Specification.
- F. The mechanical, process, and electrical drawings indicate the approximate locations of field instruments, control panels, systems and equipment as well as field mounted equipment provided by others. The instrumentation subcontractor shall examine the mechanical, process and electrical drawings to determine actual size and locations of

process connections and wiring requirements for instrumentation and controls furnished under this Contract. The instrumentation subcontractor shall inspect equipment, panels, instrumentation, controls, and appurtenances, either existing or furnished on the Project to determine requirements for interfacing with the control and information system. The Contractor shall coordinate the completion of required modifications with the associated supplier of the item furnished.

- G. The instrumentation subcontractor shall review and approve the size and routing of instrumentation and control cable and conduit systems furnished by the electrical subcontractor for suitability for use with the associated cable system.
- H. The Contractor shall coordinate the efforts of each supplier to aid in interfacing systems. This effort shall include, but shall not be limited to, the distribution of approved shop drawings to the electrical subcontractor and to the instrumentation subcontractor furnishing the equipment under this Division.
- I. The Contractor shall be responsible for providing a signal transmission system free from electrical interference that would be detrimental to the proper functioning of the instrumentation and control system equipment.
- J. The Owner shall have the right of access to the subcontractor's facility and the facilities of his equipment suppliers to observe materials and parts; witness inspections, tests and work in progress; and examine applicable design documents, records, and certifications during all stages of design, fabrication, and tests. The instrumentation subcontractor and his equipment suppliers shall furnish office space, supplies, and services required for these observation activities.
- K. The terms "Instrumentation," "Instrumentation and Control System," and "Instrumentation, Control and Information System" shall hereinafter be defined as equipment, labor, services, and documents necessary to meet the intent of the Specifications.

1.04 INSTRUMENTATION AND CONTROL SYSTEM SUBCONTRACTORS

- A. Instrumentation and control system subcontractors shall be regularly engaged in the detailed design, fabrication, installation, and startup of instrumentation and control systems for water and wastewater treatment facilities, remote telemetry systems for water supply/distribution systems, and remote telemetry systems for wastewater collection systems. Instrumentation and control system subcontractors shall have a minimum of five years of such experience and shall have completed a minimum of three projects of similar type and size as that specified herein. Where specific manufacturers/models of major hardware or software products (PLC, HMI software, network, etc.) are specified to be used on this project, the instrumentation and control system subcontractor shall have completed at least one project using that specified

hardware or software. As used herein, the term "completed" shall mean that a project has been brought to final completion and final payment has been made.

- B. Acceptable instrumentation and control system subcontractors shall be CITI, LLC; RoviSys; and Custom Controls Unlimited, Inc.; Piedmont Automation, Inc.; Revere Control Systems; Lord and Company.
- C.

1.05 DEFINITIONS

- A. Solid State: Wherever the term solid state is used to describe circuitry or components in the Specifications, it is intended that the circuitry or components shall be of the type that convey electrons by means of solid materials such as crystals or that work on magnetic principles such as ferrite cores. Vacuum tubes, gas tubes, slide wires, mechanical relays, stepping motors or other devices will not be considered as satisfying the requirements for solid state components of circuitry.
- B. Bit or Data Bit: Whenever the terms bit or data bit are used in the Specification, it is intended that one bit shall be equivalent to one binary digit of information. In specifying data transmission rate, the bit rate or data bit rate shall be the number of binary digits transmitted per second and shall not necessarily be equal to either the maximum pulse rate or average pulse rate.
- C. Integrated Circuit: Integrated circuit shall mean the physical realization of a number of circuit elements inseparably associated on or within a continuous body to perform the function of a circuit.
- D. Mean Time Between Failures (MTBF): The MTBF shall be calculated by taking the number of system operating hours logged during an arbitrary period of not less than six months and dividing by the number of failures experienced during this period plus one.
- E. Mean Time to Repair (MTTR): The MTTR shall be calculated by taking the total system down time for repair over an arbitrary period of not less than six months coinciding with that used for calculation of MTBF and dividing by the number of failures causing down time during the period.
- F. Availability: The availability of a non-redundant device or system shall be related to its MTBF and MTTR by the following formula:

$$A = 100 \times (\text{MTBF} / (\text{MTBF} + \text{MTTR})) \text{ Percent}$$

The availability of a device or system provided with an automatically switched backup device or system shall be determined by the following formula:

$$A = A_2 + 1 - ((1 - A_1) * (1 - A_1))$$

where:

A1 = availability of non-redundant device or system

A2 = availability of device or system provided with an automatically switched backup device or system

G. Abbreviations: Specification abbreviations include the following:

1. A - Availability
2. ADC - Analog to Digital Converter
3. AI - Analog Input
4. AO - Analog Output
5. AVAIL - Available
6. BCD - Binary Coded Decimal
7. CSMA/CD - Carrier Sense Multiple Access/Collision Detect
8. CPU - Central Processing Unit
9. CRC - Cyclic Redundancy Check
10. CS - Control Strategy
11. DAC - Digital to Analog Converter
12. DBMS - Data Base Management System
13. DI - Discrete Input
14. DMA - Direct Memory Access
15. DO - Discrete Output
16. DPDT - Double Pole, Double Throw
17. DVE - Digital to Video Electronics
18. EPROM - Erasable, Programmable Read Only Memory
19. FDM - Frequency Division Multiplexing
20. FSK - Frequency Shift Keyed

21. HMI - Human Machine Interface (Software)
22. I/O - Input/Output
23. LAN - Network and Communication Equipment
24. LCD - Liquid Crystal Display
25. LDFW - Lead Follow
26. MCC - Motor Control Center
27. MTBF - Mean Time Between Failures
28. MTTR - Mean Time to Repair
29. OS - Operating System
30. PAC - Programmable Automation Controller
31. PCB - Printed Circuit Board
32. PID - Proportional Integral and Derivative Control
33. PLC - Programmable Logic Controller or Programmable Controller
34. PROM - Programmable Read Only Memory
35. RAM - Random Access Memory
36. RDY - Ready
37. RMSS - Root Mean Square Summation
38. RNG - Running
39. ROM - Read Only Memory
40. RTU - Remote Telemetry Unit
41. SPDT - Single Pole, Double Throw
42. ST/SP - Start/Stop
43. TDM - Time Division Multiplexing
44. UPS - Uninterruptible Power Supply

45. VFD - Variable Frequency Drive

- H. To minimize the number of characters in words used in textual descriptions on displays, printouts and nameplates, abbreviations may be used subject to the Engineer's approval. If a specified abbreviation does not exist for a particular word, an abbreviation may be generated using the principles of masking and or vowel deletion. Masking involves retaining the first and last letters in a word and deleting one or more characters (usually vowels) from the interior of the word.

1.06 ENVIRONMENTAL CONDITIONS

- A. Instrumentation equipment and enclosures shall be suitable for ambient conditions specified. All system elements shall operate properly in the presence of telephone lines, power lines, and electrical equipment.
- B. Inside control rooms and climate-controlled electrical rooms, the temperature will normally be 20 to 25 degrees C; relative humidity 40 to 80 percent without condensation and the air will be essentially free of corrosive contaminants and moisture. Appropriate air filtering shall be provided to meet environmental conditions (e.g., dust).
- C. Other indoor areas may not be air conditioned/heated; temperatures may range between 0 and 40 degrees C with relative humidity between 40 and 95 percent.
- D. Field equipment including instrumentation and panels may be subjected to wind, rain, lightning, and corrosives in the environment, with ambient temperatures from -20 to 40 degrees C and relative humidity from 10 to 100 percent. All supports, brackets, interconnecting hardware, and fasteners shall be aluminum, type 316 stainless steel, or metal alloy as otherwise suitable for chemical resistance within chemical feed/storage areas shown on the installation detail drawings.

PART 2 – PRODUCTS (NOT USED)

PART 3 – EXECUTION

3.01 SCHEDULE OF PAYMENT

- A. Payment to the Contractor for Control and Information System materials, equipment, and labor shall be in accordance with the General and Supplementary Conditions. The schedule of values submitted as required by the General and Supplementary Conditions shall reflect a breakdown of the work required for completion of the Control and Information System. The breakdown shall include sufficient detail to permit the Engineer to administer payment for the Control and Information System.

- B. Requests for payment for materials and equipment that are not installed on site but are required for system construction and the factory witness test (e.g., digital hardware), or are properly stored as described in the General and Supplementary Conditions and herein, shall be accompanied by invoices from the original supplier to the instrumentation subcontractor substantiating the cost of the materials or equipment.
- C. Any balance remaining within the schedule of values for field instruments and other materials installed on the site, or for other materials for which payment is made by invoice, will be considered due upon completion of the Final Acceptance test.

3.02 CLEANING

- A. The Contractor shall thoroughly clean soiled surfaces of installed equipment and materials.
- B. Upon completion of the instrumentation and control work, the Contractor shall remove surplus materials, rubbish, and debris that has accumulated during the construction work. The entire area shall be left neat, clean, and acceptable to the Owner.

3.03 FINAL ACCEPTANCE

- A. Final acceptance of the Instrumentation, Control and Information System will be determined complete by the Engineer, and shall be based upon the following:
 - 1. Receipt of acceptable start up completion and availability reports and other documentation as required by the Contract Documents.
 - 2. Completion of the Availability Demonstration.
 - 3. Completion of control system training requirements.
 - 4. Completion of punch-list items that are significant in the opinion of the Engineer.
- B. Final acceptance of the System shall mark the beginning of the warranty period.

END OF SECTION

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SECTION 40 61 15
PROCESS CONTROL SYSTEM SUBMITTALS

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. The Contractor shall submit for review complete Shop Drawings for all equipment in accordance with the General and Supplemental Conditions and Division 1 of the Specifications. All submittal material shall be complete, legible, and reproducible, and shall apply specifically to this project.
- B. All submittal materials shall be tailored to this project by highlighting relevant items or crossing out non-applicable items. Generic submittals without identified options will be returned the Contractor without review.
- C. Compliance, Deviations, and Exceptions (CD&E) Letter:
 - 1. Where a named manufacturer/product or manufacturer is specified and a substitution or an "or equal" product is submitted, the submittal shall be accompanied by a "Compliance, Deviations, and Exceptions (CD&E) letter." If the required submittal is submitted without the letter, the submittal will be rejected.
 - 2. The letter shall include all comments, deviations and exceptions taken to the Drawings and Specifications by the Contractor, subcontractor (if applicable), and the equipment Manufacturer/Supplier. This letter shall include a copy of the Specification Section to which the submittal pertains. In the left margin beside each and every paragraph/item, a letter "C", "D", or "E" shall be typed or written in.
 - a. The letter "C" shall be for full compliance with the requirement.
 - b. The letter "D" shall be for a deviation from the requirement.
 - c. The letter "E" shall be for taking exception to a requirement.
 - 3. Any requirements with the letter "D" or "E" beside them shall be provided with a full typewritten explanation of the deviation/exception. Handwritten explanation of the deviations/exceptions shall not be acceptable.
 - 4. The CD&E letter shall also address deviations, and exceptions taken to each Drawing related to this Specification Section.
- D. Although this Section is intended to list the majority of submittals required for a given project, there may be additional submittal requirements in other Sections. Reference the

applicable Sections for a given topic and include additional submittal information when required.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 01 33 00 – Submittals
- B. Section 40 61 13 – Process Control System General Provisions

1.03 DIGITAL HARDWARE SUBMITTALS

- A. Submit system block diagram(s) showing:
 - 1. All equipment to be provided.
 - 2. All interconnecting cable.
 - 3. Equipment names, manufacturer, and model numbers.
 - 4. Equipment locations.
- B. Submit information for all digital equipment including, but not limited to, the following:
 - 1. Bill of materials with equipment names, manufacturers, complete model numbers and locations.
 - 2. Catalog cuts, including complete part number breakdown information.
 - 3. Complete technical, material and environmental specifications.
 - 4. Assembly drawings.
 - 5. Mounting requirements.
 - 6. Color samples.
 - 7. Nameplates.
 - 8. Environmental requirements during storage and operation.

1.04 SOFTWARE SUBMITTALS

- A. Software submittals shall include the following as a minimum:
 - 1. Bill of materials with software names, vendors, and complete listings of included software modules.
 - 2. Standard manufacturer's literature describing the products.

3. Description of function of software in Control and Information System.
4. Limitations or constraints of software.
5. Minimum system (processor and memory) requirements.
6. Operation and maintenance requirements.

B. Submit information on the following software:

1. Third-party software, including:
 - a. Operating system.
 - b. Operator workstation (SCADA or HMI) software, including all add-in software provided to perform specific functions (alarm dialers, schedulers, backup creation software, etc.).
 - c. Office-type products, such as spreadsheets, word processors, etc.
 - d. Database management software.
 - e. Communication software, including all applicable local and wide area network software.
 - f. Programmable controller programming software (where applicable).
2. Software configuration, including:
 - a. Graphic display organization.
 - b. Database configuration for operator workstations and database management system.
 - c. Trends.
 - d. System security.
 - e. Formats for all reports, including all required calculations.
 - f. Intercommunications between software products required to implement system functions.
 - g. Equipment backup configuration and requirements.

C. Control Strategies

1. Description of automatic logic and all non-standard manual logic using plain English, for non-technical persons, and written in Contractor's own words. The write-up shall include references to associated I/O, tag/loop numbers, alarming/interlocks.
2. Submitting language verbatim to Section 40 61 96 – Process Control Descriptions shall not be acceptable.

D. Application Software

1. Provide application software documentation that contains program descriptions for the operation, modification, and maintenance of all application programs provided for the digital system.
2. Application software includes all custom routines developed specifically for this project, or pre-written routines used for accomplishing specified functions for this project. This shall include any add-in custom software.

E. Graphic Displays

1. Submit all graphic displays required to perform the control and operator interface functions specified herein. Submitted graphic displays shall be for both new and modified graphics.
2. Submit the complete set of graphic displays for review by the Owner and the Engineer at least 60 days prior to commencement of factory testing.
3. Where a large number of graphic displays are required, submit an initial set of example displays for review before the complete set of displays is submitted. This initial set shall include examples of all basic graphic display design features and parameters and is intended to allow the Contractor to obtain preliminary approval of these features and parameters prior to beginning main graphic display production.
4. The Contractor shall allow for one major cycle of revisions to the displays prior to factory testing and one minor cycle of revisions following factory test. A cycle of revisions shall be defined as all revisions necessary to complete a single set of changes marked by the Engineer and the Owner. Additional corrections shall be performed during start-up as required to accommodate changes required by actual field conditions, at no additional cost to the Owner.
5. The required submittals in each revision cycle shall be full color prints of the entire set of displays.
6. Displays shall be printouts of actual process graphics implemented in the system.

7. See additional requirements in Section 40 68 00 – Process Control Software.

1.05 CONTROL PANEL SUBMITTALS

- A. Submittals shall be provided for all control panels, and shall include:
 1. Exterior panel drawings with front and side views, to scale.
 2. Interior layout drawings showing the locations and sizes of all equipment and wiring mounted within the cabinet, to scale.
 3. Panel area reserved for cable access and conduit entry.
 4. Location plans showing each panel in its assigned location.
 5. Thermal (heating and cooling) calculations
 6. Power calculations, including UPS sizing and runtime calculation, if provided.
 7. Proof of over current protective device selective coordination, if requested.
- B. Submit information for all exterior and interior panel mounted equipment including, but not limited to, the following:
 1. Bill of materials with equipment names, manufacturers, complete model numbers and locations.
 2. Catalog cuts, including complete part number breakdown information.
 3. Complete technical, material and environmental specifications.
 4. Assembly drawings.
 5. Mounting requirements.
 6. Material and color samples, where required.
 7. Nameplates.
 8. Environmental requirements during storage and operation.
- C. Submit panel wiring diagrams showing power, signal, and control wiring, including surge protection, relays, courtesy receptacles, lighting, wire size and color coding, etc. Include remote equipment labels, remote contact/signal names, remote terminal numbers, and field conduit/cable identification.

1.06 INSTRUMENT SUBMITTALS

- A. Submit information on all field instruments, including but not limited to the following:
1. Product (item) name and tag number used herein and on the Contract Drawings.
 2. Catalog cuts, including complete part number breakdown information.
 3. Manufacturer's complete model number.
 4. Location of the device.
 5. Input output characteristics.
 6. Range, size, and graduations.
 7. Physical size with dimensions, NEMA enclosure classification, and mounting details.
 8. Materials of construction of all enclosures, wetted parts and major components.
 9. Instrument or control device sizing calculations where applicable.
 10. Certified calibration data on all flow metering devices.
 11. Environmental requirements during storage and operation.
 12. Associated surge protection devices.
 13. Installation drawings/details.
 14. Material samples, where required

1.07 TESTING & START-UP (MULTIPLE SUBMITTALS)

- A. Test plans per Section 40 61 21 – Process Control System Testing, unless otherwise indicated.
1. Factory witness testing plan
 2. Field testing plan
 3. Final acceptance testing plan
 4. Instrument test plan per Section 40 70 00 – Instrumentation for Process Systems
 5. Blank calibration/verification sheets per Section 40 70 00 – Instrumentation for Process Systems

- B. Test results per Section 40 61 21 – Process Control System Testing, unless otherwise indicated
 - 1. Factory witness testing results
 - 2. Field testing results
 - 3. Final acceptance testing results
 - 4. Completed calibration/verification sheets per Section 40 70 00 – Instrumentation for Process Systems
- C. Proposed maintenance agreement per Section 40 61 24 – Quality Assurance
- D. Training per Section 40 61 26 – Process Control System Training
 - 1. Training plan for each type
 - 2. Training documentation for each type
 - 3. Training attendance logs
 - 4. Recorded video documentation, if required.

1.08 WIRING AND LOOP DIAGRAMS

- A. Submit interconnection wiring and loop diagrams for all panels and signals in the Control and Information System.
- B. Electrical interconnection diagrams shall show all terminations of equipment, including terminations to equipment and controls furnished under other Divisions, complete with equipment and cable designations. Where applicable, interconnection wiring diagrams shall be organized by input/output card. Interconnecting diagrams shall be prepared in a neat and legible manner on 11 X 17-inch reproducible prints.
- C. Loop drawings shall conform to the latest version of ISA Standards and Recommended Practices for Instrumentation and Control. Loop Drawings shall conform to ISA S5.4, Figures 1-3, Minimum Required Items [Figures 4-6, Minimum Required Items plus Optional Items].
- D. Loop drawings shall not be required as a separate document provided that the interconnecting wiring diagrams required herein contain all information required by ISA 5.4.

1.09 OPERATION AND MAINTENANCE MANUALS

- A. The Contractor shall deliver equipment operation and maintenance manuals in compliance with Section 01 33 00 – Submittals. Operation and maintenance (O&M) manuals shall consist of two basic parts:
1. Manufacturer standard O&M manuals for all equipment and software furnished under this Division.
 2. Custom O&M information describing the specific configuration of equipment and software, and the operation and maintenance requirements for this particular project.
- B. The manuals shall contain all illustrations, detailed drawings, wiring diagrams, and instructions necessary for installing, operating, and maintaining the equipment. The illustrated parts shall be numbered for identification. All modifications to manufacturer standard equipment and/or components shall be clearly identified and shown on the drawings and schematics. All information contained therein shall apply specifically to the equipment furnished and shall only include instructions that are applicable. All such illustrations shall be incorporated within the printing of the page to form a durable and permanent reference book.
- C. The manuals shall be prepared specifically for this installation and shall include all required cuts, drawings, equipment lists, descriptions, etc. that are required to instruct operation and maintenance personnel unfamiliar with such equipment. The maintenance instructions shall include troubleshooting data and full preventive maintenance schedules. The instructions shall be bound in locking 3-D-ring binders with bindings no larger than 3.5 inches. The manuals shall include 15% spare space for the addition of future material. The instructions shall include drawings reduced or folded and shall provide the following as a minimum.
1. A comprehensive index.
 2. A functional description of the entire system, with references to drawings and instructions.
 3. A complete "as built" set of all approved shop drawings, which shall reflect all work required to achieve final system acceptance.
 4. A complete list of the equipment supplied, including serial numbers, ranges, and pertinent data.
 5. Full specifications on each item.
 6. Detailed service, maintenance, and operation instructions for each item supplied.
 7. Special maintenance requirements particular to this system shall be clearly defined, along with special calibration and test procedures.

8. Complete parts lists with stock numbers and name, address, and telephone number of the local supplier.
 9. References to manufacturers' standard literature where applicable.
 10. Warning notes shall be located throughout the manual where such notes are required to prevent accidents or inadvertent misuse of equipment.
- D. The operating instructions shall clearly describe the step by step procedures that must be followed to implement all phases of all operating modes. The instructions shall be in terms understandable and usable by operating personnel and maintenance crews and shall be useful in the training of such personnel.
- E. The maintenance instructions shall describe the detailed preventive and corrective procedures required, including environmental requirements during equipment storage and system operation, to keep the System in good operating condition. All hardware maintenance documentation shall make reference to appropriate diagnostics, where applicable, and all necessary wiring diagrams, component drawings and PCB schematic drawings shall be included.
- F. The hardware maintenance documentation shall include, as a minimum, the following information:
1. Operation Information: This information shall include a detailed description of how the equipment operates and a block diagram illustrating each major assembly in the equipment.
 2. Preventive Maintenance Instructions: These instructions shall include all applicable visual examinations, hardware testing and diagnostic routines, and the adjustments necessary for periodic preventive maintenance of the System.
 3. Corrective Maintenance Instructions: These instructions shall include guides for locating malfunctions down to the card replacement level. These guides shall include adequate details for quickly and efficiently locating the cause of an equipment malfunction and shall state the probable source(s) of trouble, the symptoms, probable cause, and instructions for remedying the malfunction.
 4. Parts Information: This information shall include the identification of each replaceable or field repairable component. All parts shall be identified on a list in a drawing; the identification shall be of a level of detail sufficient for procuring any repairable or replaceable part. Cross references between equipment numbers and manufacturer's part numbers shall be provided.
- G. Software documentation shall conform to a standard format and shall include, but not be limited to, the following:

1. A program abstract that includes:
 - a. Program Name - The symbolic alphanumeric program name.
 - b. Program Title - English text identification.
 - c. Program Synopsis - A brief text shall be provided that specifies the need for the program, states when it shall be used and functionally describes all inputs, outputs and functions performed. This descriptive text shall be written in a language that is understandable by non-programming-oriented readers.
2. A program description that shall include, but not be limited to, the following:
 - a. Applicable Documents - List all documents (standard manufacturer's literature, other program descriptions, etc.) by section, if practical, that apply to the program. One complete copy of all applicable reference material shall be provided.
 - b. Input Output - Identify each input and output parameter, variable, and software element used by the program. State the purpose of all inputs, outputs, and variables.
 - c. Processing - This section shall contain a description of the overall structure and function of the program. Describe the program run stream and present a detailed description of how the program operates. Describe the timing and sequencing of operations of the program relative to other programs. Describe all interactions with other programs. Processing logic that is not readily described without considerable background information shall be handled as a special topic with references to an appendix or to control strategy document that details the necessary information. Reference shall also be made to an appendix or control strategy document for equation and program algorithm derivations.
 - d. System Configuration - Describe in detail the system configuration or status required for program implementation, if appropriate.
 - e. Limitations and Constraints - Summarize all known or anticipated limitations of the program, if appropriate.
 - f. Storage - Define program storage requirements in terms of disk or RAM memory allocation.
 - g. Verification - Describe, as a minimum, a test that can be used by the operator to assure proper program operation. Define the required system configuration, input requirements and criteria for successful test completion.

- h. Diagnostics - Describe all program diagnostics, where applicable. Descriptions shall list each error statement, indicate clearly what it means, and specify what appropriate actions should be taken.
- i. Malfunction Procedures - Specify procedures to follow for recovering from a malfunction due to either operator error or other sources.

1.10 FINAL SYSTEM DOCUMENTATION

- A. All documentation shall be delivered to the Owner prior to final system acceptance in accordance with the Contract Documents. As a minimum, final documentation shall contain all information originally part of the control system submittals.
- B. Provide a complete set of detailed electrical interconnection diagrams required to define the complete instrumentation and control system. All diagrams shall be 11 X 17-inch original reproducible prints. All diagrams shall be corrected to describe final "as built" hardware configurations and to reflect the system configuration and control methodology adopted to achieve final system acceptance.
- C. Provide system software documentation for the operation and maintenance of all system software programs provided as a part of the digital system. All system software documentation shall be amended as required to delineate all modifications and to accurately reflect the final as built software configurations.
- D. Provide application software documentation that contains program descriptions for the operation, modification, and maintenance of all application programs provided for the digital system.
- E. Provide control strategy documentation which shall include control strategy (block oriented or ladder logic) diagrams to describe the control of all processes. Control strategy documentation shall reflect the system configuration and control methodology adopted to achieve final system acceptance. Control strategy documentation shall conform to the submittal requirements listed hereinabove.
- F. O&M documentation shall be amended with all final, adjusted values for all setpoints and other operating parameters for Owner reference.
- G. The Owner recognizes the fact that not all possible problems related to real time events, software interlocks, and hardware maintenance and utilization can be discovered during the Acceptance Tests. Therefore, the instrumentation subcontractor through the Contractor shall investigate, diagnose, repair, update, and distribute all pertaining documentation of the deficiencies that become evident during the warranty period. All such documentation shall be submitted in writing to the Owner within 30 days of identifying and solving the problem.

1.11 PROGRAMS AND SOURCE LISTINGS

- A. Provide one copy of all standard, off-the-shelf system and application software (exclusive of firmware resident software) on original media furnished by the software manufacturer.
- B. Provide one copy of source listings on digital media, acceptable to Engineer, for all custom software/logic written specifically for this facility, all database files configured for this facility, and all control strategies. All source listings shall include a program abstract, program linkage and input/output data. Comments describing the program flow shall be frequently interspersed throughout each listing.
- C. All software/logic shall be in both its native format and in Adobe Portable Document Format.

1.12 SUBMITTAL/DOCUMENTATION FORMAT

- A. All drawing-type submittals and documentation shall be rendered and submitted in the latest version of AutoCAD.
- B. All textual-type submittals and documentation shall be rendered and submitted in the latest version of Microsoft Word or in searchable Adobe Portable Document Format (PDF). Raster scans will not be accepted.

1.13 ELECTRONIC O&M MANUALS

- A. Subject to acceptance by the Engineer, the O&M information may be submitted in part or in whole in an electronic format on digital media.
- B. Electronic O&M manuals shall contain information in standard formats (searchable Adobe PDF, Word, AutoCAD, HTML, etc.) and shall be easily accessible using standard, "off-the-shelf" software such as an Internet browser. Raster scans will not be accepted.

PART 2 – PRODUCTS (NOT USED)

PART 3 – EXECUTION (NOT USED)

END OF SECTION

SECTION 40 61 21
PROCESS CONTROL SYSTEM TESTING

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. The Contractor shall test the Control and Information System as specified herein to demonstrate compliance with the Contract Documents.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 40 61 13 – Process Control System General Provisions
- B. Section 40 61 21.72 – Field Testing
- C. Section 40 61 21.73 – Final Acceptance Test

1.03 SUBMITTALS

- A. For each of the specified tests, submit a test plan to the Engineer at least one month in advance of commencement of the tests. The test plan shall contain the following at a minimum:
 - 1. A schedule of all testing to be conducted.
 - 2. A brief description of the testing to be performed
 - 3. Test objectives.
 - 4. Testing criteria per the Specifications.
 - 5. Check lists and procedures for performing each of the specified tests.
 - 6. Sample test result documentation.
 - 7. Requirements for other parties.

1.04 GENERAL REQUIREMENTS

- A. All system startup and test activities shall follow detailed test procedures; check lists, etc., previously approved by the Engineer. The Engineer shall be notified at least 21 days in advance of any system tests and reserves the right to have their and/or the Owner's representatives in attendance.

- B. The Contractor shall provide the services of experienced factory trained technicians, tools and equipment to field calibrate, test, inspect, and adjust all equipment in accordance with manufacturer's specifications and instructions.
- C. The Contractor (or designee) shall maintain master logbooks for each phase of installation, startup and testing activities specified herein. Each logbook shall include signal, loop or control strategy tag number, equipment identification, description and space for signoff dates, Contractor signature and Engineer signature. Example test documentation specific to each phase of testing shall be approved prior to initiation of that testing, as specified hereinabove.
- D. All test data shall be recorded on test forms, previously approved by the Engineer. When each test has been successfully completed, a certified copy of all test results shall be furnished to the Engineer together with a clear and unequivocal statement that all specified test requirements have been met and that the system is operating in accordance with the Contract Documents.
- E. The Engineer will review test documentation in accordance with the Contract Documents and will give written notice of the acceptability of the tests within 10 days of receipt of the test results.
- F. All testing shall include time for unstructured testing where Owner and Engineer shall have access to the equipment for testing previously undefined normal and abnormal aspects, situations, and functions. Contractor or his/her designee shall provide assistance during this time, including but not limited to documenting the unstructured testing. Owner's and Engineer's unstructured testing scenarios may not be available prior to the testing period.
- G. If, in the Engineer's or Owner's opinion, Contractor is not ready for witness testing and Engineer is present, Contractor shall reimburse Owner for Engineer's labor to attend the test. Witness testing shall then be rescheduled, with sufficient notice. In the event that Engineer has traveled, even if only to the project-site, for the testing, Engineer's travel costs shall also be reimbursed. In the event that the Owner has traveled for the testing, Owner's travel costs shall also be reimbursed.

PART 2 – PRODUCTS (NOT USED)

PART 3 – EXECUTION (NOT USED)

END OF SECTION

SECTION 40 61 21.71
FACTORY WITNESS TEST

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. The Contractor shall perform a Factory Witness Test on the Control and Information System as specified herein to demonstrate compliance with the Contract Documents.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 40 61 13 – Process Control System General Provisions
- B. Section 40 61 21 – Process Control System Testing
- C. Section 40 61 21.72 – Field Testing
- D. Section 40 61 21.73 – Final Acceptance Test

1.03 FACTORY WITNESS TEST

- A. The Control and Information System equipment shall not be shipped until the Contractor receives notice of acceptability of the factory tests.
- B. Each item of equipment shall be fully factory inspected, calibrated and tested for function, operation and continuity of circuits. Exceptions shall be approved in writing by the Engineer.
- C. Each subsystem shall be fully factory tested for function and operation.
- D. System performance shall be tested using a fully integrated system, including all software and hardware. To achieve this, the entire control system, including all peripheral devices and all interconnecting cables (field instruments are not included in this requirement), shall be assembled on the factory test floor and the complete operational program loaded and simulated inputs applied.
- E. All hardware and software required to perform the specified testing shall be furnished by the Contractor at no additional cost to the Owner.
- F. The instrumentation subcontractor shall perform a 100hour full system test, during which the entire system shall operate continuously without failure in accordance with the requirements of the Contract Documents. If a system component fails during the test, the 100hour test period shall be restarted after its operation is restored.

- G. The factory testing shall demonstrate all aspects of system sizing and timing including:
1. Monitoring and control scan times at the PLC level.
 2. Response times at the operator workstation level.
- H. The overall system as well as individual component hardware shall be tested under conditions of power failure to ensure proper response as specified herein.
- I. Operator Workstation Operation This demonstration shall provide proof of system operation on an individual subsystem basis first, and then in the expected operating environment. Both normal and abnormal operating modes shall be demonstrated. Operator workstation testing shall include the following:
1. Demonstrate proper operation, under both normal and abnormal conditions of the operator workstation application software (SCADA, remote alarm dial-up, etc.). This shall include demonstration of system online diagnostics, failover features, reconfiguration operations, system initialization and restart, software fault tolerance, error detection and recovery, communications, and all additional features necessary to assure the successful operation of the system.
 2. Demonstrate the standard features of the system. This shall include proof of operation of the process control database generator, the display generator, data storage and retrieval functions, data acquisition and control, trending functions, and reporting functions.
 3. Demonstrate the configuration of the system to verify conformance with the Contract Documents. This shall include graphic displays and vectoring, operator interface functions, trending, reports, alarm management, security system configuration, etc.
 4. The system shall be operated with data input/output with the PLCs and associated panels to prove operation of all workstation functions.
 5. The testing in Items 2 and 3 above may be performed concurrently (i.e., the standard and configured features of the system may be demonstrated simultaneously).
- J. PLC Operation All functions comparable to those demonstrated for the operator workstations shall be demonstrated on the PLCs. This shall include the following:
1. Online and offline diagnostics.
 2. For redundant units, failover operation and reconfiguration.
 3. System initialization and restart.

4. Network communications, including fieldbus communications where required.
 5. Non-volatility of memory.
 6. Operation of all control logic shall be demonstrated as described herein.
- K. Process I/O Simulation - Process input/output simulation for PLCs shall be performed with a manual simulation control panel, a separate programmable logic controller, network-based simulation software, analog signal generators, and/or jumpering of discrete signals between outputs and associated inputs, or some combination of these. Alternate process I/O systems such as plugin circuit cards or I/O test modules may be utilized subject to approval by the Engineer to provide the specified simulation functions. The simulation system shall provide analog and discrete I/O hardware devices in sufficient quantity to allow complete and thorough testing of the control strategies and functions of the system. The process I/O simulation system shall be used in several ways as follows:
1. To provide a means of communications checkout from the operator workstations through the various levels of software in the PLCs and to the process, i.e., the simulation panel. Likewise, a discrete or analog input shall be initiated from the simulation panel and the result monitored at the workstations.
 2. Alarm response to discrete status changes or analog value limits shall be verified. Database entries or attributes such as engineering units and conversion equations shall be verified by varying analog inputs.
 3. To provide data for use at all levels of the control system at the time of system integration.
- L. Control Strategy Testing Provision shall be made to test all control strategies to prove the integrity of each strategy and the process control language in which it is implemented. For each control strategy, all functions shall be tested individually (where possible) and collectively to verify that the control strategy performs as described herein and as required for overall functionality within the control system.

PART 2 – PRODUCTS (NOT USED)

PART 3 – EXECUTION (NOT USED)

END OF SECTION

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SECTION 40 61 21.72

FIELD TESTING

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. The Contractor shall perform field testing on the Control and Information System as specified herein to demonstrate compliance with the Contract Documents.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 40 61 13 – Process Control System General Provisions
- B. Section 40 61 21 – Process Control System Testing
- C. Section 40 61 21.71 – Factory Witness Test
- D. Section 40 61 21.73 – Final Acceptance Test
- E. Section 40 70 00 – Instrumentation for Process Systems

1.03 GENERAL REQUIREMENTS

- A. Control system startup and testing shall be performed to ensure that all plant processes shall be systematically and safely placed under digital control in the following order:
 - 1. Primary elements such as transmitters and switch devices shall be calibrated and tested as specified in Section 40 70 00 – Instrumentation for Process Systems.
 - 2. Each final control element shall be individually tested as specified hereinafter.
 - 3. Each control loop shall be tested as specified hereinafter.
 - 4. Each control strategy shall be tested under automatic digital control as specified hereinafter.
 - 5. The entire control system shall be tested for overall monitoring, control, communication, and information management functions, and demonstrated for system availability as specified hereinafter.
- B. System startup and test activities shall include the use of water, if necessary, to establish service conditions that simulate, to the greatest extent possible, normal operating conditions in terms of applied process loads, operating ranges and environmental conditions.

- C. Each phase of testing shall be fully and successfully completed and all associated documentation submitted and approved prior to the next phase being started. Specific exceptions are allowed if written approval has been obtained in advance from the Engineer.

1.04 CONTRACTOR'S RESPONSIBILITIES

- A. The Contractor shall ensure that all mechanical equipment, equipment control panels, local control panels, field instrumentation, control system equipment and related equipment and/or systems are tested for proper installation, adjusted and calibrated on a loopbyloop basis prior to control system startup to verify that each is ready to function as specified. Each test shall be witnessed, dated and signed off by both the Contractor (or designee) and the Engineer upon satisfactory completion.
- B. The Contractor shall be responsible for coordination of meetings with all affected trades. A meeting shall be held each morning to review the day's test schedule with all affected trades. Similarly, a meeting shall be held each evening to review the day's test results and to review or revise the next day's test schedule as appropriate.
- C. The Contractor shall ensure that the electrical subcontractor conforms to the startup, test and signoff procedures specified herein to assure proper function and coordination of all motor control center control and interlock circuitry and the transmission of all discrete and/or analog signals between equipment furnished by the electrical subcontractor and the control system specified herein.
- D. The Contractor shall ensure that the HVAC subcontractor conforms to the startup, test and signoff procedures specified herein to assure proper function of all HVAC system control and interlock circuitry and the transmission of all discrete and/or analog signals between HVAC equipment and controls and the control system specified herein.

1.05 FINAL CONTROL ELEMENT TESTING

- A. The proper control of all final control elements shall be verified by tests conducted in accordance with the requirements specified herein.
- B. All modulating final control elements shall be tested for appropriate speed or position response by applying power and input demand signals, and observing the equipment for proper direction and level of reaction. Each final control element shall be tested at 0, 25, 50, 75, and 100 percent of signal input level and the results checked against specified accuracy tolerances. Final control elements, such as VFDs, that require turndown limits shall be initially set during this test.
- C. All non-modulating final control elements shall be tested for appropriate position response by applying and simulating control signals, and observing the equipment for proper reaction.

1.06 LOOP CHECKOUT

- A. Prior to control system startup and testing, each monitoring and control loop shall be tested on an individual basis from the primary element to the final element, including the operator workstation or loop controller level, for continuity and for proper operation and calibration.
- B. Signals from transducers, sensors, and transmitters shall be utilized to verify control responses. Simulated input data signals may be used subject to prior written approval by the Engineer. All modes of control shall be exercised and checked for proper operation.
- C. The accuracy of all DACs shall be verified by manually entering engineering unit data values at the operator workstation and then reading and recording the resulting analog output data.
- D. The accuracy of all ADCs shall be verified using field inputs or by manually applying input signals at the final controller, and then reading and recording the resulting analog input data at the operator workstation.
- E. Each loop tested shall be witnessed, dated and signed off by both the Contractor (or designee) and the Engineer upon satisfactory completion.

1.07 CONTROL SYSTEM STARTUP AND TESTING

- A. Control system startup and testing shall be performed to demonstrate complete compliance with all specified functional and operational requirements. Testing activities shall include the simulation of both normal and abnormal operating conditions.
- B. All digital hardware shall be fully inspected and tested for function, operation and continuity of circuits. All diagnostic programs shall be run to verify the proper operation of all digital equipment.
- C. Final control elements and ancillary equipment shall be tested under startup and steadystate operating conditions to verify that proper and stable control is achieved using local area control panels, motor control center circuits, and local field mounted control circuits. All hardwired control circuit interlocks and alarms shall be operational. The control to final control elements and ancillary equipment shall be tested using both manual and automatic (where provided) control circuits.
- D. Signals from transducers, sensors, and transmitters shall be utilized to verify control responses for final control elements. Simulated input data signals may be used subject to prior written approval by the Engineer.
- E. Each control strategy shall be tested to verify the proper operation of all required functions. The control system startup and test activities shall include procedures for

tuning all control loops incorporating PID control modules, and for adjusting and testing all control loops as required to verify specified performance.

- F. The control system startup and test activities shall include running tests to prove that the Instrumentation, Control and Information System is capable of continuously, safely and reliably regulating processes, as required by the Contract, under service conditions that simulate, to the greatest extent possible, normal plant operating ranges and environmental conditions.
- G. A witnessed functional acceptance test shall be performed to demonstrate satisfactory performance of individual monitoring and control loops and control strategies. At least one test shall be performed to verify that the control and instrumentation system is capable of simultaneously implementing all specified operations.
- H. Each loop and control strategy test shall be witnessed and signed off by both the Contractor (or designee) and the Engineer upon satisfactory completion.

1.08 FACILITY STARTUP COORDINATION

- A. Facility startup shall comply with requirements specified in the Contract Documents and those requirements specified herein. Facility startup shall commence after all previously described startup and test activities have been successfully completed and shall demonstrate that the Instrumentation, Control and Information System can meet all Contract requirements with equipment operating over full operating ranges under actual operating conditions.
- B. The control system startup period shall be coordinated with process startup activities and shall be extended as required until all plant processes are fully operational and to satisfy the Engineer that all control system Contract requirements have been fulfilled in accordance with the Contract Documents.
- C. The instrumentation subcontractor's personnel shall be resident at the facility to provide both full time (eight hours/day, five days/week) and 24 hours on call (seven days/week) support of operating and maintenance activities for the duration of the startup period.
- D. At least one qualified control systems technician shall be provided for control system startup and test activities and at least two when loop checkout is being performed.

PART 2 – PRODUCTS (NOT USED)

PART 3 – EXECUTION (NOT USED)

END OF SECTION

SECTION 40 61 21.73
FINAL ACCEPTANCE TEST

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. The Contractor shall perform the Final Acceptance Test on the Control and Information System as specified herein to demonstrate compliance with the Contract Documents.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 40 61 13 – Process Control System General Provisions
- B. Section 40 61 21 – Process Control System Testing
- C. Section 40 61 21.71 – Factory Witness Test
- D. Section 40 61 21.72 – Field Testing

1.03 AVAILABILITY DEMONSTRATION AND FINAL SYSTEM ACCEPTANCE

- A. Upon completion of all control system startup activities and prior to final system acceptance, the Contractor shall demonstrate that the availability of the entire control system, including operation under conditions of digital equipment failover, initiated either automatically or manually, shall be not less than 99.8 percent during a 30-day availability test period. The Owner shall be given two (2) weeks' notice of the starting date of the 30-day availability test.
- B. For purposes of determining availability figures, downtime of each system or portions of each system resulting from the causes specified hereunder will not be considered system failures.
 - 1. Downtime of any network-connected device that is automatically backedup upon failure shall not be considered a system failure provided that the downtime of the failed component does not exceed 24 hours.
 - 2. Downtime of a PLC that is not automatically backedup shall be considered a system failure if the downtime of the failed controller exceeds one (1) hour.
 - 3. Downtime of a portion of the system resulting from failure of any field sensor shall not be considered a system failure provided that the system operates as specified under this condition.

4. Downtime of the following devices shall not be considered a system failure provided the failed device is repaired within the specified time:
 - a. Hard disc (one day)
 - b. Workstations (one day)
 - c. Communication interfaces (eight hours)
 - d. Printer (three days)
 - e. Process control system networks (eight hours)
 - f. Off-line (optical, etc.) storage units (one day)
 - g. UPS unit (one day)
 5. Total shutdown of a single PLC resulting from a software fault shall be considered a system failure.
 6. An erroneous command to the process that can be specifically related to a software fault shall be considered as one (1) hour of downtime.
 7. The inoperability of any subsystem resulting from a software fault shall be considered a system failure.
 8. The failure of the same component more than one time during the 30-day test shall be considered a system failure.
- C. If the system fails the 30-day availability test, the 30-day test period shall be restarted after the failed component or software is repaired/replaced and full operation is restored. The system shall be demonstrated for the full 30-day period following the restart.
- D. The Contractor shall submit an availability demonstration report that shall state that all system availability requirements have been met.

PART 2 – PRODUCTS (NOT USED)

PART 3 – EXECUTION (NOT USED)

END OF SECTION

SECTION 40 61 22
TOOLS, SUPPLIES, AND SPARE PARTS, GENERAL

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. The Contractor shall provide tools, supplies, and spare parts as specified herein for the operation and maintenance of the Control and Information System.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 40 61 13 – Process Control System General Provisions

PART 2 – PRODUCTS

2.01 -SUPPLIES

- A. The Contractor shall provide supplies as specifically required in other Sections of Division 40.

2.02 SPARE PARTS

- A. Furnish spare parts for items of control and instrumentation equipment as recommended by the manufacturer and in accordance with the Contract Documents.
- B. Furnish all spares in moisture proof boxes designed to provide ample protection for their contents. Label all boxes to clearly identify contents and purpose.
- C. The Contractor shall replace all spare parts consumed during installation, testing, startup, the system availability demonstration, and the guarantee period.
- D. Refer to individual digital hardware and instrument sections for additional requirements specific to those devices.

PART 3 – EXECUTION (NOT USED)

END OF SECTION

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SECTION 40 61 23
SIGNAL COORDINATION REQUIREMENTS

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. The Contractor shall conform to the signal coordination requirements specified herein.
- B. The Contractor shall be responsible for coordinating signal types and transmission requirements between the various parties providing equipment under this Contract. This shall include, but not be limited to, distribution of appropriate shop drawings among the equipment suppliers, the electrical subcontractor, and the instrumentation subcontractor.
- C. Analog signals shall be signals for transmitting process variables, etc. from instruments and to and from panels, equipment PLCs and Control System PLCs.
- D. Discrete signals shall consist of contact closures or powered signals for transmitting status/alarm information and control commands between starters, panels, equipment PLCs, the Control System, etc.

1.02 ANALOG SIGNAL TRANSMISSION

- A. Signal transmission between electric or electronic instruments, controllers, and all equipment and control devices shall be individually isolated, linear 4-20 milliamperes and shall operate at 24 VDC.
- B. Signal output from all transmitters and controllers shall be current regulated and shall not be affected by changes in load resistance within the unit's rating.
- C. All cable shields shall be grounded at one end only, at the control panel, with terminals bonded to the panel ground bus.
- D. Analog signal isolation and/or conversion shall be provided where necessary to interface with instrumentation, equipment controls, panels, and appurtenances.
- E. Non-standard transmission systems such as pulse duration, pulse rate, and voltage regulated shall not be permitted except where specifically noted in the Contract Documents. Where transmitters with nonstandard outputs do occur, their outputs shall be converted to an isolated, linear, 4--20 milliamperes signal.
- F. The Contractor shall provide 24 V power supplies for analog signals and instruments where applicable and as required inside panels, controls, etc.

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- G. Where two-wire instruments transmit directly to the Control and Information System, the instrumentation subcontractor shall provide power supplies at the PLC-equipped control panels for those instruments.
- H. Where four-wire instruments with on-board loop power supplies transmit directly to the Control and Information System, the instrumentation subcontractor shall provide necessary signal isolators or shall otherwise isolate the input from the Control and Information System loop power supply. Similar provisions shall be made when a third element such as a recorder, indicator, or single loop controller with integral loop power supply is included in the loop.

1.03 DISCRETE INPUTS

- A. All discrete inputs to equipment and Control and Information System PLCs, from field devices, starters, panels, etc., shall be unpowered (dry) contacts in the field device or equipment, powered from the PLCs, unless specified otherwise.
- B. Sensing power (wetting voltage) supplied by the PLC shall be 24 VDC.

1.04 DISCRETE OUTPUTS

- A. All discrete outputs from local control panels and Control and Information System PLCs to field devices, starters, panels, etc., shall be 24 VDC powered (sourced) from PLC's.
- B. PLC powered discrete outputs shall energize 24 VDC pilot relay coils in the field devices, starters, panels, etc. which in turn open or close contacts in the associated control circuit. The 24 VDC relay coil, contacts, and associated control circuitry shall be furnished integral with the field device, starter, panel, etc. by the supplier and contractor furnishing the field device, starter, or panel.
- C. Where required or specified herein, discrete outputs from equipment and Control and Information System PLC's to field devices, starters, panels, motor operated valves, etc., shall be dry contact or relay outputs.
- D. Outputs to solenoid valves shall be 120 VAC, powered from the PLC or control panel unless specified or shown otherwise.

1.05 OTHER DISCRETE SIGNALS

- A. Discrete signals between starters, panels, etc. where no 24 VDC power supply is available may be 120 VAC, as long as such contacts are clearly identified in the starter, panel, etc. as being powered from a different power supply than other starter/panel components.
- B. Where applicable, warning signs shall be affixed inside the starter, panel, etc. stating that the panel is energized from multiple sources.

C. Output contacts in the starter, panel, etc., that are powered from other locations shall be provided with special tags and/or color-coding. Disconnecting terminal strips shall be provided for such contacts.

D. The above requirements shall apply to all starters and panels, regardless of supplier.

PART 2 – PRODUCTS (NOT USED)

PART 3 – EXECUTION (NOT USED)

END OF SECTION

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SECTION 40 61 24
QUALITY ASSURANCE

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. It is the intent of these Specifications and Drawings to secure high quality in materials, equipment and workmanship in order to facilitate operations and maintenance of the facility. The Contractor shall provide equipment and services to meet this intent.

1.02 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

- A. All Work shall be installed in accordance with the National Electric Code, National Electric Safety Code, OSHA, State/Commonwealth, local and other applicable codes.

1.03 QUALITY ASSURANCE - GENERAL

- A. All equipment and materials shall be new and the products of reputable recognized suppliers having adequate experience in the manufacture of these particular items.
- B. For uniformity, only one manufacturer and model will be accepted for each type of product. Where differing models are required, equipment from a single manufacturer shall be provided.
- C. Equipment shall be designed for the service intended and shall be of rugged construction, of ample strength for stresses that may occur during fabrication, transportation, and erection as well as during continuous or intermittent operation. They shall be adequately stayed, braced and anchored and shall be installed in a neat and workmanlike manner. Appearance and safety, as well as utility, shall be given consideration in the design of details.
- D. All components and devices installed shall be standard items of industrial grade, unless otherwise noted, which shall be of sturdy and durable construction and be suitable for long, troublefree service.
- E. Electronic components shall be de-rated to assure dependability and longterm stability.
- F. Printed circuit boards in field mounted equipment shall be suitable for the specified environmental conditions.
- G. Alignment and adjustments shall be non-critical, stable with temperature changes or aging and accomplished with premium grade potentiometers.

- H. Components of specially selected values shall not be inserted into standard electronic assemblies in order to meet the performance requirements of this specification.

1.04 OPTIONAL EQUIPMENT

- A. Optional or substituted equipment or both requiring changes in details or dimensions required to maintain structural, mechanical, electrical, control, operating, maintenance or design features incorporated in these Specifications and Drawings shall be made at no additional cost to the Owner. In the event that the changes are necessary, calculations and drawings showing the proposed revisions shall be submitted for approval. The Contractor shall coordinate changes with other affected trades and contracts and pay additional charges incurred.

1.05 GUARANTEE

- A. The instrumentation subcontractor through the Contractor shall install, maintain and guarantee the Instrumentation, Control and Information System as specified under the General Conditions and Division 01 of the Specifications. Maintenance personnel provided by the instrumentation subcontractor shall instruct the Owner's personnel in the operation, adjustment, calibration and repair of the equipment being serviced. Preventive and corrective activities shall be documented with service reports, which shall identify the equipment being serviced, state the condition of the equipment, describe Work performed and list materials used. A copy of service reports shall be delivered to the Owner on the day the Work is performed.
- B. The instrumentation subcontractor shall provide the services of factorytrained service technician(s) at least twice during the guarantee period, for the purpose of performing preventive hardware maintenance.
- C. Corrective hardware and software maintenance during the guarantee period shall be performed in accordance with the requirements of Division 01 and, in addition, shall meet the following requirements:
 - 1. Corrective hardware maintenance shall be performed by factorytrained service technician(s) specifically trained to service the digital equipment provided. Technicians possessing suitable training and experience shall be provided to perform corrective maintenance on other equipment. The hardware service technician(s) shall be available onsite within 24 working hours after notification by the Owner.
 - 2. Corrective software maintenance shall be performed for software provided by the instrumentation subcontractor and incorporated into the system prior to the completion of system commissioning. Software service programmer(s) shall be available for consultation within four business hours and, if required, onsite within 16 business hours after notification by the Owner. Corrective software

maintenance shall include the supply, installation and startup of application software upgrades released during the guarantee period.

3. Corrective hardware and software maintenance performed during the guarantee period shall be performed at no cost to the Owner.
 4. As used herein, the term "working hours" shall be defined as those of the treatment facility (seven days per week, 24 hours per day). The term "business hours" shall be defined as the hours between 8:00 a.m. and 5:00 p.m., local time, Monday through Friday; excluding holidays.
 5. The guarantee period shall commence upon final acceptance of the completed treatment facility in accordance with the provisions of the Contract Documents.
- D. The instrumentation subcontractor shall submit to the Owner a proposed maintenance agreement incorporating the following features:
1. Extension of preventive hardware maintenance services as described above for a period of up to five years from the expiration of the warranty period.
 2. Provisions for corrective hardware or software maintenance Work on a willcall basis for a period of up to five years from the expiration of the warranty period. Corrective maintenance Work shall be performed by properly trained personnel as described above.
- E. The proposed agreement shall include provisions for payment based upon an annual fee for preventive maintenance and cost plus expenses for corrective maintenance Work. The portion dealing with corrective maintenance shall be written to include corrective maintenance caused by actions of the Owner during the warranty period and shall contain clauses for re-negotiation of contract prices based upon changes in recognized economic indicators published by the United States Department of Commerce.

1.06 SHIPPING HANDLING AND STORAGE

- A. In addition to shipping, handling and storage requirements specified elsewhere in the Contract Documents, air conditioning/heating shall be provided for storage of field instrumentation, panels, digital equipment and ancillary devices to maintain temperatures between 20 and 25 degrees C and relative humidity 40 to 60 percent without condensation. The air shall be filtered and free of corrosive contaminants and moisture.

1.07 FABRICATION

- A. Fabrication of equipment shall conform to the codes and standards outlined in this Section, and other portions of the Contract Documents.

- B. The Engineer may inspect the fabricated equipment at the factory before shipment to job site. The Contractor shall provide the Engineer with sufficient prior notice so that an inspection can be arranged at the factory. Inspection of the equipment at the factory by the Engineer will be made after the manufacturer has performed satisfactory checks, adjustments, tests and operations.
- C. Equipment approval at the factory only allows the equipment to be shipped to the project site. The Contractor shall provide for the proper storage, installation and satisfactory startup and operation of the equipment to the satisfaction of the equipment manufacturer, the instrumentation subcontractor, and the Engineer.

PART 2 – PRODUCTS (NOT USED)

PART 3 – EXECUTION

3.01 INSTALLATION

- A. Instrumentation and control system installation Work, whether new construction or modifications to existing equipment/panels/structures, shall conform to the codes and standards outlined in this Section, and other portions of the Contract Documents.
- B. The instrumentation subcontractor shall assign a competent representative who shall provide full time coordination and supervision of onsite instrumentation and control system construction Work from commencement of construction through completion and final acceptance.
- C. Labor shall be performed by qualified craftsmen in accordance with the standards of workmanship in their profession and shall have had a minimum of three years of documented experience on similar projects.
- D. Equipment and materials shall fit properly in their installations. Work required to correct improperly fit installations shall be performed at no additional expense to the Owner.
- E. Work shall be performed in a neat and workmanlike manner. Hardware and instrumentation shall be installed in accordance with requirements specified herein, in accordance with industry best practices, in accordance with manufacturers' recommendations, and in a manner suitable for ease of operation, inspection, and maintenance. Wiring shall be neatly bundled, run in wireway, and terminated. Spare wiring shall be neatly coiled and clearly labeled at both ends for future use by the Owner. Work not meeting these requirements shall be corrected at no expense to the Owner.
- F. Sufficient commonmode and differentialmode noise rejection shall be provided to ensure proper operation of the plant process control system. General practices shall include:

1. Maintaining crossings between noisy wires and signal wires at right angles.
 2. Maintaining separation between noisy wires and signal wires as wide as practical.
 3. Grounding all signals, shields and power supplies at the process control unit or local control panel.
 4. Providing passive filters on signals with time constant compatible with scan intervals and overvoltage protection.
 5. Eliminating cable splices. Splices in instrumentation and control system signal, network, and instrument manufacturer furnished cables shall be approved in advance by the Engineer.
 6. Providing a floating output for transmitters that have their own power sources.
- G. DC and AC power grounding shall be performed in accordance with the digital hardware manufacturer's recommendations as well as all applicable code requirements.
- H. The case of each field instrument and control panel shall be grounded in compliance with the National Electric Code.
- I. Power wires shall be separated from parallelrunning signal wires by the following minimum spacing:
1. 120 VAC: 12 in
 2. 240 VAC: 18 in
 3. 480 VAC: 18 in
 4. 2000 VAC and above: 24 in
- J. The Contractor shall provide all required cutting, drilling, inserts, supports, bolts, and anchors, and shall securely attach all equipment and materials to their supports. Embedded supports for equipment furnished under this Division shall be provided and installed as shown specified herein and shown on the Drawings.
- K. Following acceptance of the factory tests by the Engineer, and in accordance with the construction schedule, the Contractor shall commence installation of the digital control system hardware. Digital system equipment items shall not be installed, however, until all architectural, mechanical, HVAC and electrical Work has been completed in the equipment rooms, MCCs, control rooms and all structural and mechanical Work has been completed within 50 feet of equipment locations.

- L. Upon completion of the above construction Work, the Contractor shall request an inspection of the abovenamed areas. The Engineer will issue a written approval to proceed with delivery and installation only after being satisfied that all Work described above has been properly performed. Digital equipment shall remain at the factory site or storage prior to approval for delivery to the project site. Partial shipments may be required to meet construction schedule requirements.

END OF SECTION

SECTION 40 61 26
PROCESS CONTROL SYSTEM TRAINING

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. To familiarize the Owner's personnel with the process control system and field instrumentation, training shall be provided as detailed hereunder.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 40 61 13 – Process Control System General Provisions

1.03 SUBMITTALS

- A. A minimum of 60 days prior to beginning training, submit a detailed training plan describing the following:
 - 1. A listing of all courses to be conducted.
 - 2. Course content.
 - 3. Applicability of each course to management, operations, maintenance, laboratory, etc., personnel.
 - 4. Course schedules.
 - 5. Qualifications and experience of individual(s) providing training.
- B. A minimum of 14 days prior to beginning each training course, submit documentation for use by the Owner's personnel during training. The training documentation shall be specific to the particular course, and shall include the following:
 - 1. A listing of all subjects to be covered.
 - 2. Course schedule.
 - 3. Documentation/lesson plans covering all subjects to be covered during the course instruction. Information shall be in a "how to" format, with sufficient background documentation and references to manufacturer literature to provide a thorough and clear understanding of the materials to be covered.

1.04 GENERAL REQUIREMENTS

- A. All costs of providing the training courses shall be borne by the Contractor.
- B. As used herein, the term "day" shall mean an eight-hour day, and the term "week" shall mean a fiveday, 40hour week.
- C. Training courses, especially those for operator training, may be required to be scheduled during non-standard business hours (i.e., not between the hours of 8:00 am and 5:00 pm) to accommodate the working schedule of the Owner's personnel. No additional compensation will be awarded to the Contractor for training at non-standard hours.
- D. All training courses shall complement the experience and skill levels of the Owner's personnel.
- E. Training courses shall be structured in order of increasing capability or security levels. The purpose of this requirement is to allow personnel with lesser training requirements or security password levels to drop out of the training at certain times while the training continues for personnel with greater requirements or higher security levels.
- F. All training courses shall include lecture as well as "hands on" experience for each of the attending personnel. The Contractor shall provide sufficient equipment for this to be accomplished. For example, training in which the instructor uses the computer and the Owner's personnel passively observe as the instructor demonstrates system functions shall not be acceptable.
- G. Unless otherwise specified, all training courses shall be conducted in the Owner's facilities.
- H. All training shall be completed prior to system acceptance.
- I. Standard manufacturer training courses are acceptable pending approval by the Engineer and Owner.

1.05 OPERATOR TRAINING

- A. Two one day courses comprised of daily half-day (four-hour) sessions for up to ten persons each shall be conducted to provide instruction in the use of the Control and Information System to monitor and control the facility.
- B. Operator training shall include familiarization training covering the Control and Information System. Operators shall be instructed in the names, locations, functions, and basic operation of all items of digital equipment and associated software.
- C. Operator training shall cover process and equipment operation both individually and collectively as an operating system. Normal as well as abnormal operating conditions

shall be covered, including the response to failure occurrences and system alarms. All operator/system interactions shall be described.

- D. Operators shall be trained to instruct other operators and shall be provided with all course materials.

1.06 MAINTENANCE TRAINING

- A. Two one-day courses shall be conducted for at least ten persons prior to the startup of digital equipment at the Owner's plant. Instruction shall be provided in the following:
 - 1. Operating all digital equipment, including system startup and shutdown procedures.
 - 2. The use of hardware diagnostic routines, test equipment and test procedures as required to enable the Owner's personnel to detect and isolate system faults to the circuit board or module level and to implement repairs by replacing failed circuit boards or modules.
 - 3. Calibration and routine maintenance procedures for all analog and digital equipment.
- B. Step by step written procedures shall be provided for all preventive maintenance tasks and for identifying hardware faults to the circuit board or module level for all items of digital equipment.
- C. All digital equipment preventive and corrective maintenance training activities shall be limited to the use of commercially available offtheshelf test equipment and to the use of diagnostic routines and hardware items which are the same as those to be provided as part of the system.

1.07 INSTRUMENT TRAINING

- A. A one-day course shall be provided at the Owner's facilities no more than three months prior to system start-up to instruct a minimum of five persons each in the calibration and preventive maintenance of the field instruments provided under this Contract.

1.08 PLC TRAINING

- A. One minimum three-day manufacturer standard training course for up to four persons shall be provided in the programming and use of PLC's to implement monitoring and control functions such as those provided for this project. Training shall cover all aspects of the PLC hardware and software, including specified programming software. This training shall be provided by the PLC manufacturer or, as directed by the manufacturer, by the authorized distributor engaged by the manufacturer to perform this training.

- B. One three-day course of specific training shall be provided for up to four persons by the instrumentation subcontractor in the use and modification of all control strategies provided under this Division.

PART 2 – PRODUCTS (NOT USED)

PART 3 – EXECUTION (NOT USED)

END OF SECTION

SECTION 40 61 90
SCHEDULES AND CONTROL DESCRIPTIONS, GENERAL

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. The Contractor shall furnish, test, install and place in satisfactory operation all hardware and software required to provide the Control and Information System as specified herein and as shown on the Drawings.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 40 61 91 – Process Control System Instrument List
- B. Section 40 61 93 – Process Control System Input/Output List
- C. Section 40 61 96 – Process Control Descriptions

PART 2 – CONVENTIONS

2.01 PLANT NUMBERING SYSTEM

- A. The plant equipment numbering system is based on a 5-digit code preceded by an equipment identification prefix and followed by a parallel designation suffix. The numbering system is broken down as follows:

XXXX¹ – X² X³ XXX⁴ XXXX⁵

Where XXXX ¹ =	Where X ² =	Where X ³ =	Where XXX ⁴ =	Where XXXX ⁵ =
Equipment Prefix (1)	Major Process of Area (2)	Sub-Process (3)	Individual Equipment Item Number (4)	Parallel Designation Suffix (5)

1. Prefix letters are added as required to label a piece of equipment or describe instrumentation/control signal types. Instrumentation prefixes shall use the convention shown in the following table.

Instrument Prefix Letters

First Letter			Succeeding Letters		
Letter	Measured or Initiating Variable	Modifier	Readout or Passive Function	Output Function	Modifier
A	Analysis		Alarm or plc/dcs discrete alarm input		
B	Burner, combustion		User's choice	User's choice	User's choice
C	Conductivity (electrical)			Control or plc/dcs analog output	
D	Density (mass) or specific gravity	Differential			
E	Voltage (emf)		Primary element		
F	Flow	Ratio (fraction)			
G	User's choice		Glass or viewing device		
H	Hand (manually initiated)				High
I	Current (electrical)		Indicate or plc/dcs analog input		
J	Power	Scan			
K	Time or time schedule	Time rate of change		Control station	
L	Level		Light (pilot)		Low
M	Moisture or humidity	Momentary			Middle or intermediate
N	User's choice		Notify or plc/dcs discrete status input	User's choice	User's choice
O	User's choice		Orifice (restriction)		
P	Pressure or vacuum		Point (test connection)		
Q	Quantity	Integrate or totalize	Integrate or totalize		
R	Radiation		Record or print		
S	Speed or frequency	Safety		Switch	
T	Temperature			Transmit	
U	Multivariable		Multifunction	Multifunction	Multifunction
V	Vibration or mechanical analysis			Valve, damper or louver	
W	Weight or force		Well		
X	Unclassified	X axis	Unclassified	Unclassified or plc/dcs discrete output	Unclassified
Y	Event, state or presence	Y axis		Relay, compute, or convert	

Instrument Prefix Letters

First Letter			Succeeding Letters		
Letter	Measured or Initiating Variable	Modifier	Readout or Passive Function	Output Function	Modifier
Z	Position, dimension	Z axis		Drive, actuator or unclassified final control element	

2. Major process areas and associated sub-processes shall use the following numbering convention:

First Digit	Second Digit	Description
1	Raw Water	
	0	1 – Raw Water Pump No. 1
	0	2 – Raw Water Pump No. 2
	0	3 – Raw Water Pump No. 3
	0	4 – Raw Water Pump No. 4
	0	5 – Raw Water Pump No. 5
	1	1 – Raw Water Flow No. 1
	1	2 – Raw Water Flow No. 2
	2	1 – Rapid Mix No. 1
	2	2 – Rapid Mix No. 2
	2	3 – Rapid Mix No. 3
	2	4 – Rapid Mix No. 4
	3	
	4	
	5	
	6	
	7	
	8	
	9	

First Digit	Second Digit	Description
2	Preliminary Treatment	
	0	1 – Flocculator No. 1
	0	2 – Flocculator No. 2
	0	3 – Flocculator No. 3
	0	4 – Flocculator No. 4

0	5 – Flocculator No. 5
0	6 – Flocculator No. 6
0	7 – Flocculator No. 7
0	8 – Flocculator No. 8
0	9 – Flocculator No. 9
1	0 – Flocculator No. 10
1	1 – Flocculator No. 11
1	2 – Flocculator No. 12
1	3 – Flocculator No. 13
1	4 – Flocculator No. 14
1	5 – Flocculator No. 15
1	6 – Flocculator No. 16
1	7 – Flocculator No. 17
1	8 – Flocculator No. 18
1	9 – Flocculator No. 19
2	0 – Flocculator No. 20 (ALT BID)
2	1 – Flocculator No. 21
2	2 – Flocculator No. 22
2	3 – Flocculator No. 23
2	4 – Flocculator No. 24
3	
4	
5	
6	
7	
8	
9	

First Digit	Second Digit	Description
3	Filtration	
	0	1 – Filter No. 1
	0	2 – Filter No. 2
	0	3 – Filter No. 3
	0	4 – Filter No. 4
	0	5 – Filter No. 5
	0	6 – Filter No. 6
	0	7 – Filter No. 7
	0	8 – Filter No. 8

0	9 – Filter No. 9
1	0 – Filter No. 10
1	1 – Filter No. 11
1	2 – Filter No. 12
1	3 – Filter No. 13
1	4 – Filter No. 14
1	5 – Filter No. 15
1	6 – Filter No. 16
1	7 – Filter No. 17
1	8 – Filter No. 18
1	9 – Filter No. 19
2	0 – Filter No. 20
2	1 – Filter No. 21
2	2 – Filter No. 22
2	3 – Filter No. 23
2	4 – Filter No. 24
3	1 – GAC No. 1
3	2 – GAC No. 2
3	3 – GAC No. 3
3	4 – GAC No. 4
3	5 – GAC No. 5
3	6 – GAC No. 6
3	7 – GAC No. 7
3	8 – GAC No. 8
3	9 – GAC No. 9
4	0 – GAC No. 10
4	1 – GAC No. 11
4	2 – GAC No. 12
5	1 – GAC Feed Pump No. 1
5	2 – GAC Feed Pump No. 2
5	3 – GAC Feed Pump No. 3
5	4 – GAC Feed Pump No. 4
5	5 – GAC Feed Pump No. 5
6	1 – GAC Backwash Pump No. 1
6	2 – GAC Backwash Pump No. 2
6	3 – GAC Backwash Pump No. 3
7	
8	1 - Filtered Water Mixer
9	1 - Influent Channel

First Digit	Second Digit	Description
4	Finished Water	
	1	1 – Finished Water Pump No. 1
	1	2 – Finished Water Pump No. 2
	1	3 – Finished Water Pump No. 3
	1	4 – Finished Water Pump No. 4
	1	5 – Finished Water Pump No. 5
	1	6 – Finished Water Pump No. 6
	1	7 – Finished Water Pump No. 7
	1	8 – Finished Water Pump No. 8
	2	1 – Backwash Pump No. 1
	2	2 – Backwash Pump No. 2
	3	1 - Finished Water Mixer
	4	1 - 4 MGD Clearwell
	5	1 - 12 MGD Clearwell
	6	1 - Finished Water Meter Vault
	7	
	8	
	9	
	0	1 - Miscellaneous

First Digit	Second Digit	Description
5	Chemical Feed Systems	
	1	Carbon Slurry
	2	Orthophosphate
	3	Fluoride
	4	Caustic
	5	Ferric
	6	Aqua Ammonia
	7	Sodium Hypochlorite
	8	
	9	
	0	Miscellaneous

First Digit	Second Digit	Description
6	Solids Handling	
	1	Gravity Thickener No. 1
	2	Gravity Thickener No. 2

3	Gravity Thickener No. 3
4	EQ Basin
5	Residuals Meter Vault
6	Thickened Residual Pumps
7	Dewatering Equipment Feed Pumps
8	Dewatering Equipment
9	Dewatering Polymer Make-Up Units
0	Miscellaneous

First Digit	Second Digit	Description
7	Elevated Tanks	
	1	
	2	
	3	
	4	
	5	
	6	
	7	
	8	
	9	
	0	Miscellaneous

First Digit	Second Digit	Description
8	Remote Pump Stations	
	1	
	2	
	3	
	4	
	5	
	6	
	7	
	8	
	9	
	0	Miscellaneous

First Digit	Second Digit	Description
9	Miscellaneous	
	1	Administration
	2	Generator
	3	1 - Drain Pump Station
	4	
	5	
	6	
	7	
	8	
	9	

3. Individual equipment item numbers are assigned per equipment type and shall use the following numbering convention:
 - a. 00-09 – Mechanical Equipment
 - b. 10-19 – Gates
 - c. 20-39 – Valves
 - d. 40-59 – Instrumentation
 - e. 60-79 – Electrical
 - f. 80-89 – HVAC
 - g. 90-99 – Miscellaneous
4. The parallel designation suffix shall be used to differentiate items of similar function and service that would otherwise have the same number. The suffix shall use the following conventions depending on application:
 - a. {none}
 - b. A, B, C,...
 - c. A1, A2, A3,...B1, B2, B3,...C1, C2, C3,...

PART 3 – EXECUTION (NOT USED)

END OF SECTION

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SECTION 40 61 91
PROCESS CONTROL SYSTEM INSTRUMENT LIST

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. The Contractor shall furnish, test, install and place in satisfactory operation all instrumentation as herein specified and as shown on the Drawings.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 40 61 90 – Schedules and Control Descriptions, General
- B. Section 40 61 93 – Process Control System Input/Output List
- C. Section 40 61 96 – Process Control Descriptions

PART 2 – PRODUCTS

2.01 NAMEPLATES

- A. Items of equipment listed in the instrument schedule, control panels, and digital hardware items shall be identified with nameplates. Each nameplate shall be located so that it is readable from the normal observation position and is clearly associated with the device or devices it identifies. Nameplates shall be positioned so that removal of the device for maintenance and repair shall not disturb the nameplate. Nameplates shall include, as necessary, the equipment identification number, description, calibrated range, and set point(s). Abbreviations of the description shall be subject to the Engineer's approval.
- B. Nameplates shall be made of 1/16-inch thick machine engraved laminated phenolic plastic having white numbers and letters not less than 3/16-inch high on a black background. Nameplates attached to instruments may be black laser etched 1/8-inch high text on stainless steel with sharp edges made smooth. Stamped text shall not be acceptable.
- C. Nameplates shall be attached to metal equipment by NEMA rated stainless steel screws and to other surfaces by an epoxy-based adhesive that is resistant to oil and moisture. In cases where the label cannot be attached by the above methods, it shall be drilled and attached to the associated device by means of a braided stainless steel wire affixed with a permanent crimp.
- D. Submit sample nameplate of each type.

PART 3 – INSTRUMENT SCHEDULE

P.O. HOFFER WTF INSTRUMENT LIST

Pressure and Differential Pressure Gauges – Section 40 73 13

Tag Number	Service Description	State/Span	Remarks
PI-35141	GAC FEED PUMP NO. 1 DISCHARGE PRESSURE		
PI-35241	GAC FEED PUMP NO. 2 DISCHARGE PRESSURE		
PI-35341	GAC FEED PUMP NO. 3 DISCHARGE PRESSURE		
PI-35441	GAC FEED PUMP NO. 4 DISCHARGE PRESSURE		
PI-36141	GAC BACKWASH PUMP NO. 1 DISCHARGE PRESSURE		
PI-36241	GAC BACKWASH PUMP NO. 2 DISCHARGE PRESSURE		
PI-36341	GAC BACKWASH PUMP NO. 3 DISCHARGE PRESSURE		
PI-93141	DRAIN PUMP STATION WET WELL PUMP NO. 1 DISCHARGE PRESSURE		
PI-93142	DRAIN PUMP STATION WET WELL PUMP NO. 2 DISCHARGE PRESSURE		

Pressure and Differential Pressure Switches – Section 40 73 36

Tag Number	Service Description	State/Span	Remarks
PSH-35141	GAC FEED PUMP NO. 1 DISCHARGE PRESSURE HIGH		
PSH-35241	GAC FEED PUMP NO. 2 DISCHARGE PRESSURE HIGH		
PSH-35341	GAC FEED PUMP NO. 3 DISCHARGE PRESSURE HIGH		
PSH-35441	GAC FEED PUMP NO. 4 DISCHARGE PRESSURE HIGH		
PSH-35541	GAC FEED PUMP NO. 5 DISCHARGE PRESSURE HIGH		FUTURE
PSH-36141	GAC BACKWASH PUMP NO. 1 DISCHARGE PRESSURE HIGH		
PSH-36241	GAC BACKWASH PUMP NO. 2 DISCHARGE PRESSURE HIGH		
PSH-36341	GAC BACKWASH PUMP NO. 3 DISCHARGE PRESSURE HIGH		

Inline Magnetic Flow Meters – Section 40 71 13.13

Tag Number	Service Description	Size	Remarks
FE/FIT-35142	GAC INFLUENT FLOW RATE	36"	
FE/FIT-36142	GAC BACKWASH FLOW RATE	24"	
FE/FIT-33141	GAC NO. 1 EFFLUENT FLOW RATE	10"	
FE/FIT-33241	GAC NO. 2 EFFLUENT FLOW RATE	10"	
FE/FIT-33341	GAC NO. 3 EFFLUENT FLOW RATE	10"	
FE/FIT-33441	GAC NO. 4 EFFLUENT FLOW RATE	10"	
FE/FIT-33541	GAC NO. 5 EFFLUENT FLOW RATE	10"	
FE/FIT-33641	GAC NO. 6 EFFLUENT FLOW RATE	10"	
FE/FIT-33741	GAC NO. 7 EFFLUENT FLOW RATE	10"	
FE/FIT-33841	GAC NO. 8 EFFLUENT FLOW RATE	10"	
FE/FIT-33941	GAC NO. 9 EFFLUENT FLOW RATE	10"	
FE/FIT-34041	GAC NO. 10 EFFLUENT FLOW RATE	10"	
FE/FIT-34141	GAC NO. 11 EFFLUENT FLOW RATE	10"	
FE/FIT-34241	GAC NO. 12 EFFLUENT FLOW RATE	10"	

Radar Level Meters – Section 40 72 23

Tag Number	Service Description	State/Span	Remarks
LE/LIT-33145	GAC COMMON CHANNEL LEVEL		Remote mount transmitter
LE/LIT-33147	GAC COMMON CHANNEL LEVEL		Remote mount transmitter
LE/LIT-33143	GAC NO. 1 LEVEL		Remote mount transmitter
LE/LIT-33243	GAC NO. 2 LEVEL		Remote mount transmitter
LE/LIT-33343	GAC NO. 3 LEVEL		Remote mount transmitter
LE/LIT-33443	GAC NO. 4 LEVEL		Remote mount transmitter
LE/LIT-33543	GAC NO. 5 LEVEL		Remote mount transmitter
LE/LIT-33643	GAC NO. 6 LEVEL		Remote mount transmitter
LE/LIT-33743	GAC NO. 7 LEVEL		Remote mount transmitter
LE/LIT-33843	GAC NO. 8 LEVEL		Remote mount transmitter
LE/LIT-33943	GAC NO. 9 LEVEL		Remote mount transmitter
LE/LIT-34043	GAC NO. 10 LEVEL		Remote mount transmitter
LE/LIT-34143	GAC NO. 11 LEVEL		Remote mount transmitter

LE/LIT-34243	GAC NO. 12 LEVEL		Remote mount transmitter
LE/LIT-93143	DRAIN PUMP STATION WET WELL LEVEL		Remote mount transmitter
LE/LIT-35147	FILTERED WATER FLUME LEVEL		Remote mount transmitter
LE/LIT-35148	FILTERED WATER FLUME LEVEL		Remote mount transmitter

Level Switches (Floats) – Section 40 72 76.26

Tag Number	Service Description	State/Span	Remarks
LSL-93144	DRAIN PUMP STATION WET WELL LEVEL	LOW	SUPPLIED BY OTHERS
LSH-93144A	DRAIN PUMP STATION WET WELL LEVEL	HIGH	SUPPLIED BY OTHERS
LSH-93144B	DRAIN PUMP STATION WET WELL LEVEL	HIGH	SUPPLIED BY OTHERS
LSHH-9314	DRAIN PUMP STATION WET WELL LEVEL	HIGH-HIGH	SUPPLIED BY OTHERS

Pressure Transmitters – Section 40 73 20

Tag Number	Service Description	State/Span	Remarks
PDIT-33142	GAC NO. 1 LOSS OF HEAD		
PDIT-33242	GAC NO. 2 LOSS OF HEAD		
PDIT-33342	GAC NO. 3 LOSS OF HEAD		
PDIT-33442	GAC NO. 4 LOSS OF HEAD		
PDIT-33542	GAC NO. 5 LOSS OF HEAD		
PDIT-33642	GAC NO. 6 LOSS OF HEAD		
PDIT-33742	GAC NO. 7 LOSS OF HEAD		
PDIT-33842	GAC NO. 8 LOSS OF HEAD		
PDIT-33942	GAC NO. 9 LOSS OF HEAD		
PDIT-34042	GAC NO. 10 LOSS OF HEAD		
PDIT-34142	GAC NO. 11 LOSS OF HEAD		
PDIT-34242	GAC NO. 12 LOSS OF HEAD		

pH-ORP Analyzers – Section 40 75 13

Tag Number	Service Description	State/Span	Remarks
AE/AIT-35143	FILTERED WATER FLUME pH		

AE/AIT-33148	EFFLUENT FLUME pH		

Chlorine Analyzers – Section 40 75 21

Tag Number	Service Description	State/Span	Remarks
AE-35146	FILTERED WATER FLUME CHLORINE		AIT-35143

Turbidity Analyzers – Section 40 75 53

Tag Number	Service Description	State/Span	Remarks
AE/AIT-35145	FILTERED WATER FLUME TURBIDITY		
AE/AIT-33150	EFFLUENT FLUME TURBIDITY		

GLENVILLE LAKE WTF INSTRUMENT LIST

Pressure and Differential Pressure Gauges – Section 40 73 13

Tag Number	Service Description	State/Span	Remarks
PI-35141	GAC FEED PUMP NO. 1 DISCHARGE PRESSURE		
PI-35241	GAC FEED PUMP NO. 2 DISCHARGE PRESSURE		
PI-35341	GAC FEED PUMP NO. 3 DISCHARGE PRESSURE		
PI-36141	GAC BACKWASH PUMP NO. 1 DISCHARGE PRESSURE		
PI-36241	GAC BACKWASH PUMP NO. 2 DISCHARGE PRESSURE		

Pressure and Differential Pressure Switches – Section 40 73 36

Tag Number	Service Description	State/Span	Remarks
PSH-35141	GAC FEED PUMP NO. 1 DISCHARGE PRESSURE HIGH		
PSH-35241	GAC FEED PUMP NO. 2 DISCHARGE PRESSURE HIGH		
PSH-35341	GAC FEED PUMP NO. 3 DISCHARGE PRESSURE HIGH		
PSH-36141	GAC BACKWASH PUMP NO. 1 DISCHARGE PRESSURE HIGH		

PSH-36241	GAC BACKWASH PUMP NO. 2 DISCHARGE PRESSURE HIGH		

Inline Magnetic Flow Meters – Section 40 71 13.13

Tag Number	Service Description	Size	Remarks
FE/FIT-35142	GAC INFLUENT FLOW RATE	36"	
FE/FIT-33145	GAC BACKWASH FLOW RATE	16"	
FE/FIT-33141	GAC NO. 1 FLOW RATE	10"	
FE/FIT-33241	GAC NO. 2 FLOW RATE	10"	
FE/FIT-33341	GAC NO. 3 FLOW RATE	10"	
FE/FIT-33441	GAC NO. 4 FLOW RATE	10"	
FE/FIT-33541	GAC NO. 5 FLOW RATE	10"	
FE/FIT-33641	GAC NO. 6 FLOW RATE	10"	
FE/FIT-33741	GAC NO. 7 FLOW RATE	10"	
FE/FIT-33841	GAC NO. 8 FLOW RATE	10"	
FE/FIT-33941	GAC NO. 9 FLOW RATE	10"	
FE/FIT-34041	GAC NO. 10 FLOW RATE	10"	

Radar Level Meters – Section 40 72 23

Tag Number	Service Description	State/Span	Remarks
LE/LIT-33150	GAC COMMON CHANNEL LEVEL		
LE/LIT-33151	GAC COMMON CHANNEL LEVEL		
LE/LIT-33143A	GAC CONTACTOR NO. 1A LEVEL		
LE/LIT-33143B	GAC CONTACTOR NO. 1B LEVEL		
LE/LIT-33243A	GAC CONTACTOR NO. 2A LEVEL		
LE/LIT-33243B	GAC CONTACTOR NO. 2B LEVEL		
LE/LIT-33343A	GAC CONTACTOR NO. 3A LEVEL		
LE/LIT-33343B	GAC CONTACTOR NO. 3B LEVEL		
LE/LIT-33443A	GAC CONTACTOR NO. 4A LEVEL		
LE/LIT-33443B	GAC CONTACTOR NO. 4B LEVEL		

LE/LIT-33543A	GAC CONTACTOR NO. 5A LEVEL		
LE/LIT-33543B	GAC CONTACTOR NO. 5B LEVEL		
LE/LIT-33643A	GAC CONTACTOR NO. 6A LEVEL		
LE/LIT-33643B	GAC CONTACTOR NO. 6B LEVEL		
LE/LIT-33743A	GAC CONTACTOR NO. 7A LEVEL		
LE/LIT-33743B	GAC CONTACTOR NO. 7B LEVEL		
LE/LIT-33843A	GAC CONTACTOR NO. 8A LEVEL		
LE/LIT-33843B	GAC CONTACTOR NO. 8B LEVEL		
LE/LIT-33943A	GAC CONTACTOR NO. 9A LEVEL		
LE/LIT-33943B	GAC CONTACTOR NO. 9B LEVEL		
LE/LIT-34043A	GAC CONTACTOR NO. 10A LEVEL		
LE/LIT-34043B	GAC CONTACTOR NO. 10B LEVEL		
LE/LIT-35147	FILTERED WATER FLUME LEVEL		
LE/LIT-35148	FILTERED WATER FLUME LEVEL		

Level Switches (Floats) – Section 40 72 76.26

Tag Number	Service Description	State/Span	Remarks
LSH-33152	CHEMICAL VAULT LEVEL	HIGH	

Pressure Transmitters – Section 40 73 20

Tag Number	Service Description	State/Span	Remarks
PDIT-33142A	GAC CONTACTOR NO. 1A LOSS OF HEAD		
PDIT-33142B	GAC CONTACTOR NO. 1B LOSS OF HEAD		
PDIT-33242A	GAC CONTACTOR NO. 2A LOSS OF HEAD		
PDIT-33242B	GAC CONTACTOR NO. 2B LOSS OF HEAD		
PDIT-33342A	GAC CONTACTOR NO. 3A LOSS OF HEAD		
PDIT-33342B	GAC CONTACTOR NO. 3B LOSS OF HEAD		
PDIT-33442A	GAC CONTACTOR NO. 4A LOSS OF HEAD		

PDIT-33442B	GAC CONTACTOR NO. 4B LOSS OF HEAD		
PDIT-33542A	GAC CONTACTOR NO. 5A LOSS OF HEAD		
PDIT-33542B	GAC CONTACTOR NO. 5B LOSS OF HEAD		
PDIT-33642A	GAC CONTACTOR NO. 6A LOSS OF HEAD		
PDIT-33642B	GAC CONTACTOR NO. 6B LOSS OF HEAD		
PDIT-33742A	GAC CONTACTOR NO. 7A LOSS OF HEAD		
PDIT-33742B	GAC CONTACTOR NO. 7B LOSS OF HEAD		
PDIT-33842A	GAC CONTACTOR NO. 8A LOSS OF HEAD		
PDIT-33842B	GAC CONTACTOR NO. 8B LOSS OF HEAD		
PDIT-33942A	GAC CONTACTOR NO. 9A LOSS OF HEAD		
PDIT-33942B	GAC CONTACTOR NO. 9B LOSS OF HEAD		
PDIT-34042A	GAC CONTACTOR NO. 10A LOSS OF HEAD		
PDIT-34042B	GAC CONTACTOR NO. 10B LOSS OF HEAD		

pH-ORP Analyzers – Section 40 75 13

Tag Number	Service Description	State/Span	Remarks
AE/AIT-35143	FILTERED WATER FLUME pH		
AE/AIT-33146	EFFLUENT FLUME pH		

Chlorine Analyzers – Section 40 75 21

Tag Number	Service Description	State/Span	Remarks
AE-35146	FILTERED WATER FLUME CHLORINE		AIT-35143

Turbidity Analyzers – Section 40 75 53

Tag Number	Service Description	State/Span	Remarks
AE/AIT-35145	FILTERED WATER FLUME TURBIDITY		
AE/AIT-33148	EFFLUENT FLUME TURBIDITY		

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SECTION 40 61 93
PROCESS CONTROL SYSTEM INPUT / OUTPUT LIST

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. The Contractor shall furnish, test, install and place in satisfactory operation all control system inputs and outputs as herein specified and as shown on the Drawings.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 40 61 90 – Schedules and Control Descriptions, General
- B. Section 40 61 91 – Process Control System Instrument List
- C. Section 40 61 96 – Process Control Descriptions

PART 2 – CONTROL SYSTEM INPUT / OUTPUT SCHEDULE

P.O. HOFFER WTF

Tag Number	Service Description	State/Span	Type	Remarks
RTU-21				
AI-35143	FILTERED WATER FLUME pH		AI	AE/AIT-35143
AI-35144	FILTERED WATER FLUME TEMPERATURE		AI	AE-35144/AIT-35143
AI-35145	FILTERED WATER FLUME TURBIDITY		AI	AE/AIT-35145
AI-35146	FILTERED WATER FLUME FREE CHLORINE		AI	AE-35146/AIT-35143
LI-35147	FILTERED WATER FLUME LEVEL		AI	LE/LIT-35147
LI-35148	FILTERED WATER FLUME LEVEL		AI	LE/LIT-35148
YLR-35121	GAC BYPASS VALVE	IN REMOTE	DI	MOV-35121
ZLO-35121	GAC BYPASS VALVE	OPEN	DI	
ZLC-35121	GAC BYPASS VALVE	CLOSED	DI	

Tag Number	Service Description	State/Span	Type	Remarks
ZSO-35121	GAC BYPASS VALVE	OPEN	DO	
ZSC-35121	GAC BYPASS VALVE	CLOSE	DO	
YLR-35101	GAC FEED PUMP NO. 1	IN REMOTE	DI	P-35101
YN-35101	GAC FEED PUMP NO. 1	RUN	DI	
YA-35101	GAC FEED PUMP NO. 1	FAIL	DI	
YY-35101	GAC FEED PUMP NO. 1	START/STOP	DO	
SI-35101	GAC FEED PUMP NO. 1 SPEED FEEDBACK	0-100%	AI	
SC-35101	GAC FEED PUMP NO. 1 SPEED CONTROL	0-100%	AO	
TAH-35101	GAC FEED PUMP NO. 1 MOTOR TEMP	HIGH	DI	
PAH-35141	GAC FEED PUMP NO. 1 DISCHARGE PRESSURE	HIGH	DI	
YLR-35201	GAC FEED PUMP NO. 2	IN REMOTE	DI	P-35201
YN-35201	GAC FEED PUMP NO. 2	RUN	DI	
YA-35201	GAC FEED PUMP NO. 2	FAIL	DI	
YY-35201	GAC FEED PUMP NO. 2	START/STOP	DO	
SI-35201	GAC FEED PUMP NO. 2 SPEED FEEDBACK	0-100%	AI	
SC-35201	GAC FEED PUMP NO. 2 SPEED CONTROL	0-100%	AO	
TAH-35201	GAC FEED PUMP NO. 2 MOTOR TEMP	HIGH	DI	
PAH-35241	GAC FEED PUMP NO. 2 DISCHARGE PRESSURE	HIGH	DI	
YLR-35301	GAC FEED PUMP NO. 3	IN REMOTE	DI	P-35301
YN-35301	GAC FEED PUMP NO. 3	RUN	DI	
YA-35301	GAC FEED PUMP NO. 3	FAIL	DI	
YY-35301	GAC FEED PUMP NO. 3	START/STOP	DO	
SI-35301	GAC FEED PUMP NO. 3 SPEED FEEDBACK	0-100%	AI	
SC-35301	GAC FEED PUMP NO. 3 SPEED CONTROL	0-100%	AO	
TAH-35301	GAC FEED PUMP NO. 3 MOTOR TEMP	HIGH	DI	
PAH-35341	GAC FEED PUMP NO. 3 DISCHARGE PRESSURE	HIGH	DI	
YLR-35401	GAC FEED PUMP NO. 4	IN REMOTE	DI	P-35401

Tag Number	Service Description	State/Span	Type	Remarks
YN-35401	GAC FEED PUMP NO. 4	RUN	DI	
YA-35401	GAC FEED PUMP NO. 4	FAIL	DI	
YY-35401	GAC FEED PUMP NO. 4	START/STOP	DO	
SI-35401	GAC FEED PUMP NO. 4 SPEED FEEDBACK	0-100%	AI	
SC-35401	GAC FEED PUMP NO. 4 SPEED CONTROL	0-100%	AO	
TAH-35401	GAC FEED PUMP NO. 4 MOTOR TEMP	HIGH	DI	
PAH-35441	GAC FEED PUMP NO. 4 DISCHARGE PRESSURE	HIGH	DI	
YLR-35501	GAC FEED PUMP NO. 5	IN REMOTE	DI	P-35501, FUTURE
YN-35501	GAC FEED PUMP NO. 5	RUN	DI	FUTURE
YA-35501	GAC FEED PUMP NO. 5	FAIL	DI	FUTURE
YY-35501	GAC FEED PUMP NO. 5	START/STOP	DO	FUTURE
SI-35501	GAC FEED PUMP NO. 5 SPEED FEEDBACK	0-100%	AI	FUTURE
SC-35501	GAC FEED PUMP NO. 5 SPEED CONTROL	0-100%	AO	FUTURE
TAH-35501	GAC FEED PUMP NO. 5 MOTOR TEMP	HIGH	DI	FUTURE
PAH-35541	GAC FEED PUMP NO. 5 DISCHARGE PRESSURE	HIGH	DI	FUTURE
FI-35142	GAC INFLUENT FLOW		AI	FE/FIT- 35142
YLR-36101	GAC BACKWASH PUMP NO. 1	IN REMOTE	DI	P-36101
YN-36101	GAC BACKWASH PUMP NO. 1	RUN	DI	
YA-36101	GAC BACKWASH PUMP NO. 1	FAIL	DI	
YY-36101	GAC BACKWASH PUMP NO. 1	START/STOP	DO	
SI-36101	GAC BACKWASH PUMP NO. 1 SPEED BACKWASHBACK	0-100%	AI	
SC-36101	GAC BACKWASH PUMP NO. 1 SPEED CONTROL	0-100%	AO	
TAH-36101	GAC BACKWASH PUMP NO. 1 MOTOR TEMP	HIGH	DI	
PAH-36141	GAC BACKWASH PUMP NO. 1 DISCHARGE PRESSURE	HIGH	DI	
YLR-36201	GAC BACKWASH PUMP NO. 2	IN REMOTE	DI	P-36201
YN-36201	GAC BACKWASH PUMP NO. 2	RUN	DI	

Tag Number	Service Description	State/Span	Type	Remarks
YA-36201	GAC BACKWASH PUMP NO. 2	FAIL	DI	
YY-36201	GAC BACKWASH PUMP NO. 2	START/STOP	DO	
SI-36201	GAC BACKWASH PUMP NO. 2 SPEED BACKWASHBACK	0-100%	AI	
SC-36201	GAC BACKWASH PUMP NO. 2 SPEED CONTROL	0-100%	AO	
TAH-36201	GAC BACKWASH PUMP NO. 2 MOTOR TEMP	HIGH	DI	
PAH-36241	GAC BACKWASH PUMP NO. 2 DISCHARGE PRESSURE	HIGH	DI	
YLR-36301	GAC BACKWASH PUMP NO. 3	IN REMOTE	DI	P-36301
YN-36301	GAC BACKWASH PUMP NO. 3	RUN	DI	
YA-36301	GAC BACKWASH PUMP NO. 3	FAIL	DI	
YY-36301	GAC BACKWASH PUMP NO. 3	START/STOP	DO	
SI-36301	GAC BACKWASH PUMP NO. 3 SPEED BACKWASHBACK	0-100%	AI	
SC-36301	GAC BACKWASH PUMP NO. 3 SPEED CONTROL	0-100%	AO	
TAH-36301	GAC BACKWASH PUMP NO. 3 MOTOR TEMP	HIGH	DI	
PAH-36341	GAC BACKWASH PUMP NO. 3 DISCHARGE PRESSURE	HIGH	DI	
LI-33145	GAC COMMON CHANNEL LEVEL		AI	LE/LIT- 33145
LI-33147	GAC COMMON CHANNEL LEVEL		AI	LE/LIT- 33147
FI-36142	GAC BACKWASH FLOW		AI	FE/FIT- 36142

RTU-22

ZSO-33121	GAC NO. 1 INFLUENT VALVE	OPEN	DO	MOV- 33121
ZSC-33121	GAC NO. 1 INFLUENT VALVE	CLOSE	DO	
ZLO-33121	GAC NO. 1 INFLUENT VALVE	OPEN	DI	
ZLC-33121	GAC NO. 1 INFLUENT VALVE	CLOSED	DI	
YLR-33121	GAC NO. 1 INFLUENT VALVE	IN REMOTE	DI	
ZSO-33122A	GAC NO. 1 WASH WATER SUPPLY ISOLATION VALVE	OPEN	DO	MOV- 33122A

Tag Number	Service Description	State/Span	Type	Remarks
ZSC-33122A	GAC NO. 1 WASH WATER SUPPLY ISOLATION VALVE	CLOSE	DO	
ZLO-33122A	GAC NO. 1 WASH WATER SUPPLY ISOLATION VALVE	OPEN	DI	
ZLC-33122A	GAC NO. 1 WASH WATER SUPPLY ISOLATION VALVE	CLOSED	DI	
YLR-33122A	GAC NO. 1 WASH WATER SUPPLY ISOLATION VALVE	IN REMOTE	DI	
ZSO-33122B	GAC NO. 1 BACKWASH WASTE ISOLATION VALVE	OPEN	DO	MOV-33122B
ZSC-33122B	GAC NO. 1 BACKWASH WASTE ISOLATION VALVE	CLOSE	DO	
ZLO-33122B	GAC NO. 1 BACKWASH WASTE ISOLATION VALVE	OPEN	DI	
ZLC-33122B	GAC NO. 1 BACKWASH WASTE ISOLATION VALVE	CLOSED	DI	
YLR-33122B	GAC NO. 1 BACKWASH WASTE ISOLATION VALVE	IN REMOTE	DI	
ZSO-33123A	GAC NO. 1 EFFLUENT ISOLATION VALVE	OPEN	DO	MOV-33123A
ZSC-33123A	GAC NO. 1 EFFLUENT ISOLATION VALVE	CLOSE	DO	
ZLO-33123A	GAC NO. 1 EFFLUENT ISOLATION VALVE	OPEN	DI	
ZLC-33123A	GAC NO. 1 EFFLUENT ISOLATION VALVE	CLOSED	DI	
YLR-33123A	GAC NO. 1 EFFLUENT ISOLATION VALVE	IN REMOTE	DI	
ZSO-33123B	GAC NO. 1 TO WASTE ISOLATION VALVE	OPEN	DO	MOV-33123B
ZSC-33123B	GAC NO. 1 TO WASTE ISOLATION VALVE	CLOSE	DO	
ZLO-33123B	GAC NO. 1 TO WASTE ISOLATION VALVE	OPEN	DI	
ZLC-33123B	GAC NO. 1 TO WASTE ISOLATION VALVE	CLOSED	DI	
YLR-33123B	GAC NO. 1 TO WASTE ISOLATION VALVE	IN REMOTE	DI	
ZI-33124	GAC NO. 1 EFFLUENT CONTROL VALVE POSITION FEEDBACK	0-100%	AI	MOV-33124
ZC-33124	GAC NO. 1 EFFLUENT CONTROL VALVE POSITION CONTROL	0-100%	AO	
YLR-33124	GAC NO. 1 EFFLUENT CONTROL VALVE	IN REMOTE	DI	
FI-33141	GAC NO. 1 EFFLUENT FLOW RATE		AI	FE/FIT-33141

Tag Number	Service Description	State/Span	Type	Remarks
PDI-33142	GAC NO. 1 LOSS OF HEAD		AI	PDIT-33142
LI-33143	GAC NO. 1 LEVEL		AI	LE/LIT-33143
ZSO-33221	GAC NO. 2 INFLUENT VALVE	OPEN	DO	MOV-33221
ZSC-33221	GAC NO. 2 INFLUENT VALVE	CLOSE	DO	
ZLO-33221	GAC NO. 2 INFLUENT VALVE	OPEN	DI	
ZLC-33221	GAC NO. 2 INFLUENT VALVE	CLOSED	DI	
YLR-33221	GAC NO. 2 INFLUENT VALVE	IN REMOTE	DI	
ZSO-33222A	GAC NO. 2 WASH WATER SUPPLY ISOLATION VALVE	OPEN	DO	MOV-33222A
ZSC-33222A	GAC NO. 2 WASH WATER SUPPLY ISOLATION VALVE	CLOSE	DO	
ZLO-33222A	GAC NO. 2 WASH WATER SUPPLY ISOLATION VALVE	OPEN	DI	
ZLC-33222A	GAC NO. 2 WASH WATER SUPPLY ISOLATION VALVE	CLOSED	DI	
YLR-33222A	GAC NO. 2 WASH WATER SUPPLY ISOLATION VALVE	IN REMOTE	DI	
ZSO-33222B	GAC NO. 2 BACKWASH WASTE ISOLATION VALVE	OPEN	DO	MOV-33222B
ZSC-33222B	GAC NO. 2 BACKWASH WASTE ISOLATION VALVE	CLOSE	DO	
ZLO-33222B	GAC NO. 2 BACKWASH WASTE ISOLATION VALVE	OPEN	DI	
ZLC-33222B	GAC NO. 2 BACKWASH WASTE ISOLATION VALVE	CLOSED	DI	
YLR-33222B	GAC NO. 2 BACKWASH WASTE ISOLATION VALVE	IN REMOTE	DI	
ZSO-33223A	GAC NO. 2 EFFLUENT ISOLATION VALVE	OPEN	DO	MOV-33223A
ZSC-33223A	GAC NO. 2 EFFLUENT ISOLATION VALVE	CLOSE	DO	
ZLO-33223A	GAC NO. 2 EFFLUENT ISOLATION VALVE	OPEN	DI	
ZLC-33223A	GAC NO. 2 EFFLUENT ISOLATION VALVE	CLOSED	DI	
YLR-33223A	GAC NO. 2 EFFLUENT ISOLATION VALVE	IN REMOTE	DI	
ZSO-33223B	GAC NO. 2 TO WASTE ISOLATION VALVE	OPEN	DO	MOV-33223B

Tag Number	Service Description	State/Span	Type	Remarks
ZSC-33223B	GAC NO. 2 TO WASTE ISOLATION VALVE	CLOSE	DO	
ZLO-33223B	GAC NO. 2 TO WASTE ISOLATION VALVE	OPEN	DI	
ZLC-33223B	GAC NO. 2 TO WASTE ISOLATION VALVE	CLOSED	DI	
YLR-33223B	GAC NO. 2 TO WASTE ISOLATION VALVE	IN REMOTE	DI	
ZI-33224	GAC NO. 2 EFFLUENT CONTROL VALVE POSITION FEEDBACK	0-100%	AI	MOV-33224
ZC-33224	GAC NO. 2 EFFLUENT CONTROL VALVE POSITION CONTROL	0-100%	AO	
YLR-33224	GAC NO. 2 EFFLUENT CONTROL VALVE	IN REMOTE	DI	
FI-33241	GAC NO. 2 EFFLUENT FLOW RATE		AI	FE/FIT-33241
PDI-33242	GAC NO. 2 LOSS OF HEAD		AI	PDIT-33242
LI-33243	GAC NO. 2 LEVEL		AI	LE/LIT-33243
ZSO-33321	GAC NO. 3 INFLUENT VALVE	OPEN	DO	MOV-33321
ZSC-33321	GAC NO. 3 INFLUENT VALVE	CLOSE	DO	
ZLO-33321	GAC NO. 3 INFLUENT VALVE	OPEN	DI	
ZLC-33321	GAC NO. 3 INFLUENT VALVE	CLOSED	DI	
YLR-33321	GAC NO. 3 INFLUENT VALVE	IN REMOTE	DI	
ZSO-33322A	GAC NO. 3 WASH WATER SUPPLY ISOLATION VALVE	OPEN	DO	MOV-33322A
ZSC-33322A	GAC NO. 3 WASH WATER SUPPLY ISOLATION VALVE	CLOSE	DO	
ZLO-33322A	GAC NO. 3 WASH WATER SUPPLY ISOLATION VALVE	OPEN	DI	
ZLC-33322A	GAC NO. 3 WASH WATER SUPPLY ISOLATION VALVE	CLOSED	DI	
YLR-33322A	GAC NO. 3 WASH WATER SUPPLY ISOLATION VALVE	IN REMOTE	DI	
ZSO-33322B	GAC NO. 3 BACKWASH WASTE ISOLATION VALVE	OPEN	DO	MOV-33322B
ZSC-33322B	GAC NO. 3 BACKWASH WASTE ISOLATION VALVE	CLOSE	DO	

Tag Number	Service Description	State/Span	Type	Remarks
ZLO-33322B	GAC NO. 3 BACKWASH WASTE ISOLATION VALVE	OPEN	DI	
ZLC-33322B	GAC NO. 3 BACKWASH WASTE ISOLATION VALVE	CLOSED	DI	
YLR-33322B	GAC NO. 3 BACKWASH WASTE ISOLATION VALVE	IN REMOTE	DI	
ZSO-33323A	GAC NO. 3 EFFLUENT ISOLATION VALVE	OPEN	DO	MOV-33323A
ZSC-33323A	GAC NO. 3 EFFLUENT ISOLATION VALVE	CLOSE	DO	
ZLO-33323A	GAC NO. 3 EFFLUENT ISOLATION VALVE	OPEN	DI	
ZLC-33323A	GAC NO. 3 EFFLUENT ISOLATION VALVE	CLOSED	DI	
YLR-33323A	GAC NO. 3 EFFLUENT ISOLATION VALVE	IN REMOTE	DI	
ZSO-33323B	GAC NO. 3 TO WASTE ISOLATION VALVE	OPEN	DO	MOV-33323B
ZSC-33323B	GAC NO. 3 TO WASTE ISOLATION VALVE	CLOSE	DO	
ZLO-33323B	GAC NO. 3 TO WASTE ISOLATION VALVE	OPEN	DI	
ZLC-33323B	GAC NO. 3 TO WASTE ISOLATION VALVE	CLOSED	DI	
YLR-33323B	GAC NO. 3 TO WASTE ISOLATION VALVE	IN REMOTE	DI	
ZI-33324	GAC NO. 3 EFFLUENT CONTROL VALVE POSITION FEEDBACK	0-100%	AI	MOV-33324
ZC-33324	GAC NO. 3 EFFLUENT CONTROL VALVE POSITION CONTROL	0-100%	AO	
YLR-33324	GAC NO. 3 EFFLUENT CONTROL VALVE	IN REMOTE	DI	
FI-33341	GAC NO. 3 EFFLUENT FLOW RATE		AI	FE/FIT-33341
PDI-33342	GAC NO. 3 LOSS OF HEAD		AI	PDIT-33342
LI-33343	GAC NO. 3 LEVEL		AI	LE/LIT-33343
ZSO-33421	GAC NO. 4 INFLUENT VALVE	OPEN	DO	MOV-33421
ZSC-33421	GAC NO. 4 INFLUENT VALVE	CLOSE	DO	
ZLO-33421	GAC NO. 4 INFLUENT VALVE	OPEN	DI	

Tag Number	Service Description	State/Span	Type	Remarks
ZLC-33421	GAC NO. 4 INFLUENT VALVE	CLOSED	DI	
YLR-33421	GAC NO. 4 INFLUENT VALVE	IN REMOTE	DI	
ZSO-33422A	GAC NO. 4 WASH WATER SUPPLY ISOLATION VALVE	OPEN	DO	MOV-33422A
ZSC-33422A	GAC NO. 4 WASH WATER SUPPLY ISOLATION VALVE	CLOSE	DO	
ZLO-33422A	GAC NO. 4 WASH WATER SUPPLY ISOLATION VALVE	OPEN	DI	
ZLC-33422A	GAC NO. 4 WASH WATER SUPPLY ISOLATION VALVE	CLOSED	DI	
YLR-33422A	GAC NO. 4 WASH WATER SUPPLY ISOLATION VALVE	IN REMOTE	DI	
ZSO-33422B	GAC NO. 4 BACKWASH WASTE ISOLATION VALVE	OPEN	DO	MOV-33422B
ZSC-33422B	GAC NO. 4 BACKWASH WASTE ISOLATION VALVE	CLOSE	DO	
ZLO-33422B	GAC NO. 4 BACKWASH WASTE ISOLATION VALVE	OPEN	DI	
ZLC-33422B	GAC NO. 4 BACKWASH WASTE ISOLATION VALVE	CLOSED	DI	
YLR-33422B	GAC NO. 4 BACKWASH WASTE ISOLATION VALVE	IN REMOTE	DI	
ZSO-33423A	GAC NO. 4 EFFLUENT ISOLATION VALVE	OPEN	DO	MOV-33423A
ZSC-33423A	GAC NO. 4 EFFLUENT ISOLATION VALVE	CLOSE	DO	
ZLO-33423A	GAC NO. 4 EFFLUENT ISOLATION VALVE	OPEN	DI	
ZLC-33423A	GAC NO. 4 EFFLUENT ISOLATION VALVE	CLOSED	DI	
YLR-33423A	GAC NO. 4 EFFLUENT ISOLATION VALVE	IN REMOTE	DI	
ZSO-33423B	GAC NO. 4 TO WASTE ISOLATION VALVE	OPEN	DO	MOV-33423B
ZSC-33423B	GAC NO. 4 TO WASTE ISOLATION VALVE	CLOSE	DO	
ZLO-33423B	GAC NO. 4 TO WASTE ISOLATION VALVE	OPEN	DI	
ZLC-33423B	GAC NO. 4 TO WASTE ISOLATION VALVE	CLOSED	DI	
YLR-33423B	GAC NO. 4 TO WASTE ISOLATION VALVE	IN REMOTE	DI	
ZI-33424	GAC NO. 4 EFFLUENT CONTROL VALVE POSITION FEEDBACK	0-100%	AI	MOV-33424
ZC-33424	GAC NO. 4 EFFLUENT CONTROL VALVE POSITION CONTROL	0-100%	AO	

Tag Number	Service Description	State/Span	Type	Remarks
YLR-33424	GAC NO. 4 EFFLUENT CONTROL VALVE	IN REMOTE	DI	
FI-33441	GAC NO. 4 EFFLUENT FLOW RATE		AI	FE/FIT-33441
PDI-33442	GAC NO. 4 LOSS OF HEAD		AI	PDIT-33442
LI-33443	GAC NO. 4 LEVEL		AI	LE/LIT-33443

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ZSO-33521	GAC NO. 5 INFLUENT VALVE	OPEN	DO	MOV-33521
ZSC-33521	GAC NO. 5 INFLUENT VALVE	CLOSE	DO	
ZLO-33521	GAC NO. 5 INFLUENT VALVE	OPEN	DI	
ZLC-33521	GAC NO. 5 INFLUENT VALVE	CLOSED	DI	
YLR-33521	GAC NO. 5 INFLUENT VALVE	IN REMOTE	DI	
ZSO-33522A	GAC NO. 5 WASH WATER SUPPLY ISOLATION VALVE	OPEN	DO	MOV-33522A
ZSC-33522A	GAC NO. 5 WASH WATER SUPPLY ISOLATION VALVE	CLOSE	DO	
ZLO-33522A	GAC NO. 5 WASH WATER SUPPLY ISOLATION VALVE	OPEN	DI	
ZLC-33522A	GAC NO. 5 WASH WATER SUPPLY ISOLATION VALVE	CLOSED	DI	
YLR-33522A	GAC NO. 5 WASH WATER SUPPLY ISOLATION VALVE	IN REMOTE	DI	
ZSO-33522B	GAC NO. 5 BACKWASH WASTE ISOLATION VALVE	OPEN	DO	MOV-33522B
ZSC-33522B	GAC NO. 5 BACKWASH WASTE ISOLATION VALVE	CLOSE	DO	
ZLO-33522B	GAC NO. 5 BACKWASH WASTE ISOLATION VALVE	OPEN	DI	
ZLC-33522B	GAC NO. 5 BACKWASH WASTE ISOLATION VALVE	CLOSED	DI	
YLR-33522B	GAC NO. 5 BACKWASH WASTE ISOLATION VALVE	IN REMOTE	DI	
ZSO-33523A	GAC NO. 5 EFFLUENT ISOLATION VALVE	OPEN	DO	MOV-33523A
ZSC-33523A	GAC NO. 5 EFFLUENT ISOLATION VALVE	CLOSE	DO	

Tag Number	Service Description	State/Span	Type	Remarks
ZLO-33523A	GAC NO. 5 EFFLUENT ISOLATION VALVE	OPEN	DI	
ZLC-33523A	GAC NO. 5 EFFLUENT ISOLATION VALVE	CLOSED	DI	
YLR-33523A	GAC NO. 5 EFFLUENT ISOLATION VALVE	IN REMOTE	DI	
ZSO-33523B	GAC NO. 5 TO WASTE ISOLATION VALVE	OPEN	DO	MOV-33523B
ZSC-33523B	GAC NO. 5 TO WASTE ISOLATION VALVE	CLOSE	DO	
ZLO-33523B	GAC NO. 5 TO WASTE ISOLATION VALVE	OPEN	DI	
ZLC-33523B	GAC NO. 5 TO WASTE ISOLATION VALVE	CLOSED	DI	
YLR-33523B	GAC NO. 5 TO WASTE ISOLATION VALVE	IN REMOTE	DI	
ZI-33524	GAC NO. 5 EFFLUENT CONTROL VALVE POSITION FEEDBACK	0-100%	AI	MOV-33524
ZC-33524	GAC NO. 5 EFFLUENT CONTROL VALVE POSITION CONTROL	0-100%	AO	
YLR-33524	GAC NO. 5 EFFLUENT CONTROL VALVE	IN REMOTE	DI	
FI-33541	GAC NO. 5 EFFLUENT FLOW RATE		AI	FE/FIT-33541
PDI-33542	GAC NO. 5 LOSS OF HEAD		AI	PDIT-33542
LI-33543	GAC NO. 5 LEVEL		AI	LE/LIT-33543
ZSO-33621	GAC NO. 6 INFLUENT VALVE	OPEN	DO	MOV-33621
ZSC-33621	GAC NO. 6 INFLUENT VALVE	CLOSE	DO	
ZLO-33621	GAC NO. 6 INFLUENT VALVE	OPEN	DI	
ZLC-33621	GAC NO. 6 INFLUENT VALVE	CLOSED	DI	
YLR-33621	GAC NO. 6 INFLUENT VALVE	IN REMOTE	DI	
ZSO-33622A	GAC NO. 6 WASH WATER SUPPLY ISOLATION VALVE	OPEN	DO	MOV-33622A
ZSC-33622A	GAC NO. 6 WASH WATER SUPPLY ISOLATION VALVE	CLOSE	DO	
ZLO-33622A	GAC NO. 6 WASH WATER SUPPLY ISOLATION VALVE	OPEN	DI	

Tag Number	Service Description	State/Span	Type	Remarks
ZLC-33622A	GAC NO. 6 WASH WATER SUPPLY ISOLATION VALVE	CLOSED	DI	
YLR-33622A	GAC NO. 6 WASH WATER SUPPLY ISOLATION VALVE	IN REMOTE	DI	
ZSO-33622B	GAC NO. 6 BACKWASH WASTE ISOLATION VALVE	OPEN	DO	MOV-33622B
ZSC-33622B	GAC NO. 6 BACKWASH WASTE ISOLATION VALVE	CLOSE	DO	
ZLO-33622B	GAC NO. 6 BACKWASH WASTE ISOLATION VALVE	OPEN	DI	
ZLC-33622B	GAC NO. 6 BACKWASH WASTE ISOLATION VALVE	CLOSED	DI	
YLR-33622B	GAC NO. 6 BACKWASH WASTE ISOLATION VALVE	IN REMOTE	DI	
ZSO-33623A	GAC NO. 6 EFFLUENT ISOLATION VALVE	OPEN	DO	MOV-33623A
ZSC-33623A	GAC NO. 6 EFFLUENT ISOLATION VALVE	CLOSE	DO	
ZLO-33623A	GAC NO. 6 EFFLUENT ISOLATION VALVE	OPEN	DI	
ZLC-33623A	GAC NO. 6 EFFLUENT ISOLATION VALVE	CLOSED	DI	
YLR-33623A	GAC NO. 6 EFFLUENT ISOLATION VALVE	IN REMOTE	DI	
ZSO-33623B	GAC NO. 6 TO WASTE ISOLATION VALVE	OPEN	DO	MOV-33623B
ZSC-33623B	GAC NO. 6 TO WASTE ISOLATION VALVE	CLOSE	DO	
ZLO-33623B	GAC NO. 6 TO WASTE ISOLATION VALVE	OPEN	DI	
ZLC-33623B	GAC NO. 6 TO WASTE ISOLATION VALVE	CLOSED	DI	
YLR-33623B	GAC NO. 6 TO WASTE ISOLATION VALVE	IN REMOTE	DI	
ZI-33624	GAC NO. 6 EFFLUENT CONTROL VALVE POSITION FEEDBACK	0-100%	AI	MOV-33624
ZC-33624	GAC NO. 6 EFFLUENT CONTROL VALVE POSITION CONTROL	0-100%	AO	
YLR-33624	GAC NO. 6 EFFLUENT CONTROL VALVE	IN REMOTE	DI	
FI-33641	GAC NO. 6 EFFLUENT FLOW RATE		AI	FE/FIT-33641
PDI-33642	GAC NO. 6 LOSS OF HEAD		AI	PDIT-33642

Tag Number	Service Description	State/Span	Type	Remarks
LI-33643	GAC NO. 6 LEVEL		AI	LE/LIT-33643
ZSO-33721	GAC NO. 7 INFLUENT VALVE	OPEN	DO	MOV-33721
ZSC-33721	GAC NO. 7 INFLUENT VALVE	CLOSE	DO	
ZLO-33721	GAC NO. 7 INFLUENT VALVE	OPEN	DI	
ZLC-33721	GAC NO. 7 INFLUENT VALVE	CLOSED	DI	
YLR-33721	GAC NO. 7 INFLUENT VALVE	IN REMOTE	DI	
ZSO-33722A	GAC NO. 7 WASH WATER SUPPLY ISOLATION VALVE	OPEN	DO	MOV-33722A
ZSC-33722A	GAC NO. 7 WASH WATER SUPPLY ISOLATION VALVE	CLOSE	DO	
ZLO-33722A	GAC NO. 7 WASH WATER SUPPLY ISOLATION VALVE	OPEN	DI	
ZLC-33722A	GAC NO. 7 WASH WATER SUPPLY ISOLATION VALVE	CLOSED	DI	
YLR-33722A	GAC NO. 7 WASH WATER SUPPLY ISOLATION VALVE	IN REMOTE	DI	
ZSO-33722B	GAC NO. 7 BACKWASH WASTE ISOLATION VALVE	OPEN	DO	MOV-33722B
ZSC-33722B	GAC NO. 7 BACKWASH WASTE ISOLATION VALVE	CLOSE	DO	
ZLO-33722B	GAC NO. 7 BACKWASH WASTE ISOLATION VALVE	OPEN	DI	
ZLC-33722B	GAC NO. 7 BACKWASH WASTE ISOLATION VALVE	CLOSED	DI	
YLR-33722B	GAC NO. 7 BACKWASH WASTE ISOLATION VALVE	IN REMOTE	DI	
ZSO-33723A	GAC NO. 7 EFFLUENT ISOLATION VALVE	OPEN	DO	MOV-33723A
ZSC-33723A	GAC NO. 7 EFFLUENT ISOLATION VALVE	CLOSE	DO	
ZLO-33723A	GAC NO. 7 EFFLUENT ISOLATION VALVE	OPEN	DI	
ZLC-33723A	GAC NO. 7 EFFLUENT ISOLATION VALVE	CLOSED	DI	
YLR-33723A	GAC NO. 7 EFFLUENT ISOLATION VALVE	IN REMOTE	DI	
ZSO-33723B	GAC NO. 7 TO WASTE ISOLATION VALVE	OPEN	DO	MOV-33723B
ZSC-33723B	GAC NO. 7 TO WASTE ISOLATION VALVE	CLOSE	DO	
ZLO-33723B	GAC NO. 7 TO WASTE ISOLATION VALVE	OPEN	DI	

Tag Number	Service Description	State/Span	Type	Remarks
ZLC-33723B	GAC NO. 7 TO WASTE ISOLATION VALVE	CLOSED	DI	
YLR-33723B	GAC NO. 7 TO WASTE ISOLATION VALVE	IN REMOTE	DI	
ZI-33724	GAC NO. 7 EFFLUENT CONTROL VALVE POSITION FEEDBACK	0-100%	AI	MOV-33724
ZC-33724	GAC NO. 7 EFFLUENT CONTROL VALVE POSITION CONTROL	0-100%	AO	
YLR-33724	GAC NO. 7 EFFLUENT CONTROL VALVE	IN REMOTE	DI	
FI-33741	GAC NO. 7 EFFLUENT FLOW RATE		AI	FE/FIT-33741
PDI-33742	GAC NO. 7 LOSS OF HEAD		AI	PDIT-33742
LI-33743	GAC NO. 7 LEVEL		AI	LE/LIT-33743
ZSO-33821	GAC NO. 8 INFLUENT VALVE	OPEN	DO	MOV-33821
ZSC-33821	GAC NO. 8 INFLUENT VALVE	CLOSE	DO	
ZLO-33821	GAC NO. 8 INFLUENT VALVE	OPEN	DI	
ZLC-33821	GAC NO. 8 INFLUENT VALVE	CLOSED	DI	
YLR-33821	GAC NO. 8 INFLUENT VALVE	IN REMOTE	DI	
ZSO-33822A	GAC NO. 8 WASH WATER SUPPLY ISOLATION VALVE	OPEN	DO	MOV-33822A
ZSC-33822A	GAC NO. 8 WASH WATER SUPPLY ISOLATION VALVE	CLOSE	DO	
ZLO-33822A	GAC NO. 8 WASH WATER SUPPLY ISOLATION VALVE	OPEN	DI	
ZLC-33822A	GAC NO. 8 WASH WATER SUPPLY ISOLATION VALVE	CLOSED	DI	
YLR-33822A	GAC NO. 8 WASH WATER SUPPLY ISOLATION VALVE	IN REMOTE	DI	
ZSO-33822B	GAC NO. 8 BACKWASH WASTE ISOLATION VALVE	OPEN	DO	MOV-33822B
ZSC-33822B	GAC NO. 8 BACKWASH WASTE ISOLATION VALVE	CLOSE	DO	
ZLO-33822B	GAC NO. 8 BACKWASH WASTE ISOLATION VALVE	OPEN	DI	
ZLC-33822B	GAC NO. 8 BACKWASH WASTE ISOLATION VALVE	CLOSED	DI	

Tag Number	Service Description	State/Span	Type	Remarks
YLR-33822B	GAC NO. 8 BACKWASH WASTE ISOLATION VALVE	IN REMOTE	DI	
ZSO-33823A	GAC NO. 8 EFFLUENT ISOLATION VALVE	OPEN	DO	MOV-33823A
ZSC-33823A	GAC NO. 8 EFFLUENT ISOLATION VALVE	CLOSE	DO	
ZLO-33823A	GAC NO. 8 EFFLUENT ISOLATION VALVE	OPEN	DI	
ZLC-33823A	GAC NO. 8 EFFLUENT ISOLATION VALVE	CLOSED	DI	
YLR-33823A	GAC NO. 8 EFFLUENT ISOLATION VALVE	IN REMOTE	DI	
ZSO-33823B	GAC NO. 8 TO WASTE ISOLATION VALVE	OPEN	DO	MOV-33823B
ZSC-33823B	GAC NO. 8 TO WASTE ISOLATION VALVE	CLOSE	DO	
ZLO-33823B	GAC NO. 8 TO WASTE ISOLATION VALVE	OPEN	DI	
ZLC-33823B	GAC NO. 8 TO WASTE ISOLATION VALVE	CLOSED	DI	
YLR-33823B	GAC NO. 8 TO WASTE ISOLATION VALVE	IN REMOTE	DI	
ZI-33824	GAC NO. 8 EFFLUENT CONTROL VALVE POSITION FEEDBACK	0-100%	AI	MOV-33824
ZC-33824	GAC NO. 8 EFFLUENT CONTROL VALVE POSITION CONTROL	0-100%	AO	
YLR-33824	GAC NO. 8 EFFLUENT CONTROL VALVE	IN REMOTE	DI	
FI-33841	GAC NO. 8 EFFLUENT FLOW RATE		AI	FE/FIT-33841
PDI-33842	GAC NO. 8 LOSS OF HEAD		AI	PDIT-33842
LI-33843	GAC NO. 8 LEVEL		AI	LE/LIT-33843
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ZSO-33921	GAC NO. 9 INFLUENT VALVE	OPEN	DO	MOV-33921
ZSC-33921	GAC NO. 9 INFLUENT VALVE	CLOSE	DO	
ZLO-33921	GAC NO. 9 INFLUENT VALVE	OPEN	DI	
ZLC-33921	GAC NO. 9 INFLUENT VALVE	CLOSED	DI	
YLR-33921	GAC NO. 9 INFLUENT VALVE	IN REMOTE	DI	

Tag Number	Service Description	State/Span	Type	Remarks
ZSO-33922A	GAC NO. 9 WASH WATER SUPPLY ISOLATION VALVE	OPEN	DO	MOV-33922A
ZSC-33922A	GAC NO. 9 WASH WATER SUPPLY ISOLATION VALVE	CLOSE	DO	
ZLO-33922A	GAC NO. 9 WASH WATER SUPPLY ISOLATION VALVE	OPEN	DI	
ZLC-33922A	GAC NO. 9 WASH WATER SUPPLY ISOLATION VALVE	CLOSED	DI	
YLR-33922A	GAC NO. 9 WASH WATER SUPPLY ISOLATION VALVE	IN REMOTE	DI	
ZSO-33922B	GAC NO. 9 BACKWASH WASTE ISOLATION VALVE	OPEN	DO	MOV-33922B
ZSC-33922B	GAC NO. 9 BACKWASH WASTE ISOLATION VALVE	CLOSE	DO	
ZLO-33922B	GAC NO. 9 BACKWASH WASTE ISOLATION VALVE	OPEN	DI	
ZLC-33922B	GAC NO. 9 BACKWASH WASTE ISOLATION VALVE	CLOSED	DI	
YLR-33922B	GAC NO. 9 BACKWASH WASTE ISOLATION VALVE	IN REMOTE	DI	
ZSO-33923A	GAC NO. 9 EFFLUENT ISOLATION VALVE	OPEN	DO	MOV-33923A
ZSC-33923A	GAC NO. 9 EFFLUENT ISOLATION VALVE	CLOSE	DO	
ZLO-33923A	GAC NO. 9 EFFLUENT ISOLATION VALVE	OPEN	DI	
ZLC-33923A	GAC NO. 9 EFFLUENT ISOLATION VALVE	CLOSED	DI	
YLR-33923A	GAC NO. 9 EFFLUENT ISOLATION VALVE	IN REMOTE	DI	
ZSO-33923B	GAC NO. 9 TO WASTE ISOLATION VALVE	OPEN	DO	MOV-33923B
ZSC-33923B	GAC NO. 9 TO WASTE ISOLATION VALVE	CLOSE	DO	
ZLO-33923B	GAC NO. 9 TO WASTE ISOLATION VALVE	OPEN	DI	
ZLC-33923B	GAC NO. 9 TO WASTE ISOLATION VALVE	CLOSED	DI	
YLR-33923B	GAC NO. 9 TO WASTE ISOLATION VALVE	IN REMOTE	DI	
ZI-33924	GAC NO. 9 EFFLUENT CONTROL VALVE POSITION FEEDBACK	0-100%	AI	MOV-33924
ZC-33924	GAC NO. 9 EFFLUENT CONTROL VALVE POSITION CONTROL	0-100%	AO	
YLR-33924	GAC NO. 9 EFFLUENT CONTROL VALVE	IN REMOTE	DI	

Tag Number	Service Description	State/Span	Type	Remarks
FI-33941	GAC NO. 9 EFFLUENT FLOW RATE		AI	FE/FIT-33941
PDI-33942	GAC NO. 9 LOSS OF HEAD		AI	PDIT-33942
LI-33943	GAC NO. 9 LEVEL		AI	LE/LIT-33943
ZSO-34021	GAC NO. 10 INFLUENT VALVE	OPEN	DO	MOV-34021
ZSC-34021	GAC NO. 10 INFLUENT VALVE	CLOSE	DO	
ZLO-34021	GAC NO. 10 INFLUENT VALVE	OPEN	DI	
ZLC-34021	GAC NO. 10 INFLUENT VALVE	CLOSED	DI	
YLR-34021	GAC NO. 10 INFLUENT VALVE	IN REMOTE	DI	
ZSO-34022A	GAC NO. 10 WASH WATER SUPPLY ISOLATION VALVE	OPEN	DO	MOV-34022A
ZSC-34022A	GAC NO. 10 WASH WATER SUPPLY ISOLATION VALVE	CLOSE	DO	
ZLO-34022A	GAC NO. 10 WASH WATER SUPPLY ISOLATION VALVE	OPEN	DI	
ZLC-34022A	GAC NO. 10 WASH WATER SUPPLY ISOLATION VALVE	CLOSED	DI	
YLR-34022A	GAC NO. 10 WASH WATER SUPPLY ISOLATION VALVE	IN REMOTE	DI	
ZSO-34022B	GAC NO. 10 BACKWASH WASTE ISOLATION VALVE	OPEN	DO	MOV-34022B
ZSC-34022B	GAC NO. 10 BACKWASH WASTE ISOLATION VALVE	CLOSE	DO	
ZLO-34022B	GAC NO. 10 BACKWASH WASTE ISOLATION VALVE	OPEN	DI	
ZLC-34022B	GAC NO. 10 BACKWASH WASTE ISOLATION VALVE	CLOSED	DI	
YLR-34022B	GAC NO. 10 BACKWASH WASTE ISOLATION VALVE	IN REMOTE	DI	
ZSO-34023A	GAC NO. 10 EFFLUENT ISOLATION VALVE	OPEN	DO	MOV-34023A
ZSC-34023A	GAC NO. 10 EFFLUENT ISOLATION VALVE	CLOSE	DO	
ZLO-34023A	GAC NO. 10 EFFLUENT ISOLATION VALVE	OPEN	DI	
ZLC-34023A	GAC NO. 10 EFFLUENT ISOLATION VALVE	CLOSED	DI	

Tag Number	Service Description	State/Span	Type	Remarks
YLR-34023A	GAC NO. 10 EFFLUENT ISOLATION VALVE	IN REMOTE	DI	
ZSO-34023B	GAC NO. 10 TO WASTE ISOLATION VALVE	OPEN	DO	MOV-34023B
ZSC-34023B	GAC NO. 10 TO WASTE ISOLATION VALVE	CLOSE	DO	
ZLO-34023B	GAC NO. 10 TO WASTE ISOLATION VALVE	OPEN	DI	
ZLC-34023B	GAC NO. 10 TO WASTE ISOLATION VALVE	CLOSED	DI	
YLR-34023B	GAC NO. 10 TO WASTE ISOLATION VALVE	IN REMOTE	DI	
ZI-34024	GAC NO. 10 EFFLUENT CONTROL VALVE POSITION FEEDBACK	0-100%	AI	MOV-34024
ZC-34024	GAC NO. 10 EFFLUENT CONTROL VALVE POSITION CONTROL	0-100%	AO	
YLR-34024	GAC NO. 10 EFFLUENT CONTROL VALVE	IN REMOTE	DI	
FI-34041	GAC NO. 10 EFFLUENT FLOW RATE		AI	FE/FIT-34041
PDI-34042	GAC NO. 10 LOSS OF HEAD		AI	PDIT-34042
LI-34043	GAC NO. 10 LEVEL		AI	LE/LIT-34043
ZSO-34121	GAC NO. 11 INFLUENT VALVE	OPEN	DO	MOV-34121
ZSC-34121	GAC NO. 11 INFLUENT VALVE	CLOSE	DO	
ZLO-34121	GAC NO. 11 INFLUENT VALVE	OPEN	DI	
ZLC-34121	GAC NO. 11 INFLUENT VALVE	CLOSED	DI	
YLR-34121	GAC NO. 11 INFLUENT VALVE	IN REMOTE	DI	
ZSO-34122A	GAC NO. 11 WASH WATER SUPPLY ISOLATION VALVE	OPEN	DO	MOV-34122A
ZSC-34122A	GAC NO. 11 WASH WATER SUPPLY ISOLATION VALVE	CLOSE	DO	
ZLO-34122A	GAC NO. 11 WASH WATER SUPPLY ISOLATION VALVE	OPEN	DI	
ZLC-34122A	GAC NO. 11 WASH WATER SUPPLY ISOLATION VALVE	CLOSED	DI	

Tag Number	Service Description	State/Span	Type	Remarks
YLR-34122A	GAC NO. 11 WASH WATER SUPPLY ISOLATION VALVE	IN REMOTE	DI	
ZSO-34122B	GAC NO. 11 BACKWASH WASTE ISOLATION VALVE	OPEN	DO	MOV-34122B
ZSC-34122B	GAC NO. 11 BACKWASH WASTE ISOLATION VALVE	CLOSE	DO	
ZLO-34122B	GAC NO. 11 BACKWASH WASTE ISOLATION VALVE	OPEN	DI	
ZLC-34122B	GAC NO. 11 BACKWASH WASTE ISOLATION VALVE	CLOSED	DI	
YLR-34122B	GAC NO. 11 BACKWASH WASTE ISOLATION VALVE	IN REMOTE	DI	
ZSO-34123A	GAC NO. 11 EFFLUENT ISOLATION VALVE	OPEN	DO	MOV-34123A
ZSC-34123A	GAC NO. 11 EFFLUENT ISOLATION VALVE	CLOSE	DO	
ZLO-34123A	GAC NO. 11 EFFLUENT ISOLATION VALVE	OPEN	DI	
ZLC-34123A	GAC NO. 11 EFFLUENT ISOLATION VALVE	CLOSED	DI	
YLR-34123A	GAC NO. 11 EFFLUENT ISOLATION VALVE	IN REMOTE	DI	
ZSO-34123B	GAC NO. 11 TO WASTE ISOLATION VALVE	OPEN	DO	MOV-34123B
ZSC-34123B	GAC NO. 11 TO WASTE ISOLATION VALVE	CLOSE	DO	
ZLO-34123B	GAC NO. 11 TO WASTE ISOLATION VALVE	OPEN	DI	
ZLC-34123B	GAC NO. 11 TO WASTE ISOLATION VALVE	CLOSED	DI	
YLR-34123B	GAC NO. 11 TO WASTE ISOLATION VALVE	IN REMOTE	DI	
ZI-34124	GAC NO. 11 EFFLUENT CONTROL VALVE POSITION FEEDBACK	0-100%	AI	MOV-34124
ZC-34124	GAC NO. 11 EFFLUENT CONTROL VALVE POSITION CONTROL	0-100%	AO	
YLR-34124	GAC NO. 11 EFFLUENT CONTROL VALVE	IN REMOTE	DI	
FI-34141	GAC NO. 11 EFFLUENT FLOW RATE		AI	FE/FIT-34141
PDI-34142	GAC NO. 11 LOSS OF HEAD		AI	PDIT-34142

Tag Number	Service Description	State/Span	Type	Remarks
LI-34143	GAC NO. 11 LEVEL		AI	LE/LIT-34143
ZSO-34221	GAC NO. 12 INFLUENT VALVE	OPEN	DO	MOV-34221
ZSC-34221	GAC NO. 12 INFLUENT VALVE	CLOSE	DO	
ZLO-34221	GAC NO. 12 INFLUENT VALVE	OPEN	DI	
ZLC-34221	GAC NO. 12 INFLUENT VALVE	CLOSED	DI	
YLR-34221	GAC NO. 12 INFLUENT VALVE	IN REMOTE	DI	
ZSO-34222A	GAC NO. 12 WASH WATER SUPPLY ISOLATION VALVE	OPEN	DO	MOV-34222A
ZSC-34222A	GAC NO. 12 WASH WATER SUPPLY ISOLATION VALVE	CLOSE	DO	
ZLO-34222A	GAC NO. 12 WASH WATER SUPPLY ISOLATION VALVE	OPEN	DI	
ZLC-34222A	GAC NO. 12 WASH WATER SUPPLY ISOLATION VALVE	CLOSED	DI	
YLR-34222A	GAC NO. 12 WASH WATER SUPPLY ISOLATION VALVE	IN REMOTE	DI	
ZSO-34222B	GAC NO. 12 BACKWASH WASTE ISOLATION VALVE	OPEN	DO	MOV-34222B
ZSC-34222B	GAC NO. 12 BACKWASH WASTE ISOLATION VALVE	CLOSE	DO	
ZLO-34222B	GAC NO. 12 BACKWASH WASTE ISOLATION VALVE	OPEN	DI	
ZLC-34222B	GAC NO. 12 BACKWASH WASTE ISOLATION VALVE	CLOSED	DI	
YLR-34222B	GAC NO. 12 BACKWASH WASTE ISOLATION VALVE	IN REMOTE	DI	
ZSO-34223A	GAC NO. 12 EFFLUENT ISOLATION VALVE	OPEN	DO	MOV-34223A
ZSC-34223A	GAC NO. 12 EFFLUENT ISOLATION VALVE	CLOSE	DO	
ZLO-34223A	GAC NO. 12 EFFLUENT ISOLATION VALVE	OPEN	DI	
ZLC-34223A	GAC NO. 12 EFFLUENT ISOLATION VALVE	CLOSED	DI	
YLR-34223A	GAC NO. 12 EFFLUENT ISOLATION VALVE	IN REMOTE	DI	
ZSO-34223B	GAC NO. 12 TO WASTE ISOLATION VALVE	OPEN	DO	MOV-34223B
ZSC-34223B	GAC NO. 12 TO WASTE ISOLATION VALVE	CLOSE	DO	

Tag Number	Service Description	State/Span	Type	Remarks
ZLO-34223B	GAC NO. 12 TO WASTE ISOLATION VALVE	OPEN	DI	
ZLC-34223B	GAC NO. 12 TO WASTE ISOLATION VALVE	CLOSED	DI	
YLR-34223B	GAC NO. 12 TO WASTE ISOLATION VALVE	IN REMOTE	DI	
ZI-34224	GAC NO. 12 EFFLUENT CONTROL VALVE POSITION FEEDBACK	0-100%	AI	MOV-34224
ZC-34224	GAC NO. 12 EFFLUENT CONTROL VALVE POSITION CONTROL	0-100%	AO	
YLR-34224	GAC NO. 12 EFFLUENT CONTROL VALVE	IN REMOTE	DI	
FI-34241	GAC NO. 12 EFFLUENT FLOW RATE		AI	FE/FIT-34241
PDI-34242	GAC NO. 12 LOSS OF HEAD		AI	PDIT-34242
LI-34243	GAC NO. 12 LEVEL		AI	LE/LIT-34243

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AI-33148	EFFLUENT FLUME pH		AI	AE/AIT-33148
AI-33149	EFFLUENT FLUME TEMP		AI	AI-33149/AIT-33148
AI-33150	EFFLUENT FLUME TURBIDITY		AI	AE/AIT-33150
LI-93143	DRAIN PUMP STATION WET WELL LEVEL		AI	LE/LIT-93143
YLR-93101	DRAIN PUMP NO. 1	AUTO	DI	P-93101
YN-93101	DRAIN PUMP NO. 1	RUN	DI	
YA-93101	DRAIN PUMP NO. 1	FAIL	DI	
YLR-93102	DRAIN PUMP NO. 2	AUTO	DI	P-93102
YN-93102	DRAIN PUMP NO. 2	RUN	DI	
YA-93102	DRAIN PUMP NO. 2	FAIL	DI	

Tag Number	Service Description	State/Span	Type	Remarks
LAL-93144	DRAIN PUMP STATION WET WELL LEVEL	ALL PUMPS OFF	DI	LSL-93144
LAH-93144A	DRAIN PUMP STATION WET WELL LEVEL	LEAD ON	DI	LSH-93144A
LAH-93144B	DRAIN PUMP STATION WET WELL LEVEL	LAG ON	DI	LSH-93144B
LAHH-93144	DRAIN PUMP STATION WET WELL LEVEL	HIGH-HIGH ALARM	DI	LSHH-93144
	GAC FACILITY EXTERIOR LIGHTING CONTACTOR	ON/OFF	DI	
	GAC FACILITY INTERIOR LIGHTING CONTACTOR	ON/OFF	DI	
	GAC FACILITY EXHAUST FANS	RUN	DI	
	GAC FACILITY EXHAUST FANS	FAIL	DI	

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Tag Number	Service Description	State/Span	Type	Remarks
RTU-7				
YLR-35121	GAC BYPASS VALVE	IN REMOTE	DI	MOV-35121
ZLO-35121	GAC BYPASS VALVE	OPEN	DI	
ZLC-35121	GAC BYPASS VALVE	CLOSED	DI	
ZSO-35121	GAC BYPASS VALVE	OPEN	DO	
ZSC-35121	GAC BYPASS VALVE	CLOSE	DO	
AI-35143	FILTERED WATER FLUME pH		AI	AE/AIT-35143
AI-35144	FILTERED WATER FLUME TEMP		AI	AE-35144/AIT-35143
AI-35145	FILTERED WATER FLUME TURBIDITY		AI	AE/AIT-35145
AI-35146	FILTERED WATER FLUME FREE CHLORINE		AI	AE-35146/AIT-35143

Tag Number	Service Description	State/Span	Type	Remarks
LI-35147	FILTERED WATER FLUME LEVEL		AI	LE/LIT-35147
LI-35148	FILTERED WATER FLUME LEVEL		AI	LE/LIT-35148
YLR-35101	GAC FEED PUMP NO. 1	IN REMOTE	DI	P-35101
YN-35101	GAC FEED PUMP NO. 1	RUN	DI	
YA-35101	GAC FEED PUMP NO. 1	FAIL	DI	
YY-35101	GAC FEED PUMP NO. 1	START/STOP	DO	
SI-35101	GAC FEED PUMP NO. 1 SPEED FEEDBACK	0-100%	AI	
SC-35101	GAC FEED PUMP NO. 1 SPEED CONTROL	0-100%	AO	
TAH-35101	GAC FEED PUMP NO. 1 MOTOR TEMP	HIGH	DI	
PAH-35141	GAC FEED PUMP NO. 1 DISCHARGE PRESSURE	HIGH	DI	
YLR-35201	GAC FEED PUMP NO. 2	IN REMOTE	DI	P-35201
YN-35201	GAC FEED PUMP NO. 2	RUN	DI	
YA-35201	GAC FEED PUMP NO. 2	FAIL	DI	
YY-35201	GAC FEED PUMP NO. 2	START/STOP	DO	
SI-35201	GAC FEED PUMP NO. 2 SPEED FEEDBACK	0-100%	AI	
SC-35201	GAC FEED PUMP NO. 2 SPEED CONTROL	0-100%	AO	
TAH-35201	GAC FEED PUMP NO. 2 MOTOR TEMP	HIGH	DI	
PAH-35241	GAC FEED PUMP NO. 2 DISCHARGE PRESSURE	HIGH	DI	
YLR-35301	GAC FEED PUMP NO. 3	IN REMOTE	DI	P-35301
YN-35301	GAC FEED PUMP NO. 3	RUN	DI	
YA-35301	GAC FEED PUMP NO. 3	FAIL	DI	
YY-35301	GAC FEED PUMP NO. 3	START/STOP	DO	
SI-35301	GAC FEED PUMP NO. 3 SPEED FEEDBACK	0-100%	AI	
SC-35301	GAC FEED PUMP NO. 3 SPEED CONTROL	0-100%	AO	
TAH-35301	GAC FEED PUMP NO. 3 MOTOR TEMP	HIGH	DI	
PAH-35341	GAC FEED PUMP NO. 3 DISCHARGE PRESSURE	HIGH	DI	

Tag Number	Service Description	State/Span	Type	Remarks
FI-35142	GAC INFLUENT FLOW		AI	FE/FIT-35142
YLR-36101	GAC BACKWASH PUMP NO. 1	IN REMOTE	DI	P-36101
YN-36101	GAC BACKWASH PUMP NO. 1	RUN	DI	
YA-36101	GAC BACKWASH PUMP NO. 1	FAIL	DI	
YY-36101	GAC BACKWASH PUMP NO. 1	START/STOP	DO	
SI-36101	GAC BACKWASH PUMP NO. 1 SPEED BACKWASHBACK	0-100%	AI	
SC-36101	GAC BACKWASH PUMP NO. 1 SPEED CONTROL	0-100%	AO	
TAH-36101	GAC BACKWASH PUMP NO. 1 MOTOR TEMP	HIGH	DI	
PAH-36141	GAC BACKWASH PUMP NO. 1 DISCHARGE PRESSURE	HIGH	DI	
YLR-36201	GAC BACKWASH PUMP NO. 2	IN REMOTE	DI	P-36201
YN-36201	GAC BACKWASH PUMP NO. 2	RUN	DI	
YA-36201	GAC BACKWASH PUMP NO. 2	FAIL	DI	
YY-36201	GAC BACKWASH PUMP NO. 2	START/STOP	DO	
SI-36201	GAC BACKWASH PUMP NO. 2 SPEED BACKWASHBACK	0-100%	AI	
SC-36201	GAC BACKWASH PUMP NO. 2 SPEED CONTROL	0-100%	AO	
TAH-36201	GAC BACKWASH PUMP NO. 2 MOTOR TEMP	HIGH	DI	
PAH-36241	GAC BACKWASH PUMP NO. 2 DISCHARGE PRESSURE	HIGH	DI	
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ZSO-33121	GAC NO. 1 INFLUENT VALVE	OPEN	DO	MOV-33121
ZSC-33121	GAC NO. 1 INFLUENT VALVE	CLOSE	DO	
ZLO-33121	GAC NO. 1 INFLUENT VALVE	OPEN	DI	
ZLC-33121	GAC NO. 1 INFLUENT VALVE	CLOSED	DI	
YLR-33121	GAC NO. 1 INFLUENT VALVE	IN REMOTE	DI	
ZSO-33122A	GAC NO. 1 WASH WATER SUPPLY ISOLATION VALVE	OPEN	DO	MOV-33122A
ZSC-33122A	GAC NO. 1 WASH WATER SUPPLY ISOLATION VALVE	CLOSE	DO	

Tag Number	Service Description	State/Span	Type	Remarks
ZLO-33122A	GAC NO. 1 WASH WATER SUPPLY ISOLATION VALVE	OPEN	DI	
ZLC-33122A	GAC NO. 1 WASH WATER SUPPLY ISOLATION VALVE	CLOSED	DI	
YLR-33122A	GAC NO. 1 WASH WATER SUPPLY ISOLATION VALVE	IN REMOTE	DI	
ZSO-33122B	GAC NO. 1 BACKWASH WASTE ISOLATION VALVE	OPEN	DO	MOV-33122B
ZSC-33122B	GAC NO. 1 BACKWASH WASTE ISOLATION VALVE	CLOSE	DO	
ZLO-33122B	GAC NO. 1 BACKWASH WASTE ISOLATION VALVE	OPEN	DI	
ZLC-33122B	GAC NO. 1 BACKWASH WASTE ISOLATION VALVE	CLOSED	DI	
YLR-33122B	GAC NO. 1 BACKWASH WASTE ISOLATION VALVE	IN REMOTE	DI	
ZSO-33123A	GAC NO. 1 EFFLUENT ISOLATION VALVE	OPEN	DO	MOV-33123A
ZSC-33123A	GAC NO. 1 EFFLUENT ISOLATION VALVE	CLOSE	DO	
ZLO-33123A	GAC NO. 1 EFFLUENT ISOLATION VALVE	OPEN	DI	
ZLC-33123A	GAC NO. 1 EFFLUENT ISOLATION VALVE	CLOSED	DI	
YLR-33123A	GAC NO. 1 EFFLUENT ISOLATION VALVE	IN REMOTE	DI	
ZSO-33123B	GAC NO. 1 TO WASTE ISOLATION VALVE	OPEN	DO	MOV-33123B
ZSC-33123B	GAC NO. 1 TO WASTE ISOLATION VALVE	CLOSE	DO	
ZLO-33123B	GAC NO. 1 TO WASTE ISOLATION VALVE	OPEN	DI	
ZLC-33123B	GAC NO. 1 TO WASTE ISOLATION VALVE	CLOSED	DI	
YLR-33123B	GAC NO. 1 TO WASTE ISOLATION VALVE	IN REMOTE	DI	
ZI-33124	GAC NO. 1 EFFLUENT CONTROL VALVE POSITION FEEDBACK	0-100%	AI	MOV-33124
ZC-33124	GAC NO. 1 EFFLUENT CONTROL VALVE POSITION CONTROL	0-100%	AO	
YLR-33124	GAC NO. 1 EFFLUENT CONTROL VALVE	IN REMOTE	DI	
FI-33141	GAC NO. 1 EFFLUENT FLOW RATE		AI	FE/FIT-33141
PDI-33142A	GAC NO. 1 LEFT CONTACTOR LOSS OF HEAD		AI	PDIT-33142A

Tag Number	Service Description	State/Span	Type	Remarks
PDI-33142B	GAC NO. 1 RIGHT CONTACTOR LOSS OF HEAD		AI	PDIT-33142B
LI-33143A	GAC NO. 1 LEFT CONTACTOR LEVEL		AI	LE/LIT-33143A
LI-33143B	GAC NO. 1 RIGHT CONTACTOR LEVEL		AI	LE/LIT-33143B
ZSO-33125	GAC NO. 1 LEFT CONTACTOR EFFLUENT ISOLATION VALVE	OPEN	DO	MOV-33125
ZSC-33125	GAC NO. 1 LEFT CONTACTOR EFFLUENT ISOLATION VALVE	CLOSE	DO	
ZLO-33125	GAC NO. 1 LEFT CONTACTOR EFFLUENT ISOLATION VALVE	OPEN	DI	
ZLC-33125	GAC NO. 1 LEFT CONTACTOR EFFLUENT ISOLATION VALVE	CLOSED	DI	
YLR-33125	GAC NO. 1 LEFT CONTACTOR EFFLUENT ISOLATION VALVE	IN REMOTE	DI	
ZSO-33126	GAC NO. 1 RIGHT CONTACTOR EFFLUENT ISOLATION VALVE	OPEN	DO	MOV-33126
ZSC-33126	GAC NO. 1 RIGHT CONTACTOR EFFLUENT ISOLATION VALVE	CLOSE	DO	
ZLO-33126	GAC NO. 1 RIGHT CONTACTOR EFFLUENT ISOLATION VALVE	OPEN	DI	
ZLC-33126	GAC NO. 1 RIGHT CONTACTOR EFFLUENT ISOLATION VALVE	CLOSED	DI	
YLR-33126	GAC NO. 1 RIGHT CONTACTOR EFFLUENT ISOLATION VALVE	IN REMOTE	DI	
ZSO-33221	GAC NO. 2 INFLUENT VALVE	OPEN	DO	MOV-33221
ZSC-33221	GAC NO. 2 INFLUENT VALVE	CLOSE	DO	
ZLO-33221	GAC NO. 2 INFLUENT VALVE	OPEN	DI	
ZLC-33221	GAC NO. 2 INFLUENT VALVE	CLOSED	DI	
YLR-33221	GAC NO. 2 INFLUENT VALVE	IN REMOTE	DI	
ZSO-33222A	GAC NO. 2 WASH WATER SUPPLY ISOLATION VALVE	OPEN	DO	MOV-33222A
ZSC-33222A	GAC NO. 2 WASH WATER SUPPLY ISOLATION VALVE	CLOSE	DO	
ZLO-33222A	GAC NO. 2 WASH WATER SUPPLY ISOLATION VALVE	OPEN	DI	
ZLC-33222A	GAC NO. 2 WASH WATER SUPPLY ISOLATION VALVE	CLOSED	DI	
YLR-33222A	GAC NO. 2 WASH WATER SUPPLY ISOLATION VALVE	IN REMOTE	DI	

Tag Number	Service Description	State/Span	Type	Remarks
ZSO-33222B	GAC NO. 2 BACKWASH WASTE ISOLATION VALVE	OPEN	DO	MOV-33222B
ZSC-33222B	GAC NO. 2 BACKWASH WASTE ISOLATION VALVE	CLOSE	DO	
ZLO-33222B	GAC NO. 2 BACKWASH WASTE ISOLATION VALVE	OPEN	DI	
ZLC-33222B	GAC NO. 2 BACKWASH WASTE ISOLATION VALVE	CLOSED	DI	
YLR-33222B	GAC NO. 2 BACKWASH WASTE ISOLATION VALVE	IN REMOTE	DI	
ZSO-33223A	GAC NO. 2 EFFLUENT ISOLATION VALVE	OPEN	DO	MOV-33223A
ZSC-33223A	GAC NO. 2 EFFLUENT ISOLATION VALVE	CLOSE	DO	
ZLO-33223A	GAC NO. 2 EFFLUENT ISOLATION VALVE	OPEN	DI	
ZLC-33223A	GAC NO. 2 EFFLUENT ISOLATION VALVE	CLOSED	DI	
YLR-33223A	GAC NO. 2 EFFLUENT ISOLATION VALVE	IN REMOTE	DI	
ZSO-33223B	GAC NO. 2 TO WASTE ISOLATION VALVE	OPEN	DO	MOV-33223B
ZSC-33223B	GAC NO. 2 TO WASTE ISOLATION VALVE	CLOSE	DO	
ZLO-33223B	GAC NO. 2 TO WASTE ISOLATION VALVE	OPEN	DI	
ZLC-33223B	GAC NO. 2 TO WASTE ISOLATION VALVE	CLOSED	DI	
YLR-33223B	GAC NO. 2 TO WASTE ISOLATION VALVE	IN REMOTE	DI	
ZI-33224	GAC NO. 2 EFFLUENT CONTROL VALVE POSITION FEEDBACK	0-100%	AI	MOV-33224
ZC-33224	GAC NO. 2 EFFLUENT CONTROL VALVE POSITION CONTROL	0-100%	AO	
YLR-33224	GAC NO. 2 EFFLUENT CONTROL VALVE	IN REMOTE	DI	
FI-33241	GAC NO. 2 EFFLUENT FLOW RATE		AI	FE/FIT-33241
PDI-33242A	GAC NO. 2 LEFT CONTACTOR LOSS OF HEAD		AI	PDIT-33242A
PDI-33242B	GAC NO. 2 RIGHT CONTACTOR LOSS OF HEAD		AI	PDIT-33242B
LI-33243A	GAC NO. 2 LEFT CONTACTOR LEVEL		AI	LE/LIT-33243A

Tag Number	Service Description	State/Span	Type	Remarks
LI-33243B	GAC NO. 2 RIGHT CONTACTOR LEVEL		AI	LE/LIT-33243B
ZSO-33225	GAC NO. 2 LEFT CONTACTOR EFFLUENT ISOLATION VALVE	OPEN	DO	MOV-33225
ZSC-33225	GAC NO. 2 LEFT CONTACTOR EFFLUENT ISOLATION VALVE	CLOSE	DO	
ZLO-33225	GAC NO. 2 LEFT CONTACTOR EFFLUENT ISOLATION VALVE	OPEN	DI	
ZLC-33225	GAC NO. 2 LEFT CONTACTOR EFFLUENT ISOLATION VALVE	CLOSED	DI	
YLR-33225	GAC NO. 2 LEFT CONTACTOR EFFLUENT ISOLATION VALVE	IN REMOTE	DI	
ZSO-33226	GAC NO. 2 RIGHT CONTACTOR EFFLUENT ISOLATION VALVE	OPEN	DO	MOV-33226
ZSC-33226	GAC NO. 2 RIGHT CONTACTOR EFFLUENT ISOLATION VALVE	CLOSE	DO	
ZLO-33226	GAC NO. 2 RIGHT CONTACTOR EFFLUENT ISOLATION VALVE	OPEN	DI	
ZLC-33226	GAC NO. 2 RIGHT CONTACTOR EFFLUENT ISOLATION VALVE	CLOSED	DI	
YLR-33226	GAC NO. 2 RIGHT CONTACTOR EFFLUENT ISOLATION VALVE	IN REMOTE	DI	

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ZSO-33321	GAC NO. 3 INFLUENT VALVE	OPEN	DO	MOV-33321
ZSC-33321	GAC NO. 3 INFLUENT VALVE	CLOSE	DO	
ZLO-33321	GAC NO. 3 INFLUENT VALVE	OPEN	DI	
ZLC-33321	GAC NO. 3 INFLUENT VALVE	CLOSED	DI	
YLR-33321	GAC NO. 3 INFLUENT VALVE	IN REMOTE	DI	
ZSO-33322A	GAC NO. 3 WASH WATER SUPPLY ISOLATION VALVE	OPEN	DO	MOV-33322A
ZSC-33322A	GAC NO. 3 WASH WATER SUPPLY ISOLATION VALVE	CLOSE	DO	
ZLO-33322A	GAC NO. 3 WASH WATER SUPPLY ISOLATION VALVE	OPEN	DI	
ZLC-33322A	GAC NO. 3 WASH WATER SUPPLY ISOLATION VALVE	CLOSED	DI	
YLR-33322A	GAC NO. 3 WASH WATER SUPPLY ISOLATION VALVE	IN REMOTE	DI	
ZSO-33322B	GAC NO. 3 BACKWASH WASTE ISOLATION VALVE	OPEN	DO	MOV-33322B

Tag Number	Service Description	State/Span	Type	Remarks
ZSC-33322B	GAC NO. 3 BACKWASH WASTE ISOLATION VALVE	CLOSE	DO	
ZLO-33322B	GAC NO. 3 BACKWASH WASTE ISOLATION VALVE	OPEN	DI	
ZLC-33322B	GAC NO. 3 BACKWASH WASTE ISOLATION VALVE	CLOSED	DI	
YLR-33322B	GAC NO. 3 BACKWASH WASTE ISOLATION VALVE	IN REMOTE	DI	
ZSO-33323A	GAC NO. 3 EFFLUENT ISOLATION VALVE	OPEN	DO	MOV-33323A
ZSC-33323A	GAC NO. 3 EFFLUENT ISOLATION VALVE	CLOSE	DO	
ZLO-33323A	GAC NO. 3 EFFLUENT ISOLATION VALVE	OPEN	DI	
ZLC-33323A	GAC NO. 3 EFFLUENT ISOLATION VALVE	CLOSED	DI	
YLR-33323A	GAC NO. 3 EFFLUENT ISOLATION VALVE	IN REMOTE	DI	
ZSO-33323B	GAC NO. 3 TO WASTE ISOLATION VALVE	OPEN	DO	MOV-33323B
ZSC-33323B	GAC NO. 3 TO WASTE ISOLATION VALVE	CLOSE	DO	
ZLO-33323B	GAC NO. 3 TO WASTE ISOLATION VALVE	OPEN	DI	
ZLC-33323B	GAC NO. 3 TO WASTE ISOLATION VALVE	CLOSED	DI	
YLR-33323B	GAC NO. 3 TO WASTE ISOLATION VALVE	IN REMOTE	DI	
ZI-33324	GAC NO. 3 EFFLUENT CONTROL VALVE POSITION FEEDBACK	0-100%	AI	MOV-33324
ZC-33324	GAC NO. 3 EFFLUENT CONTROL VALVE POSITION CONTROL	0-100%	AO	
YLR-33324	GAC NO. 3 EFFLUENT CONTROL VALVE	IN REMOTE	DI	
FI-33341	GAC NO. 3 EFFLUENT FLOW RATE		AI	FE/FIT-33341
PDI-33342A	GAC NO. 3 LEFT CONTACTOR LOSS OF HEAD		AI	PDIT-33342A
PDI-33342B	GAC NO. 3 RIGHT CONTACTOR LOSS OF HEAD		AI	PDIT-33342B
LI-33343A	GAC NO. 3 LEFT CONTACTOR LEVEL		AI	LE/LIT-33343A
LI-33343B	GAC NO. 3 RIGHT CONTACTOR LEVEL		AI	LE/LIT-33343B

Tag Number	Service Description	State/Span	Type	Remarks
ZSO-33325	GAC NO. 3 LEFT CONTACTOR EFFLUENT ISOLATION VALVE	OPEN	DO	MOV-33325
ZSC-33325	GAC NO. 3 LEFT CONTACTOR EFFLUENT ISOLATION VALVE	CLOSE	DO	
ZLO-33325	GAC NO. 3 LEFT CONTACTOR EFFLUENT ISOLATION VALVE	OPEN	DI	
ZLC-33325	GAC NO. 3 LEFT CONTACTOR EFFLUENT ISOLATION VALVE	CLOSED	DI	
YLR-33325	GAC NO. 3 LEFT CONTACTOR EFFLUENT ISOLATION VALVE	IN REMOTE	DI	
ZSO-33326	GAC NO. 3 RIGHT CONTACTOR EFFLUENT ISOLATION VALVE	OPEN	DO	MOV-33326
ZSC-33326	GAC NO. 3 RIGHT CONTACTOR EFFLUENT ISOLATION VALVE	CLOSE	DO	
ZLO-33326	GAC NO. 3 RIGHT CONTACTOR EFFLUENT ISOLATION VALVE	OPEN	DI	
ZLC-33326	GAC NO. 3 RIGHT CONTACTOR EFFLUENT ISOLATION VALVE	CLOSED	DI	
YLR-33326	GAC NO. 3 RIGHT CONTACTOR EFFLUENT ISOLATION VALVE	IN REMOTE	DI	
ZSO-33421	GAC NO. 4 INFLUENT VALVE	OPEN	DO	MOV-33421
ZSC-33421	GAC NO. 4 INFLUENT VALVE	CLOSE	DO	
ZLO-33421	GAC NO. 4 INFLUENT VALVE	OPEN	DI	
ZLC-33421	GAC NO. 4 INFLUENT VALVE	CLOSED	DI	
YLR-33421	GAC NO. 4 INFLUENT VALVE	IN REMOTE	DI	
ZSO-33422A	GAC NO. 4 WASH WATER SUPPLY ISOLATION VALVE	OPEN	DO	MOV-33422A
ZSC-33422A	GAC NO. 4 WASH WATER SUPPLY ISOLATION VALVE	CLOSE	DO	
ZLO-33422A	GAC NO. 4 WASH WATER SUPPLY ISOLATION VALVE	OPEN	DI	
ZLC-33422A	GAC NO. 4 WASH WATER SUPPLY ISOLATION VALVE	CLOSED	DI	
YLR-33422A	GAC NO. 4 WASH WATER SUPPLY ISOLATION VALVE	IN REMOTE	DI	
ZSO-33422B	GAC NO. 4 BACKWASH WASTE ISOLATION VALVE	OPEN	DO	MOV-33422B
ZSC-33422B	GAC NO. 4 BACKWASH WASTE ISOLATION VALVE	CLOSE	DO	
ZLO-33422B	GAC NO. 4 BACKWASH WASTE ISOLATION VALVE	OPEN	DI	
ZLC-33422B	GAC NO. 4 BACKWASH WASTE ISOLATION VALVE	CLOSED	DI	

Tag Number	Service Description	State/Span	Type	Remarks
YLR-33422B	GAC NO. 4 BACKWASH WASTE ISOLATION VALVE	IN REMOTE	DI	
ZSO-33423A	GAC NO. 4 EFFLUENT ISOLATION VALVE	OPEN	DO	MOV-33423A
ZSC-33423A	GAC NO. 4 EFFLUENT ISOLATION VALVE	CLOSE	DO	
ZLO-33423A	GAC NO. 4 EFFLUENT ISOLATION VALVE	OPEN	DI	
ZLC-33423A	GAC NO. 4 EFFLUENT ISOLATION VALVE	CLOSED	DI	
YLR-33423A	GAC NO. 4 EFFLUENT ISOLATION VALVE	IN REMOTE	DI	
ZSO-33423B	GAC NO. 4 TO WASTE ISOLATION VALVE	OPEN	DO	MOV-33423B
ZSC-33423B	GAC NO. 4 TO WASTE ISOLATION VALVE	CLOSE	DO	
ZLO-33423B	GAC NO. 4 TO WASTE ISOLATION VALVE	OPEN	DI	
ZLC-33423B	GAC NO. 4 TO WASTE ISOLATION VALVE	CLOSED	DI	
YLR-33423B	GAC NO. 4 TO WASTE ISOLATION VALVE	IN REMOTE	DI	
ZI-33424	GAC NO. 4 EFFLUENT CONTROL VALVE POSITION FEEDBACK	0-100%	AI	MOV-33424
ZC-33424	GAC NO. 4 EFFLUENT CONTROL VALVE POSITION CONTROL	0-100%	AO	
YLR-33424	GAC NO. 4 EFFLUENT CONTROL VALVE	IN REMOTE	DI	
FI-33441	GAC NO. 4 EFFLUENT FLOW RATE		AI	FE/FIT-33441
PDI-33442A	GAC NO. 4 LEFT CONTACTOR LOSS OF HEAD		AI	PDIT-33442A
PDI-33442B	GAC NO. 4 RIGHT CONTACTOR LOSS OF HEAD		AI	PDIT-33442B
LI-33443A	GAC NO. 4 LEFT CONTACTOR LEVEL		AI	LE/LIT-33443A
LI-33443B	GAC NO. 4 RIGHT CONTACTOR LEVEL		AI	LE/LIT-33443B
ZSO-33425	GAC NO. 4 LEFT CONTACTOR EFFLUENT ISOLATION VALVE	OPEN	DO	MOV-33425
ZSC-33425	GAC NO. 4 LEFT CONTACTOR EFFLUENT ISOLATION VALVE	CLOSE	DO	
ZLO-33425	GAC NO. 4 LEFT CONTACTOR EFFLUENT ISOLATION VALVE	OPEN	DI	

Tag Number	Service Description	State/Span	Type	Remarks
ZLC-33425	GAC NO. 4 LEFT CONTACTOR EFFLUENT ISOLATION VALVE	CLOSED	DI	
YLR-33425	GAC NO. 4 LEFT CONTACTOR EFFLUENT ISOLATION VALVE	IN REMOTE	DI	
ZSO-33426	GAC NO. 4 RIGHT CONTACTOR EFFLUENT ISOLATION VALVE	OPEN	DO	MOV-33426
ZSC-33426	GAC NO. 4 RIGHT CONTACTOR EFFLUENT ISOLATION VALVE	CLOSE	DO	
ZLO-33426	GAC NO. 4 RIGHT CONTACTOR EFFLUENT ISOLATION VALVE	OPEN	DI	
ZLC-33426	GAC NO. 4 RIGHT CONTACTOR EFFLUENT ISOLATION VALVE	CLOSED	DI	
YLR-33426	GAC NO. 4 RIGHT CONTACTOR EFFLUENT ISOLATION VALVE	IN REMOTE	DI	
RTU-10				
ZSO-33521	GAC NO. 5 INFLUENT VALVE	OPEN	DO	MOV-33521
ZSC-33521	GAC NO. 5 INFLUENT VALVE	CLOSE	DO	
ZLO-33521	GAC NO. 5 INFLUENT VALVE	OPEN	DI	
ZLC-33521	GAC NO. 5 INFLUENT VALVE	CLOSED	DI	
YLR-33521	GAC NO. 5 INFLUENT VALVE	IN REMOTE	DI	
ZSO-33522A	GAC NO. 5 WASH WATER SUPPLY ISOLATION VALVE	OPEN	DO	MOV-33522A
ZSC-33522A	GAC NO. 5 WASH WATER SUPPLY ISOLATION VALVE	CLOSE	DO	
ZLO-33522A	GAC NO. 5 WASH WATER SUPPLY ISOLATION VALVE	OPEN	DI	
ZLC-33522A	GAC NO. 5 WASH WATER SUPPLY ISOLATION VALVE	CLOSED	DI	
YLR-33522A	GAC NO. 5 WASH WATER SUPPLY ISOLATION VALVE	IN REMOTE	DI	
ZSO-33522B	GAC NO. 5 BACKWASH WASTE ISOLATION VALVE	OPEN	DO	MOV-33522B
ZSC-33522B	GAC NO. 5 BACKWASH WASTE ISOLATION VALVE	CLOSE	DO	
ZLO-33522B	GAC NO. 5 BACKWASH WASTE ISOLATION VALVE	OPEN	DI	
ZLC-33522B	GAC NO. 5 BACKWASH WASTE ISOLATION VALVE	CLOSED	DI	
YLR-33522B	GAC NO. 5 BACKWASH WASTE ISOLATION VALVE	IN REMOTE	DI	

Tag Number	Service Description	State/Span	Type	Remarks
ZSO-33523A	GAC NO. 5 EFFLUENT ISOLATION VALVE	OPEN	DO	MOV-33523A
ZSC-33523A	GAC NO. 5 EFFLUENT ISOLATION VALVE	CLOSE	DO	
ZLO-33523A	GAC NO. 5 EFFLUENT ISOLATION VALVE	OPEN	DI	
ZLC-33523A	GAC NO. 5 EFFLUENT ISOLATION VALVE	CLOSED	DI	
YLR-33523A	GAC NO. 5 EFFLUENT ISOLATION VALVE	IN REMOTE	DI	
ZSO-33523B	GAC NO. 5 TO WASTE ISOLATION VALVE	OPEN	DO	MOV-33523B
ZSC-33523B	GAC NO. 5 TO WASTE ISOLATION VALVE	CLOSE	DO	
ZLO-33523B	GAC NO. 5 TO WASTE ISOLATION VALVE	OPEN	DI	
ZLC-33523B	GAC NO. 5 TO WASTE ISOLATION VALVE	CLOSED	DI	
YLR-33523B	GAC NO. 5 TO WASTE ISOLATION VALVE	IN REMOTE	DI	
ZI-33524	GAC NO. 5 EFFLUENT CONTROL VALVE POSITION FEEDBACK	0-100%	AI	MOV-33524
ZC-33524	GAC NO. 5 EFFLUENT CONTROL VALVE POSITION CONTROL	0-100%	AO	
YLR-33524	GAC NO. 5 EFFLUENT CONTROL VALVE	IN REMOTE	DI	
FI-33541	GAC NO. 5 EFFLUENT FLOW RATE		AI	FE/FIT-33541
PDI-33542A	GAC NO. 5 LEFT CONTACTOR LOSS OF HEAD		AI	PDIT-33542A
PDI-33542B	GAC NO. 5 RIGHT CONTACTOR LOSS OF HEAD		AI	PDIT-33542B
LI-33543A	GAC NO. 5 LEFT CONTACTOR LEVEL		AI	LE/LIT-33543A
LI-33543B	GAC NO. 5 RIGHT CONTACTOR LEVEL		AI	LE/LIT-33543B
ZSO-33525	GAC NO. 5 LEFT CONTACTOR EFFLUENT ISOLATION VALVE	OPEN	DO	MOV-33525
ZSC-33525	GAC NO. 5 LEFT CONTACTOR EFFLUENT ISOLATION VALVE	CLOSE	DO	
ZLO-33525	GAC NO. 5 LEFT CONTACTOR EFFLUENT ISOLATION VALVE	OPEN	DI	
ZLC-33525	GAC NO. 5 LEFT CONTACTOR EFFLUENT ISOLATION VALVE	CLOSED	DI	
YLR-33525	GAC NO. 5 LEFT CONTACTOR EFFLUENT ISOLATION VALVE	IN REMOTE	DI	

Tag Number	Service Description	State/Span	Type	Remarks
ZSO-33526	GAC NO. 5 RIGHT CONTACTOR EFFLUENT ISOLATION VALVE	OPEN	DO	MOV- 33526
ZSC-33526	GAC NO. 5 RIGHT CONTACTOR EFFLUENT ISOLATION VALVE	CLOSE	DO	
ZLO-33526	GAC NO. 5 RIGHT CONTACTOR EFFLUENT ISOLATION VALVE	OPEN	DI	
ZLC-33526	GAC NO. 5 RIGHT CONTACTOR EFFLUENT ISOLATION VALVE	CLOSED	DI	
YLR-33526	GAC NO. 5 RIGHT CONTACTOR EFFLUENT ISOLATION VALVE	IN REMOTE	DI	
ZSO-33621	GAC NO. 6 INFLUENT VALVE	OPEN	DO	MOV- 33621
ZSC-33621	GAC NO. 6 INFLUENT VALVE	CLOSE	DO	
ZLO-33621	GAC NO. 6 INFLUENT VALVE	OPEN	DI	
ZLC-33621	GAC NO. 6 INFLUENT VALVE	CLOSED	DI	
YLR-33621	GAC NO. 6 INFLUENT VALVE	IN REMOTE	DI	
ZSO-33622A	GAC NO. 6 WASH WATER SUPPLY ISOLATION VALVE	OPEN	DO	MOV- 33622A
ZSC-33622A	GAC NO. 6 WASH WATER SUPPLY ISOLATION VALVE	CLOSE	DO	
ZLO-33622A	GAC NO. 6 WASH WATER SUPPLY ISOLATION VALVE	OPEN	DI	
ZLC-33622A	GAC NO. 6 WASH WATER SUPPLY ISOLATION VALVE	CLOSED	DI	
YLR-33622A	GAC NO. 6 WASH WATER SUPPLY ISOLATION VALVE	IN REMOTE	DI	
ZSO-33622B	GAC NO. 6 BACKWASH WASTE ISOLATION VALVE	OPEN	DO	MOV- 33622B
ZSC-33622B	GAC NO. 6 BACKWASH WASTE ISOLATION VALVE	CLOSE	DO	
ZLO-33622B	GAC NO. 6 BACKWASH WASTE ISOLATION VALVE	OPEN	DI	
ZLC-33622B	GAC NO. 6 BACKWASH WASTE ISOLATION VALVE	CLOSED	DI	
YLR-33622B	GAC NO. 6 BACKWASH WASTE ISOLATION VALVE	IN REMOTE	DI	
ZSO-33623A	GAC NO. 6 EFFLUENT ISOLATION VALVE	OPEN	DO	MOV- 33623A
ZSC-33623A	GAC NO. 6 EFFLUENT ISOLATION VALVE	CLOSE	DO	
ZLO-33623A	GAC NO. 6 EFFLUENT ISOLATION VALVE	OPEN	DI	

Tag Number	Service Description	State/Span	Type	Remarks
ZLC-33623A	GAC NO. 6 EFFLUENT ISOLATION VALVE	CLOSED	DI	
YLR-33623A	GAC NO. 6 EFFLUENT ISOLATION VALVE	IN REMOTE	DI	
ZSO-33623B	GAC NO. 6 TO WASTE ISOLATION VALVE	OPEN	DO	MOV-33623B
ZSC-33623B	GAC NO. 6 TO WASTE ISOLATION VALVE	CLOSE	DO	
ZLO-33623B	GAC NO. 6 TO WASTE ISOLATION VALVE	OPEN	DI	
ZLC-33623B	GAC NO. 6 TO WASTE ISOLATION VALVE	CLOSED	DI	
YLR-33623B	GAC NO. 6 TO WASTE ISOLATION VALVE	IN REMOTE	DI	
ZI-33624	GAC NO. 6 EFFLUENT CONTROL VALVE POSITION FEEDBACK	0-100%	AI	MOV-33624
ZC-33624	GAC NO. 6 EFFLUENT CONTROL VALVE POSITION CONTROL	0-100%	AO	
YLR-33624	GAC NO. 6 EFFLUENT CONTROL VALVE	IN REMOTE	DI	
FI-33641	GAC NO. 6 EFFLUENT FLOW RATE		AI	FE/FIT-33641
PDI-33642A	GAC NO. 6 LEFT CONTACTOR LOSS OF HEAD		AI	PDIT-33642A
PDI-33642B	GAC NO. 6 RIGHT CONTACTOR LOSS OF HEAD		AI	PDIT-33642B
LI-33643A	GAC NO. 6 LEFT CONTACTOR LEVEL		AI	LE/LIT-33643A
LI-33643B	GAC NO. 6 RIGHT CONTACTOR LEVEL		AI	LE/LIT-33643B
ZSO-33625	GAC NO. 6 LEFT CONTACTOR EFFLUENT ISOLATION VALVE	OPEN	DO	MOV-33625
ZSC-33625	GAC NO. 6 LEFT CONTACTOR EFFLUENT ISOLATION VALVE	CLOSE	DO	
ZLO-33625	GAC NO. 6 LEFT CONTACTOR EFFLUENT ISOLATION VALVE	OPEN	DI	
ZLC-33625	GAC NO. 6 LEFT CONTACTOR EFFLUENT ISOLATION VALVE	CLOSED	DI	
YLR-33625	GAC NO. 6 LEFT CONTACTOR EFFLUENT ISOLATION VALVE	IN REMOTE	DI	
ZSO-33626	GAC NO. 6 RIGHT CONTACTOR EFFLUENT ISOLATION VALVE	OPEN	DO	MOV-33626
ZSC-33626	GAC NO. 6 RIGHT CONTACTOR EFFLUENT ISOLATION VALVE	CLOSE	DO	

Tag Number	Service Description	State/Span	Type	Remarks
ZLO-33626	GAC NO. 6 RIGHT CONTACTOR EFFLUENT ISOLATION VALVE	OPEN	DI	
ZLC-33626	GAC NO. 6 RIGHT CONTACTOR EFFLUENT ISOLATION VALVE	CLOSED	DI	
YLR-33626	GAC NO. 6 RIGHT CONTACTOR EFFLUENT ISOLATION VALVE	IN REMOTE	DI	
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ZSO-33721	GAC NO. 7 INFLUENT VALVE	OPEN	DO	MOV- 33721
ZSC-33721	GAC NO. 7 INFLUENT VALVE	CLOSE	DO	
ZLO-33721	GAC NO. 7 INFLUENT VALVE	OPEN	DI	
ZLC-33721	GAC NO. 7 INFLUENT VALVE	CLOSED	DI	
YLR-33721	GAC NO. 7 INFLUENT VALVE	IN REMOTE	DI	
ZSO-33722A	GAC NO. 7 WASH WATER SUPPLY ISOLATION VALVE	OPEN	DO	MOV- 33722A
ZSC-33722A	GAC NO. 7 WASH WATER SUPPLY ISOLATION VALVE	CLOSE	DO	
ZLO-33722A	GAC NO. 7 WASH WATER SUPPLY ISOLATION VALVE	OPEN	DI	
ZLC-33722A	GAC NO. 7 WASH WATER SUPPLY ISOLATION VALVE	CLOSED	DI	
YLR-33722A	GAC NO. 7 WASH WATER SUPPLY ISOLATION VALVE	IN REMOTE	DI	
ZSO-33722B	GAC NO. 7 BACKWASH WASTE ISOLATION VALVE	OPEN	DO	MOV- 33722B
ZSC-33722B	GAC NO. 7 BACKWASH WASTE ISOLATION VALVE	CLOSE	DO	
ZLO-33722B	GAC NO. 7 BACKWASH WASTE ISOLATION VALVE	OPEN	DI	
ZLC-33722B	GAC NO. 7 BACKWASH WASTE ISOLATION VALVE	CLOSED	DI	
YLR-33722B	GAC NO. 7 BACKWASH WASTE ISOLATION VALVE	IN REMOTE	DI	
ZSO-33723A	GAC NO. 7 EFFLUENT ISOLATION VALVE	OPEN	DO	MOV- 33723A
ZSC-33723A	GAC NO. 7 EFFLUENT ISOLATION VALVE	CLOSE	DO	
ZLO-33723A	GAC NO. 7 EFFLUENT ISOLATION VALVE	OPEN	DI	
ZLC-33723A	GAC NO. 7 EFFLUENT ISOLATION VALVE	CLOSED	DI	
YLR-33723A	GAC NO. 7 EFFLUENT ISOLATION VALVE	IN REMOTE	DI	

Tag Number	Service Description	State/Span	Type	Remarks
ZSO-33723B	GAC NO. 7 TO WASTE ISOLATION VALVE	OPEN	DO	MOV-33723B
ZSC-33723B	GAC NO. 7 TO WASTE ISOLATION VALVE	CLOSE	DO	
ZLO-33723B	GAC NO. 7 TO WASTE ISOLATION VALVE	OPEN	DI	
ZLC-33723B	GAC NO. 7 TO WASTE ISOLATION VALVE	CLOSED	DI	
YLR-33723B	GAC NO. 7 TO WASTE ISOLATION VALVE	IN REMOTE	DI	
ZI-33724	GAC NO. 7 EFFLUENT CONTROL VALVE POSITION FEEDBACK	0-100%	AI	MOV-33724
ZC-33724	GAC NO. 7 EFFLUENT CONTROL VALVE POSITION CONTROL	0-100%	AO	
YLR-33724	GAC NO. 7 EFFLUENT CONTROL VALVE	IN REMOTE	DI	
FI-33741	GAC NO. 7 EFFLUENT FLOW RATE		AI	FE/FIT-33741
PDI-33742A	GAC NO. 7 LEFT CONTACTOR LOSS OF HEAD		AI	PDIT-33742A
PDI-33742B	GAC NO. 7 RIGHT CONTACTOR LOSS OF HEAD		AI	PDIT-33742B
LI-33743A	GAC NO. 7 LEFT CONTACTOR LEVEL		AI	LE/LIT-33743A
LI-33743B	GAC NO. 7 RIGHT CONTACTOR LEVEL		AI	LE/LIT-33743B
ZSO-33725	GAC NO. 7 LEFT CONTACTOR EFFLUENT ISOLATION VALVE	OPEN	DO	MOV-33725
ZSC-33725	GAC NO. 7 LEFT CONTACTOR EFFLUENT ISOLATION VALVE	CLOSE	DO	
ZLO-33725	GAC NO. 7 LEFT CONTACTOR EFFLUENT ISOLATION VALVE	OPEN	DI	
ZLC-33725	GAC NO. 7 LEFT CONTACTOR EFFLUENT ISOLATION VALVE	CLOSED	DI	
YLR-33725	GAC NO. 7 LEFT CONTACTOR EFFLUENT ISOLATION VALVE	IN REMOTE	DI	
ZSO-33726	GAC NO. 7 RIGHT CONTACTOR EFFLUENT ISOLATION VALVE	OPEN	DO	MOV-33726
ZSC-33726	GAC NO. 7 RIGHT CONTACTOR EFFLUENT ISOLATION VALVE	CLOSE	DO	
ZLO-33726	GAC NO. 7 RIGHT CONTACTOR EFFLUENT ISOLATION VALVE	OPEN	DI	
ZLC-33726	GAC NO. 7 RIGHT CONTACTOR EFFLUENT ISOLATION VALVE	CLOSED	DI	

Tag Number	Service Description	State/Span	Type	Remarks
YLR-33726	GAC NO. 7 RIGHT CONTACTOR EFFLUENT ISOLATION VALVE	IN REMOTE	DI	
ZSO-33821	GAC NO. 8 INFLUENT VALVE	OPEN	DO	MOV- 33821
ZSC-33821	GAC NO. 8 INFLUENT VALVE	CLOSE	DO	
ZLO-33821	GAC NO. 8 INFLUENT VALVE	OPEN	DI	
ZLC-33821	GAC NO. 8 INFLUENT VALVE	CLOSED	DI	
YLR-33821	GAC NO. 8 INFLUENT VALVE	IN REMOTE	DI	
ZSO-33822A	GAC NO. 8 WASH WATER SUPPLY ISOLATION VALVE	OPEN	DO	MOV- 33822A
ZSC-33822A	GAC NO. 8 WASH WATER SUPPLY ISOLATION VALVE	CLOSE	DO	
ZLO-33822A	GAC NO. 8 WASH WATER SUPPLY ISOLATION VALVE	OPEN	DI	
ZLC-33822A	GAC NO. 8 WASH WATER SUPPLY ISOLATION VALVE	CLOSED	DI	
YLR-33822A	GAC NO. 8 WASH WATER SUPPLY ISOLATION VALVE	IN REMOTE	DI	
ZSO-33822B	GAC NO. 8 BACKWASH WASTE ISOLATION VALVE	OPEN	DO	MOV- 33822B
ZSC-33822B	GAC NO. 8 BACKWASH WASTE ISOLATION VALVE	CLOSE	DO	
ZLO-33822B	GAC NO. 8 BACKWASH WASTE ISOLATION VALVE	OPEN	DI	
ZLC-33822B	GAC NO. 8 BACKWASH WASTE ISOLATION VALVE	CLOSED	DI	
YLR-33822B	GAC NO. 8 BACKWASH WASTE ISOLATION VALVE	IN REMOTE	DI	
ZSO-33823A	GAC NO. 8 EFFLUENT ISOLATION VALVE	OPEN	DO	MOV- 33823A
ZSC-33823A	GAC NO. 8 EFFLUENT ISOLATION VALVE	CLOSE	DO	
ZLO-33823A	GAC NO. 8 EFFLUENT ISOLATION VALVE	OPEN	DI	
ZLC-33823A	GAC NO. 8 EFFLUENT ISOLATION VALVE	CLOSED	DI	
YLR-33823A	GAC NO. 8 EFFLUENT ISOLATION VALVE	IN REMOTE	DI	
ZSO-33823B	GAC NO. 8 TO WASTE ISOLATION VALVE	OPEN	DO	MOV- 33823B
ZSC-33823B	GAC NO. 8 TO WASTE ISOLATION VALVE	CLOSE	DO	
ZLO-33823B	GAC NO. 8 TO WASTE ISOLATION VALVE	OPEN	DI	

Tag Number	Service Description	State/Span	Type	Remarks
ZLC-33823B	GAC NO. 8 TO WASTE ISOLATION VALVE	CLOSED	DI	
YLR-33823B	GAC NO. 8 TO WASTE ISOLATION VALVE	IN REMOTE	DI	
ZI-33824	GAC NO. 8 EFFLUENT CONTROL VALVE POSITION FEEDBACK	0-100%	AI	MOV-33824
ZC-33824	GAC NO. 8 EFFLUENT CONTROL VALVE POSITION CONTROL	0-100%	AO	
YLR-33824	GAC NO. 8 EFFLUENT CONTROL VALVE	IN REMOTE	DI	
FI-33841	GAC NO. 8 EFFLUENT FLOW RATE		AI	FE/FIT-33841
PDI-33842A	GAC NO. 8 LEFT CONTACTOR LOSS OF HEAD		AI	PDIT-33842A
PDI-33842B	GAC NO. 8 RIGHT CONTACTOR LOSS OF HEAD		AI	PDIT-33842B
LI-33843A	GAC NO. 8 LEFT CONTACTOR LEVEL		AI	LE/LIT-33843A
LI-33843B	GAC NO. 8 RIGHT CONTACTOR LEVEL		AI	LE/LIT-33843B
ZSO-33825	GAC NO. 8 LEFT CONTACTOR EFFLUENT ISOLATION VALVE	OPEN	DO	MOV-33825
ZSC-33825	GAC NO. 8 LEFT CONTACTOR EFFLUENT ISOLATION VALVE	CLOSE	DO	
ZLO-33825	GAC NO. 8 LEFT CONTACTOR EFFLUENT ISOLATION VALVE	OPEN	DI	
ZLC-33825	GAC NO. 8 LEFT CONTACTOR EFFLUENT ISOLATION VALVE	CLOSED	DI	
YLR-33825	GAC NO. 8 LEFT CONTACTOR EFFLUENT ISOLATION VALVE	IN REMOTE	DI	
ZSO-33826	GAC NO. 8 RIGHT CONTACTOR EFFLUENT ISOLATION VALVE	OPEN	DO	MOV-33826
ZSC-33826	GAC NO. 8 RIGHT CONTACTOR EFFLUENT ISOLATION VALVE	CLOSE	DO	
ZLO-33826	GAC NO. 8 RIGHT CONTACTOR EFFLUENT ISOLATION VALVE	OPEN	DI	
ZLC-33826	GAC NO. 8 RIGHT CONTACTOR EFFLUENT ISOLATION VALVE	CLOSED	DI	
YLR-33826	GAC NO. 8 RIGHT CONTACTOR EFFLUENT ISOLATION VALVE	IN REMOTE	DI	

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Tag Number	Service Description	State/Span	Type	Remarks
ZSO-33921	GAC NO. 9 INFLUENT VALVE	OPEN	DO	MOV-33921
ZSC-33921	GAC NO. 9 INFLUENT VALVE	CLOSE	DO	
ZLO-33921	GAC NO. 9 INFLUENT VALVE	OPEN	DI	
ZLC-33921	GAC NO. 9 INFLUENT VALVE	CLOSED	DI	
YLR-33921	GAC NO. 9 INFLUENT VALVE	IN REMOTE	DI	
ZSO-33922A	GAC NO. 9 WASH WATER SUPPLY ISOLATION VALVE	OPEN	DO	MOV-33922A
ZSC-33922A	GAC NO. 9 WASH WATER SUPPLY ISOLATION VALVE	CLOSE	DO	
ZLO-33922A	GAC NO. 9 WASH WATER SUPPLY ISOLATION VALVE	OPEN	DI	
ZLC-33922A	GAC NO. 9 WASH WATER SUPPLY ISOLATION VALVE	CLOSED	DI	
YLR-33922A	GAC NO. 9 WASH WATER SUPPLY ISOLATION VALVE	IN REMOTE	DI	
ZSO-33922B	GAC NO. 9 BACKWASH WASTE ISOLATION VALVE	OPEN	DO	MOV-33922B
ZSC-33922B	GAC NO. 9 BACKWASH WASTE ISOLATION VALVE	CLOSE	DO	
ZLO-33922B	GAC NO. 9 BACKWASH WASTE ISOLATION VALVE	OPEN	DI	
ZLC-33922B	GAC NO. 9 BACKWASH WASTE ISOLATION VALVE	CLOSED	DI	
YLR-33922B	GAC NO. 9 BACKWASH WASTE ISOLATION VALVE	IN REMOTE	DI	
ZSO-33923A	GAC NO. 9 EFFLUENT ISOLATION VALVE	OPEN	DO	MOV-33923A
ZSC-33923A	GAC NO. 9 EFFLUENT ISOLATION VALVE	CLOSE	DO	
ZLO-33923A	GAC NO. 9 EFFLUENT ISOLATION VALVE	OPEN	DI	
ZLC-33923A	GAC NO. 9 EFFLUENT ISOLATION VALVE	CLOSED	DI	
YLR-33923A	GAC NO. 9 EFFLUENT ISOLATION VALVE	IN REMOTE	DI	
ZSO-33923B	GAC NO. 9 TO WASTE ISOLATION VALVE	OPEN	DO	MOV-33923B
ZSC-33923B	GAC NO. 9 TO WASTE ISOLATION VALVE	CLOSE	DO	
ZLO-33923B	GAC NO. 9 TO WASTE ISOLATION VALVE	OPEN	DI	
ZLC-33923B	GAC NO. 9 TO WASTE ISOLATION VALVE	CLOSED	DI	
YLR-33923B	GAC NO. 9 TO WASTE ISOLATION VALVE	IN REMOTE	DI	

Tag Number	Service Description	State/Span	Type	Remarks
ZI-33924	GAC NO. 9 EFFLUENT CONTROL VALVE POSITION FEEDBACK	0-100%	AI	MOV-33924
ZC-33924	GAC NO. 9 EFFLUENT CONTROL VALVE POSITION CONTROL	0-100%	AO	
YLR-33924	GAC NO. 9 EFFLUENT CONTROL VALVE	IN REMOTE	DI	
FI-33941	GAC NO. 9 EFFLUENT FLOW RATE		AI	FE/FIT-33941
PDI-33942A	GAC NO. 9 LEFT CONTACTOR LOSS OF HEAD		AI	PDIT-33942A
PDI-33942B	GAC NO. 9 RIGHT CONTACTOR LOSS OF HEAD		AI	PDIT-33942B
LI-33943A	GAC NO. 9 LEFT CONTACTOR LEVEL		AI	LE/LIT-33943A
LI-33943B	GAC NO. 9 RIGHT CONTACTOR LEVEL		AI	LE/LIT-33943B
ZSO-33925	GAC NO. 9 LEFT CONTACTOR EFFLUENT ISOLATION VALVE	OPEN	DO	MOV-33925
ZSC-33925	GAC NO. 9 LEFT CONTACTOR EFFLUENT ISOLATION VALVE	CLOSE	DO	
ZLO-33925	GAC NO. 9 LEFT CONTACTOR EFFLUENT ISOLATION VALVE	OPEN	DI	
ZLC-33925	GAC NO. 9 LEFT CONTACTOR EFFLUENT ISOLATION VALVE	CLOSED	DI	
YLR-33925	GAC NO. 9 LEFT CONTACTOR EFFLUENT ISOLATION VALVE	IN REMOTE	DI	
ZSO-33926	GAC NO. 9 RIGHT CONTACTOR EFFLUENT ISOLATION VALVE	OPEN	DO	MOV-33926
ZSC-33926	GAC NO. 9 RIGHT CONTACTOR EFFLUENT ISOLATION VALVE	CLOSE	DO	
ZLO-33926	GAC NO. 9 RIGHT CONTACTOR EFFLUENT ISOLATION VALVE	OPEN	DI	
ZLC-33926	GAC NO. 9 RIGHT CONTACTOR EFFLUENT ISOLATION VALVE	CLOSED	DI	
YLR-33926	GAC NO. 9 RIGHT CONTACTOR EFFLUENT ISOLATION VALVE	IN REMOTE	DI	
ZSO-34021	GAC NO. 10 INFLUENT VALVE	OPEN	DO	MOV-34021
ZSC-34021	GAC NO. 10 INFLUENT VALVE	CLOSE	DO	
ZLO-34021	GAC NO. 10 INFLUENT VALVE	OPEN	DI	

Tag Number	Service Description	State/Span	Type	Remarks
ZLC-34021	GAC NO. 10 INFLUENT VALVE	CLOSED	DI	
YLR-34021	GAC NO. 10 INFLUENT VALVE	IN REMOTE	DI	
ZSO-34022A	GAC NO. 10 WASH WATER SUPPLY ISOLATION VALVE	OPEN	DO	MOV-34022A
ZSC-34022A	GAC NO. 10 WASH WATER SUPPLY ISOLATION VALVE	CLOSE	DO	
ZLO-34022A	GAC NO. 10 WASH WATER SUPPLY ISOLATION VALVE	OPEN	DI	
ZLC-34022A	GAC NO. 10 WASH WATER SUPPLY ISOLATION VALVE	CLOSED	DI	
YLR-34022A	GAC NO. 10 WASH WATER SUPPLY ISOLATION VALVE	IN REMOTE	DI	
ZSO-34022B	GAC NO. 10 BACKWASH WASTE ISOLATION VALVE	OPEN	DO	MOV-34022B
ZSC-34022B	GAC NO. 10 BACKWASH WASTE ISOLATION VALVE	CLOSE	DO	
ZLO-34022B	GAC NO. 10 BACKWASH WASTE ISOLATION VALVE	OPEN	DI	
ZLC-34022B	GAC NO. 10 BACKWASH WASTE ISOLATION VALVE	CLOSED	DI	
YLR-34022B	GAC NO. 10 BACKWASH WASTE ISOLATION VALVE	IN REMOTE	DI	
ZSO-34023A	GAC NO. 10 EFFLUENT ISOLATION VALVE	OPEN	DO	MOV-34023A
ZSC-34023A	GAC NO. 10 EFFLUENT ISOLATION VALVE	CLOSE	DO	
ZLO-34023A	GAC NO. 10 EFFLUENT ISOLATION VALVE	OPEN	DI	
ZLC-34023A	GAC NO. 10 EFFLUENT ISOLATION VALVE	CLOSED	DI	
YLR-34023A	GAC NO. 10 EFFLUENT ISOLATION VALVE	IN REMOTE	DI	
ZSO-34023B	GAC NO. 10 TO WASTE ISOLATION VALVE	OPEN	DO	MOV-34023B
ZSC-34023B	GAC NO. 10 TO WASTE ISOLATION VALVE	CLOSE	DO	
ZLO-34023B	GAC NO. 10 TO WASTE ISOLATION VALVE	OPEN	DI	
ZLC-34023B	GAC NO. 10 TO WASTE ISOLATION VALVE	CLOSED	DI	
YLR-34023B	GAC NO. 10 TO WASTE ISOLATION VALVE	IN REMOTE	DI	

Tag Number	Service Description	State/Span	Type	Remarks
ZI-34024	GAC NO. 10 EFFLUENT CONTROL VALVE POSITION FEEDBACK	0-100%	AI	MOV-34024
ZC-34024	GAC NO. 10 EFFLUENT CONTROL VALVE POSITION CONTROL	0-100%	AO	
YLR-34024	GAC NO. 10 EFFLUENT CONTROL VALVE	IN REMOTE	DI	
FI-34041	GAC NO. 10 EFFLUENT FLOW RATE		AI	FE/FIT-34041
PDI-34042A	GAC NO. 10 LEFT CONTACTOR LOSS OF HEAD		AI	PDIT-34042A
PDI-34042B	GAC NO. 10 RIGHT CONTACTOR LOSS OF HEAD		AI	PDIT-34042B
LI-34043A	GAC NO. 10 LEFT CONTACTOR LEVEL		AI	LE/LIT-34043A
LI-34043B	GAC NO. 10 RIGHT CONTACTOR LEVEL		AI	LE/LIT-34043B
ZSO-34025	GAC NO. 10 LEFT CONTACTOR EFFLUENT ISOLATION VALVE	OPEN	DO	MOV-34025
ZSC-34025	GAC NO. 10 LEFT CONTACTOR EFFLUENT ISOLATION VALVE	CLOSE	DO	
ZLO-34025	GAC NO. 10 LEFT CONTACTOR EFFLUENT ISOLATION VALVE	OPEN	DI	
ZLC-34025	GAC NO. 10 LEFT CONTACTOR EFFLUENT ISOLATION VALVE	CLOSED	DI	
YLR-34025	GAC NO. 10 LEFT CONTACTOR EFFLUENT ISOLATION VALVE	IN REMOTE	DI	
ZSO-34026	GAC NO. 10 RIGHT CONTACTOR EFFLUENT ISOLATION VALVE	OPEN	DO	MOV-34026
ZSC-34026	GAC NO. 10 RIGHT CONTACTOR EFFLUENT ISOLATION VALVE	CLOSE	DO	
ZLO-34026	GAC NO. 10 RIGHT CONTACTOR EFFLUENT ISOLATION VALVE	OPEN	DI	
ZLC-34026	GAC NO. 10 RIGHT CONTACTOR EFFLUENT ISOLATION VALVE	CLOSED	DI	
YLR-34026	GAC NO. 10 RIGHT CONTACTOR EFFLUENT ISOLATION VALVE	IN REMOTE	DI	
LI-33150	COMMON CHANNEL LEVEL		AI	LE/LIT-33150
LI-33151	COMMON CHANNEL LEVEL		AI	LE/LIT-33151
LAH-33152	CHEMICAL VAULT LEVEL ALARM	HIGH	DI	LSH-33152

Tag Number	Service Description	State/Span	Type	Remarks
AI-33146	EFFLUENT FLUME pH		AI	AE/AIT-33146
AI-33147	EFFLUENT FLUME TEMP		AI	AE-33147/AIT-33146
AI-33148	EFFLUENT FLUME TURBIDITY		AI	AE/AIT-33148
FI-33145	FLOW FROM BACKWASH PUMP STATION		AI	FE/FIT-33145
RTU-7				
LAH-4303	AQUA AMMONIA SUMP ALARM LEVEL	HIGH	DI	LSH-4303
FAH-56140	AQUA AMMONIA EYEWASH/SHOWER	ACTIVATED	DI	FSH-56140
FAH-56141	AQUA AMMONIA EYEWASH/SHOWER	ACTIVATED	DI	FSH-56141
	GAC FACILITY EXTERIOR LIGHTING CONTACTOR	ON/OFF	DI	
	GAC FACILITY INTERIOR LIGHTING CONTACTOR	ON/OFF	DI	
	GAC FACILITY EXHAUST FANS	RUN	DI	
	GAC FACILITY EXHAUST FANS	FAIL	DI	

1. NOTES: Input/Output types are as follows:
 - a. DI – Discrete Input
 - b. DO – Discrete Output
 - c. AI – Analog Input
 - d. AO – Analog Output
 - e. RS485 – Serial Communications Link

2. All available information from each VFD via its RS485 port shall be provided to the PLC.

PART 3 – EXECUTION (NOT USED)

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SECTION 40 61 96
PROCESS CONTROL DESCRIPTIONS

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. The Contractor shall furnish, test, install and place in satisfactory operation all equipment as herein specified and as shown on the Drawings. THE CONTRACTOR SHALL BE RESPONSIBLE FOR FURNISHING COMPLETE FUNCTIONING SYSTEMS AS DESCRIBED HEREIN.
- B. Together with the control system input/output schedule, the equipment specifications (including functional descriptions for local equipment control panels), and the Drawings, the functional control descriptions describe the required operation, monitoring, and control of the facilities included in this Contract.
- C. THE FUNCTIONAL DESCRIPTIONS CONTAIN REQUIREMENTS FOR FURNISHING AND INSTALLING LABOR AND MATERIALS THAT MAY NOT APPEAR ELSEWHERE IN THE CONTRACT DOCUMENTS.
- D. All equipment and services required in equipment local control panels provided to implement the monitoring and control functions described herein or in the process input/output schedules shall be provided by the Contractor through individual equipment suppliers.
- E. Unless specifically stated otherwise, all interconnected wiring between all instruments, panels, controls, and other devices listed in the functional descriptions as required to provide all functions specified herein shall be furnished by the electrical subcontractor under Division 26. The electrical subcontractor shall provide all cable and conduit required to carry all signals listed in the process input/output schedules. Special cables that are required for interconnection between sensors or probes and transmitters or signal conditioners shall be furnished with the instrumentation devices by the equipment supplier.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 01 14 00 – Coordination with Owner's Operations
- B. Section 40 61 90 – Schedules and Control Descriptions, General
- C. Section 40 61 91 – Process Control System Instrument List

- D. Section 40 61 93 – Process Control System Input/Output List

PART 2 – FUNCTIONAL CONTROL DESCRIPTIONS, GENERAL

2.01 DEFINITIONS

- A. RUNNING status signals shall be from auxiliary contacts provided with the motor control equipment (i.e., starter, VFD, SCR, etc.).
- B. AUTO status signals shall be defined as HAND-OFF-AUTO switch in the AUTO position or process control system in AUTO (versus MANUAL).
- C. FAIL status signals shall be defined as motor overload and/or any other shut down mode such as overtorque, overtemperature, low oil pressure, high vibration, etc.
- D. READY status signal shall be defined as all conditions, including equipment control power, satisfied to permit remote control of the equipment.

2.02 CONVENTIONS

- A. Operator workstation graphic display symbols and indicator lights on all MCC's, control panels, starter enclosures, etc. shall conform to the following color convention:
 - 1. Running/On/Open: Green
 - 2. Auto/Ready: White
 - 3. Stopped/Off/Closed: Red
 - 4. Fail/Alarm: Amber
 - 5. Generic Status: Blue or White

2.03 PROCESS CONTROL

- A. Where setpoints, operating limits, and other control settings are provided by the functional descriptions, these settings shall be initial settings only and shall be used for assistance in the initial startup of the plant. All such settings shall be fully adjustable and, based on actual operating conditions, the instrumentation subcontractor shall make all necessary adjustments to provide smooth, stable operation at no additional cost to the Owner.
- B. Provision shall be made in PLC logic to suppress nuisance alarms and control actions by the following means:

1. For alarms and control actions derived from analog input signals, use adjustable time delays and deadbands.
 2. For alarms and control actions derived from discrete input signals, use adjustable time delays.
 3. Initial settings for time delays shall be 10 seconds (range 0-120 seconds). Initial settings for deadbands shall be 5% of span (range 0-100%).
 4. Equipment that is started or stopped manually by the operator shall start or stop immediately, with no time delay.
- C. All setpoint control shall be by PID control algorithms. Where only proportional control is specified, tuning constants shall be used to reduce the Integral and Derivative functions to zero. All setpoints, sequence times, sequence orders, dead bands, PID tuning parameters, PLC delay timers, variable speed operating range limits, and similar control constants shall be accessible and alterable from the operator workstations.
- D. Unless otherwise specified, all equipment shall automatically restart after a power failure utilizing adjustable start delay timers in PLC control logic. Unless otherwise specified, all PLC control strategies shall be based upon automatic restart after a power failure and shall return to a normal control mode upon restoration of power.
- E. The PLC shall be capable of receiving initial run-time values for existing and proposed equipment. Initial run-time shall not automatically be assumed to be zero.
- F. A control discrepancy alarm shall be generated through the PLC for any drive, motor, etc. for which a command has been issued, but for which the PLC is not receiving a confirming status signal (e.g., start command with no run feedback). The failure shall be logged.
- G. An instrument failure alarm shall be generated for any instrument which is generating a signal that is less than 4 mA or greater than 20 mA.
- H. Unless otherwise specified in an individual control description, an instrument failure or control discrepancy alarm shall cause the control strategy to maintain last values and to generate an alarm. Manual initiation of the automatic control strategy shall be required.
- I. A control program that controls multiple pieces of equipment shall not be prevented from running because not all of the equipment is in AUTO. If equipment within an equipment chain is required to be running for program operation and it is running in HAND or MANUAL, then the program shall run and control the other equipment that is in AUTO.
- J. All PLC wait states (internal time delays, etc.) after an operator action shall be displayed on the operator workstation.

PART 3 – FUNCTIONAL CONTROL DESCRIPTIONS

3.01 INTERMEDIATE PUMP STATION (P.O. HOFFER WTF)

A. Process Overview

1. The GAC Feed Pumps convey filtered water from the Filtered Water Flume to the GAC contactors. The Filtered Water Flume provides forward flow equalization and storage of filtered water, supplying influent to the GAC contactors. The Filtered Water Flume will have a level setpoint as specified herein which controls the speed of the GAC Feed Pumps. High water levels within the Filtered Water Flume will trigger the bypass valve to open and discharge to the clearwells by gravity.
2. Each pump shall be provided with a variable frequency drive (VFD), furnished under Division 26 and located in the GAC Facility Electrical Room. Pumps shall be controlled manually through local controls located at each pump VFD panel, or automatically by SCADA.

B. Control Equipment

1. The following GAC feed pumping system equipment is controlled or monitored by SCADA:
 - a. Four (4) vertical turbine GAC Feed Pumps furnished under Division 43 with VFDs furnished under Division 26 (P-35101 through P-35401),
 - b. Four (4) pressure switches (PSH-35141 through PSH-35441) furnished under Division 40, as shown on the Drawings,
 - c. Two (2) Filtered Water Flume Level Sensors furnished under Division 40 (LE/LIT-35147 and LE/LIT-35148),
 - d. One (1) magnetic flow meter, furnished under Division 40 (FE/FIT-35142).
2. A Local Control Station (LCS) shall be furnished under Division 26 for each pump, located at the pump. The LCS shall include the following:
 - a. H-O-A Switch
 - b. Pump START and STOP pushbuttons
 - c. EMERGENCY STOP pushbutton

C. Control Operations

1. When the H-O-A switch is in the HAND position, the pump shall run and speed shall be controlled by the local speed controller at the VFD. When the H-O-A switch is in the OFF position, the pump shall not run under any condition. When the H-O-A switch is in the AUTO position, the operation of the pump shall be controlled remotely by the PLC.
2. The operator shall enter a Filtered Water Flume operational level setpoint at the operator workstation. The PLC shall calculate pump start and stop levels that are initially set at 12 inches above and 12 inches below the level setpoint, respectively. The pumps shall operate in a Lead/Lag1/Lag2/Standby sequence to maintain the operational level setpoint.
3. The PLC shall continuously monitor both level devices in the flume. Flume level measurements from both level devices shall be displayed on the HMI. The level devices shall be used for control with the following functionality:
 - a. Under DUTY/STANDBY mode, the pumps shall operate off of a single level device (DUTY), that is initially selected by the operator at the HMI screen. The operator shall be able to disable either level signal at the HMI at any point. The duty level signal shall automatically failover to the other measurement upon signal loss or invalid signal ($< 4 \text{ mA}$ or $> 20 \text{ mA}$) as long as the standby instrument has a valid signal. An alarm shall be generated at the HMI if the measurements differ from each other by $\pm 10\%$ (initial setting, adjustable) or more.
 - b. Adjustable level setpoints shall initially be set as follows:

Level Setpoint	Elevation
High-High (Emergency Bypass)	98.83
Pump Start	97.33
Operational Setpoint	96.33
Pump Stop	95.33

D. Pump Start/Stop Control

1. The PLC shall start the lead pump (when no pumps are running) or the next pump in the sequence when all of the following are true:
 - a. Filtered Water Flume level reaches the corresponding pump start setpoint.
 - b. All running pumps are operating at maximum speed.

- c. A 20-second time delay has elapsed.
- 2. The PLC shall stop the next pump in the sequence when all of the following are true:
 - a. Flume level reaches the corresponding pump stop setpoint.
 - b. All running pumps are operating at minimum speed.
 - c. A 20-second time delay has elapsed.
- 3. Bumpless transfer shall be provided when a pump's operational mode is changed from either manual to automatic or from automatic to manual.
 - a. When a non-operating pump changes modes (e.g. when a pump changes from auto to manual mode), its operational state shall remain unchanged.
 - b. When an operating pump changes from auto to manual mode, it shall continue running and there shall be no "blips" in the associated PLC start command.
 - c. When an operating pump changes from manual to auto mode, the pump shall continue running until the automatic control strategy stops it. For example, if two pumps are operating together while one is in automatic mode and the other is in manual mode and the system is in a steady state condition, neither pump shall be stopped if the manually controlled pump's mode is changed to automatic mode.
- 4. The PLC shall stop all operating pumps and shall generate an alarm at the HMI upon any of the following conditions:
 - a. Loss of level measurement signal
 - b. Loss of flow measurement signal or no flow condition

E. Pump Speed Control

- 1. Pump speeds shall be controlled to maintain the operational level setpoint.
- 2. All running pumps shall operate at the same speed and shall be ramped up and down together. When a new pump is started, the speed of the operating pumps shall be ramped down to minimum speed to match the speed of the starting pump to prevent momentary flow rate spikes ("bumps") in the process. When a pump is shut down, the speed of the operating pumps shall be ramped up to the maximum

speed associated with the number of pumps running to prevent momentary flow rate spikes (“bumps”) in the process.

3. Pumps shall be provided with speed clamps depending on the number of pumps in operation. These speed clamps shall be adjusted to accommodate field conditions, but shall be initially set according to the following table:

No. Pumps Running	1	2	3	4
Max Speed, %	100	100	100	100
Min Speed, %	50	50	50	50

F. Pump Rotation

1. The operator shall select either manual or automatic pump rotation mode at the HMI. Pump lead/lag designation shall be continuously displayed on the HMI.
 - a. In manual rotation mode, the operator shall manually enter the desired pump lead/lag/standby sequence at the HMI.
 - b. In automatic rotation mode, the PLC shall generate the pump lead/lag/standby sequence based on current run times in ascending order. The sequence shall be automatically reordered to equalize run times each time all pumps are off.
2. If the process has not caused the pumps to rotate in either mode, the pumps shall rotate either every 24 hours (operator adjustable setpoint 1-48 hours or never) or at an operator-entered time of day. The operator shall be able to select one or the other rotation method at the HMI – the two methods shall not be simultaneously enabled.
 - a. In manual rotation mode, the current lead pump shall become the last available pump, and the balance of the available pumps shall be incremented within the sequence (i.e., the sequence shall be reordered such that Lag1 pump becomes the new lead pump, Lag2 pump becomes the new Lag1 pump, etc.).
 - b. In automatic rotation mode, the sequence shall be reordered based on current run time values as described above. The pump with the lowest run time shall become the lead pump.
 - c. If a currently running pump is still required to be running after the sequence is reordered, the pump shall run continuously through the process and shall not be called to stop during the reordering of the rotation sequence. For

example, if two pumps are currently running when the sequence is reordered and the current lead pump becomes the new lag, that pump shall not be stopped and started in rapid succession.

3. If a pump that is called to start fails to start after a 10-second time delay or if a pump in operation fails, the next available lag pump shall be immediately started. The failed pump shall be removed from the rotation sequence and an alarm shall be triggered at the OWS.
4. Pumps that are out of service, in manual control, or failed shall not be considered for automatic control and shall not be included in the alternation sequence. An unavailable (not in remote control, in manual control, in a restrictive or restart time delay, or failed) pump shall never be designated higher in the sequence than an available pump, e.g., an unavailable pump shall not be labeled "Lag1" while another available pump is labeled "Lag2".
5. An alarm shall be provided to notify operators when the number of pumps available for automatic control is insufficient to meet process demands.

3.02 GRANULAR ACTIVATED CARBON CONTACTORS (P.O. HOFFER WTF)

A. Process Overview

1. The process includes twelve (12) single-cell granular activated carbon (GAC) contactors located downstream of the conventional filters. Each contactor is designed to treat approximately 8% of the process flow (2.7 MGD) with an approximate empty bed contact time of 20 minutes and an approximate hydraulic loading rate of 4 gallons per minute/square foot of media surface area. The contactors have approximately 11 feet of GAC installed as an adsorption media, supported by underdrains. The GAC media adsorbs trace organic contaminants as well as PFAS compounds. Each contactor unit shall be equipped with a radar level sensor, loss-of-head differential pressure transmitter, and effluent flow control valve. The effluent control valve shall maintain a constant flowrate through the contactor based on the Intermediate Pump Station discharge flow rate, the level in the contactor influent channel, and the number of contactors in service. A magnetic flow meter shall be provided for contactor effluent and GAC-to-waste. The contactors are washed using backwash pumps located within the GAC Facility. The programming for all contactors shall be the same.

B. Control Equipment

1. The following OPEN/CLOSE valves are provided for each contactor:
 - a. Contactor influent valve

- b. Backwash supply valve
 - c. Backwash waste valve
 - d. Contactor effluent isolation valve
 - e. GAC-to-waste valve
- 2. The following modulating valves are provided for each contactor:
 - a. Contactor effluent flow control valve
- 3. A magnetic flow meter shall be provided to measure the effluent flow from each contactor, furnished under Division 40.
- 4. A radar level sensor and indicating transmitter shall be provided for each contactor, furnished under Division 40.
- 5. A differential pressure transmitter shall be provided for each contactor to measure loss of head, furnished under Division 40.
- 6. Three (3) GAC backwash supply pumps are located within the GAC Facility, furnished under Division 43.
- 7. Three (3) pressure switches shall be provided to protect the backwash supply pumps, furnished under Division 40.
- 8. One (1) backwash supply magnetic flow meter shall be provided, furnished under Division 40.
- 9. Two (2) radar level sensors and indicating transmitters shall be provided for the common GAC influent channel, furnished under Division 40.
- 10. One (1) combined GAC effluent pH analyzer (AE/AIT-33148) shall be provided, furnished under Division 40.
- 11. One (1) combined GAC effluent turbidity analyzer (AE/AIT-33150) shall be provided, furnished under Division 40.

C. Control Operations

- 1. A Valve Fail alarm shall be triggered for any open/close valve that loses a position feedback signal for more than 120 seconds.
- 2. The PLC shall monitor and display the following in SCADA for each contactor:

- a. The status of each contactor (normal filtration mode, backwash mode, out of service)
- b. Position of all contactor valves (open/close, or % open for modulating valves)
- c. Status of all valves
 - 1) Auto/Manual on SCADA
 - 2) Local/Remote at the valve
 - 3) Indicate as Ready when in AUTO mode on SCADA and in Remote mode on the valve.
- d. Contactor effluent flow, contactor water level, and loss-of-head differential pressure
- e. Actual run (in service) time and total time between backwashes.
- f. Unit filter run volume (UFRV) = gallons treated per square foot of contactor area per run
- g. Total backwash water volume and total GAC-to-waste water volume.

3.03 NORMAL GAC OPERATION (P.O. HOFFER WTF)

A. Process Overview

- 1. The PLC shall allow each of the contactors to be operated either manually or automatically from the SCADA system during normal operation.

B. Control Equipment

- 1. Control equipment as specified under "GAC Contactors" herein.

C. Control Operations

- 1. During normal operation, contactor valve position shall be as follows:
 - a. Contactor influent valve - open
 - b. Backwash supply valve - closed
 - c. Backwash waste valve - closed

- d. Contactor effluent isolation valve – open
 - e. GAC-to-waste valve - closed
 - f. Contactor flow control modulating valve – open
2. The sequence for placing a contactor into service is as follows:
- a. The influent valve shall open, and the contactor effluent isolation valve shall open.
 - b. The contactor effluent flow control valve shall open and modulate to maintain the effluent flow setpoint.
3. During normal operation, effluent flow control shall be achieved via cascaded PID control loops that maintain a constant level setpoint in the contactor influent channel. The master level controller (LE/LIT-33145 & 33147) shall provide identical flow rate setpoints to the contactor rate control loop for each in-service contactor. The individual contactor rate control loops shall modulate the associated rate control valve to maintain that flow setpoint.
- a. If the runtime for any contactor exceeds the alarm setpoint, an alarm shall be triggered in SCADA. The runtime alarm shall be independently adjustable for each contactor. The alarm setpoint shall be initially set at 672 hours.
4. During normal operation, the differential pressure transmitter provided at each contactor shall transmit an analog signal proportional to contactor head loss to the PLC.
- a. If the loss of head reaches the high loss of head alarm setpoint, an alarm shall be triggered and displayed in SCADA. The alarm setpoint shall be independently adjustable for each contactor. The alarm set point shall be initially set at 8.5 ft of water column and alarm after a 30 second delay.
5. During normal operation, the combined contactor effluent turbidity analyzer shall transmit an analog signal proportional to the effluent turbidity to the PLC.
- a. If the combined effluent turbidity reaches the effluent turbidity alarm setpoint (adjustable, with initial setpoint value of 0.1 NTU), an alarm shall be triggered and displayed in SCADA.
6. When a contactor is taken out of service, all the contactor valves shall be automatically placed into the closed position. Each time a contactor is taken “out-

of-service”, the remaining contactors shall share the influent flow normally handled by the contactor taken out of service.

7. When combined GAC effluent pH is above or below an operator adjustable threshold, an alarm shall be sent to SCADA.

3.04 GAC BACKWASH (P.O. HOFFER WTF)

A. Process Overview

1. Contactor controls will allow each of the contactors to be backwashed from the SCADA system either manually or automatically during normal operation. The PLC shall allow only one contactor to be backwashed at a time.
2. The PLC shall not allow a contactor and a filter to be backwashed simultaneously. If both a contactor and a filter are called to be backwashed, preference will be given to the filter backwash, however, if a contactor is in the process of being backwashed, the backwash will not be interrupted and the filter will be backwashed upon completion of the contactor backwash sequence.

B. Control Equipment

1. Control equipment as specified under “GAC Contactors” herein.

C. Control Operations

1. A contactor backwash shall be initiated manually by the operator. High loss of head and an operator-entered elapsed time since the last backwash shall generate an alarm condition.
2. Valve positions shall be confirmed before advancing to the next sequence step.
3. Prior to initiating a contactor backwash the following conditions must be met:
 - a. All valves on the contactor to be backwashed must be in Remote.
 - b. A minimum of two (2) GAC Backwash Supply Pumps must be in AUTO.
 - c. Backwash cannot be active for any other contactor or filter.
 - d. A prompt shall be provided if clearwell level is below the adjustable low level setpoint (0-8 feet) when operator selects “Initiate Backwash”.
 - e. A prompt shall be provided if the Residuals Collection Tank level is above the adjustable high level setpoint (0-10 feet) when operator selects “Initiate Backwash”.

4. The operators shall enter the following backwash parameters via SCADA:
 - a. Low wash rate/duration (up)
 - b. High wash rate/duration
 - c. Low wash rate/duration (down)
 - d. GAC-to-waste limit (minimum time to terminate GAC-to-waste)
 - e. Maximum elapsed time between backwashes
 - f. Maximum loss of head
5. Initial flow rates and durations for the sequences described above are as follows:

	Flow Rate	Duration
Low-Rate Backwash (Up)	3,500 GPM	400 Seconds
High-Rate Backwash	8,000 GPM	600 Seconds
Low-Rate Backwash (Down)	3,500 GPM	200 Seconds

6. Once a backwash is initiated, the contactor rate-of-flow controller shall no longer respond to the setpoint flowrate. The contactor rate setting shall track the setpoint for the remaining in-service contactors to provide for a “bumpless” return to service. The remaining contactors in service shall adjust their effluent flow rate accordingly to maintain the plant production rate (i.e., Intermediate Pump Station discharge flow rate shall not change).
7. Pump Control
 - a. The variable speed pumps and the associated magnetic flow meter (FE/FIT-36142) shall be used for flow setpoint control, in accordance with Paragraph 2.03-C of this Section.
8. Backwash Sequence
 - a. Contactor drain down: the contactor backwash sequence shall begin with the closing of the contactor influent valve. Closing the influent valve shall stop the run (contactor in service) clock for the runtime calculation and require redistribution of flow across the contactors that remain in service. The contactor shall continue to process water (effluent flow control valve

shall remain in its previous position) until the level is drawn down to approximately 12 inches above the media as measured by the level sensor. An alarm shall occur if the minimum water level is not obtained within 30 minutes. After the water level reaches the setpoint level, the effluent valve shall close. The backwash waste valve shall then open.

- b. A button shall be provided within SCADA to allow the operator to skip the “Contactor Drain Down” sequence in the event the operator manually drains down the contactor and desires to Initiate Backwash from this step.
- c. Low-rate backwash: The backwash supply valve shall open, and its position shall be confirmed. After the backwash supply valve is confirmed to be open, two (2) GAC Backwash Supply Pumps shall start. The Backwash Supply Pumps shall ramp to meet the low-rate backwash flow setpoint. The low-rate backwash shall continue for the preset time duration.
- d. High-rate backwash: Together, both pumps shall ramp over the course of 2 minutes (adjustable) to meet the high-rate backwash flow setpoint. The high-rate backwash shall continue for the preset time duration.
- e. Final backwash: the GAC Backwash Supply Pumps shall ramp over the course of 2 minutes (adjustable) to meet the final backwash flow setpoint. The final backwash shall continue for the preset time duration. At the conclusion of the final backwash cycle, the backwash waste valve shall close and the contactor shall be filled to its normal operating level via the GAC Backwash Supply Pumps. Once the normal level is reached, the GAC Backwash Supply Pumps shall shut down and the backwash supply valve shall close. After a preset (adjustable) time delay, the GAC-to-waste sequence shall be automatically initiated.
- f. GAC-to-waste: the GAC-to-waste valve shall open and the contactor effluent control valve shall modulate its position to meet the effluent flow setpoint. The GAC-to-waste step shall continue until the minimum GAC-to-waste duration is achieved. After the duration has expired, the contactor may conclude the GAC-to-waste cycle provided that:
 - 1) If the operator selects “Abort Rewash”, the GAC-to-waste valve shall close and the contactor shall be marked “offline”.
- g. After the GAC-to-waste sequence has concluded, the GAC-to-waste valve, effluent flow control valve, and contactor influent valve shall close.
- h. When a contactor is in the automatic backwash mode, any disruption in the backwash cycle such as a valve position failure or power failure shall cause

the program to take and mark the contactor offline. The influent, effluent, and GAC-to-waste valves shall be closed. The contactor shall remain marked offline until an operator determines the reason for the disruption in the backwash cycle and manually initiates the backwash sequence.

- i. The following conditions shall initiate a "Backwash Fail" alarm on the operator workstation and shall be reason for marking the contactor offline:
 - 1) GAC Backwash Supply Pump fail
 - 2) Contactor level, backwash flow rate signal in bad quality
 - 3) Valve open/close fail
 - 4) Backwash flow rate fails to achieve within 5% setpoint within an operator-adjustable allotted time
 - 5) Plant power failure during backwash

3.05 GAC CONTACTOR VALVES (P.O. HOFFER WTF)

A. Process Overview

- 1. Butterfly valves with electrically operated actuators shall be provided for all GAC contactors as specified in Division 40 and as shown on the Drawings.

B. Control Equipment

- 1. Control equipment as specified under "GAC Contactors" herein.

C. Control Operations

- 1. When the valve actuator selector switch is in the LOCAL position, the valve shall be controlled by the OPEN-CLOSE selector switch at the actuator.
- 2. When the valve actuator selector switch is in the REMOTE position, the valve position shall be controlled either automatically through the PLC as described herein or in remote manual from the SCADA system.
- 3. When the valve actuator selector switch is in the OFF position, the valve shall not operate under any condition.

3.06 EMERGENCY BYPASS MODE (P.O. HOFFER WTF)

A. Process Overview

1. A butterfly valve with electrically operated actuator shall be provided for emergency bypass of the GAC process as specified in Division 40 and as shown on the Drawings.

B. Control Equipment

1. One (1) new OPEN/CLOSE valve located in the yard for bypass of the GAC process.

C. Control Operations

1. When the "HIGH-HIGH" level setpoint is reached in the Filtered Water Flume while all GAC Feed Pumps are operating at full speed, "Emergency Bypass Mode" shall be automatically triggered in SCADA, accompanied by an alarm at the OWS.
 - a. The Emergency Bypass Valve (MOV-35121) shall be opened.
 - b. The input signal for flow pacing of the Finished Water chemicals shall be switched to the totalized Filtered Water Flow (from the sum of the individual Filter Effluent Flowmeters). These chemicals shall include the following:
 - 1) ZO
 - 2) HF
 - 3) SH
 - c. All GAC Feed Pumps shall be shut down as specified herein under "Intermediate Pump Station".
2. "Emergency Bypass Mode" shall continue until operations staff initiate "Normal Operating Mode" at the OWS. At that time:
 - a. The Emergency Bypass Valve (MOV-35121) shall be closed.
 - b. The input signal for flow pacing of the Finished Water chemicals shall be switched to the totalized GAC Feed Flow (from FE/FIT-35142).
 - c. The GAC Feed Pumps shall be started as specified herein under "Intermediate Pump Station".

3.07 INTERMEDIATE PUMP STATION (GLENVILLE LAKE WTF)

A. Process Overview

1. The GAC Feed Pumps convey filtered water from the Filtered Water Flume to the GAC contactors. The Filtered Water Flume provides forward flow equalization and storage of filtered water, supplying influent to the GAC contactors. The Filtered Water Flume will normally be full of water, with a level setpoint controlling the speed of the GAC Feed Pumps. High water levels within the Filtered Water Flume will trigger the bypass valves to open and discharge to the clearwells by gravity.
2. Each pump shall be provided with a variable frequency drive (VFD), furnished under Division 26 and located in the GAC Facility Electrical Room. Pumps shall be controlled manually through local controls located at each pump, or automatically by SCADA.

B. Control Equipment

1. The following GAC feed pumping system equipment is controlled or monitored by SCADA:
 - a. Three (3) vertical turbine GAC Feed Pumps furnished under Division 43 with VFDs furnished under Division 26 (P-35101 through P-35301),
 - b. Three (3) pressure switches (PSH-35141 through PSH-35341) furnished under Division 40, as shown on the Drawings,
 - c. Two (2) Filtered Water Flume Level Sensors furnished under Division 40 (LE/LIT-35147 and LE/LIT-35148),
 - d. One (1) magnetic flow meter, furnished under Division 40 (FE/FIT-35142).
2. A Local Control Station (LCS) shall be furnished under Division 26 for each pump, located at the pump. The LCS shall include the following:
 - a. H-O-A Switch
 - b. Pump START and STOP pushbuttons
 - c. EMERGENCY STOP pushbutton

C. Control Operations

1. When the H-O-A switch is in the HAND position, the pump shall run and speed shall be controlled by the local speed controller at the VFD. When the H-O-A switch is in the OFF position, the pump shall not run under any condition. When the H-O-A switch is in the AUTO position, the operation of the pump shall be controlled remotely by the PLC.

2. The operator shall enter a Filtered Water Flume operational level setpoint at the operator workstation. The PLC shall calculate pump start and stop levels that are initially set at 12 inches above and 12 inches below the level setpoint, respectively. The pumps shall operate in a Lead/Lag1/Standby sequence to maintain the operational level setpoint.
3. The PLC shall continuously monitor both level devices in the flume. Flume level measurements from both level devices shall be displayed on the HMI. The level devices shall be used for control with the following functionality:
 - a. Under DUTY/STANDBY mode, the pumps shall operate off of a single level device (DUTY), that is initially selected by the operator at the HMI screen. The operator shall be able to disable either level signal at the HMI at any point. The duty level signal shall automatically failover to the other measurement upon signal loss or invalid signal ($< 4 \text{ mA}$ or $> 20 \text{ mA}$) as long as the standby instrument has a valid signal. An alarm shall be generated at the HMI if the measurements differ from each other by $\pm 10\%$ (initial setting, adjustable) or more.
 - b. Adjustable level setpoints shall initially be set as follows:

Level Setpoint	Elevation
High-High (Emergency Bypass)	113.08
Pump Start	111.58
Operational Setpoint	110.58
Pump Stop	109.58

D. Pump Start/Stop Control

1. The PLC shall start the lead pump (when no pumps are running) or the next pump in the sequence when all of the following are true:
 - a. Filtered Water Flume level reaches the corresponding pump start setpoint.
 - b. All running pumps are operating at maximum speed.
 - c. A 20-second time delay has elapsed.
2. The PLC shall stop the next pump in the sequence when all of the following are true:

- a. Flume level reaches the corresponding pump stop setpoint.
 - b. All running pumps are operating at minimum speed.
 - c. A 20-second time delay has elapsed.
- 3. Bumpless transfer shall be provided when a pump's operational mode is changed from either manual to automatic or from automatic to manual.
 - a. When a non-operating pump changes modes (e.g. when a pump changes from auto to manual mode), its operational state shall remain unchanged.
 - b. When an operating pump changes from auto to manual mode, it shall continue running and there shall be no "blips" in the associated PLC start command.
 - c. When an operating pump changes from manual to auto mode, the pump shall continue running until the automatic control strategy stops it. For example, if two pumps are operating together while one is in automatic mode and the other is in manual mode and the system is in a steady state condition, neither pump shall be stopped if the manually controlled pump's mode is changed to automatic mode.
- 4. The PLC shall stop all operating pumps and shall generate an alarm at the HMI upon any of the following conditions:
 - a. Loss of level measurement signal

E. Pump Speed Control

- 1. Pump speeds shall be controlled to maintain the operational level setpoint.
- 2. All running pumps shall operate at the same speed and shall be ramped up and down together. When a new pump is started, the speed of the operating pumps shall be ramped down to minimum speed to match the speed of the starting pump to prevent momentary flow rate spikes ("bumps") in the process. When a pump is shut down, the speed of the operating pumps shall be ramped up to the maximum speed associated with the number of pumps running to prevent momentary flow rate spikes ("bumps") in the process.
- 3. Pumps shall be provided with speed clamps depending on the number of pumps in operation. These speed clamps shall be adjusted to accommodate field conditions, but shall be initially set according to the following table:

No. Pumps Running	1	2	3
Max Speed, %	100	100	100
Min Speed, %	50	50	50

F. Pump Rotation

1. The operator shall select either manual or automatic pump rotation mode at the HMI. Pump lead/lag designation shall be continuously displayed on the HMI.
 - a. In manual rotation mode, the operator shall manually enter the desired pump lead/lag/standby sequence at the HMI.
 - b. In automatic rotation mode, the PLC shall generate the pump lead/lag/standby sequence based on current run times in ascending order. The sequence shall be automatically reordered to equalize run times each time all pumps are off.
2. If the process has not caused the pumps to rotate in either mode, the pumps shall rotate either every 24 hours (operator adjustable setpoint 1-48 hours or never) or at an operator-entered time of day. The operator shall be able to select one or the other rotation method at the HMI – the two methods shall not be simultaneously enabled.
 - a. In manual rotation mode, the current lead pump shall become the last available pump, and the balance of the available pumps shall be incremented within the sequence (i.e., the sequence shall be reordered such that Lag1 pump becomes the new lead pump, Lag2 pump becomes the new Lag1 pump, etc.).
 - b. In automatic rotation mode, the sequence shall be reordered based on current run time values as described above. The pump with the lowest run time shall become the lead pump.
 - c. If a currently running pump is still required to be running after the sequence is reordered, the pump shall run continuously through the process and shall not be called to stop during the reordering of the rotation sequence. For example, if two pumps are currently running when the sequence is reordered and the current lead pump becomes the new lag, that pump shall not be stopped and started in rapid succession.
3. If a pump that is called to start fails to start after a 10-second time delay or if a pump in operation fails, the next available lag pump shall be immediately started. The failed pump shall be removed from the rotation sequence and an alarm shall be triggered at the OWS.

4. Pumps that are out of service, in manual control, or failed shall not be considered for automatic control and shall not be included in the alternation sequence. An unavailable (not in remote control, in manual control, in a restrictive or restart time delay, or failed) pump shall never be designated higher in the sequence than an available pump, e.g., an unavailable pump shall not be labeled "Lag1" while another available pump is labeled "Lag2".
5. An alarm shall be provided to notify operators when the number of pumps available for automatic control is insufficient to meet process demands.

3.08 GRANULAR ACTIVATED CARBON CONTACTORS (GLENVILLE LAKE WTF)

A. Process Overview

1. The process includes ten (10) dual-cell granular activated carbon (GAC) contactors located downstream of the conventional filters. Each contactor is designed to treat approximately 10% of the process flow (2.4 MGD) with an approximate empty bed contact time of 20 minutes and an approximate hydraulic loading rate of 4 gallons per minute/square foot of media surface area. The contactors have approximately 11 feet of GAC installed as an adsorption media, supported by underdrains. The GAC media adsorbs trace organic contaminants as well as PFAS compounds. Each contactor cell shall be equipped with a radar level sensor and loss-of-head differential pressure transmitter. A common effluent flow control valve will serve both cells. The effluent control valve shall maintain a constant flowrate through the contactor based on the Intermediate Pump Station discharge flow rate, the level in the contactor influent channel, and the number of contactors in service. A magnetic flow meter shall be provided for contactor effluent and GAC-to-waste. The contactors are washed using backwash pumps collocated with the Intermediate Pumps. The programming for all contactors shall be the same.

B. Control Equipment

1. The following OPEN/CLOSE valves are provided for each contactor:
 - a. Contactor influent valve
 - b. Backwash supply valve
 - c. Backwash waste valve
 - d. Contactor effluent isolation valve
 - e. GAC-to-waste valve

- f. Left cell isolation valve
 - g. Right cell isolation valve
- 2. The following modulating valves are provided for each contactor:
 - a. Contactor effluent flow control valve
- 3. A magnetic flow meter shall be provided to measure the effluent flow from each contactor, furnished under Division 40.
- 4. A radar level sensor and indicating transmitter shall be provided for each cell (2 per contactor), furnished under Division 40.
- 5. A differential pressure transmitter shall be provided for each cell (2 per contactor) to measure loss of head, furnished under Division 40.
- 6. Two (2) GAC backwash supply pumps are located adjacent to the Intermediate Pumps, furnished under Division 43.
- 7. Two (2) pressure switches shall be provided to protect the backwash supply pumps, furnished under Division 40.
- 8. One (1) backwash supply magnetic flow meter shall be provided, furnished under Division 40.
- 9. Two (2) radar level sensors and indicating transmitters shall be provided for the common GAC influent channel, furnished under Division 40.
- 10. One (1) combined GAC effluent pH analyzer shall be provided, furnished under Division 40.
- 11. One (1) combined GAC effluent turbidity analyzer shall be provided, furnished under Division 40.

C. Control Operations

- 1. A Valve Fail alarm shall be triggered for any open/close valve that loses a position feedback signal for more than 120 seconds.
- 2. The PLC shall monitor and display the following in SCADA for each contactor:
 - a. The status of each contactor (normal filtration mode, backwash mode, out of service)

- b. Position of all contactor valves (open/close, or % open for modulating valves)
- c. Status of all valves
 - 1) Auto/Manual on SCADA
 - 2) Local/Remote at the valve
 - 3) Indicate as Ready when in AUTO mode on SCADA and in Remote mode on the valve.
- d. Contactor effluent flow, contactor water level, and loss-of-head differential pressure
- e. Actual run (in service) time and total time between backwashes.
- f. Unit filter run volume (UFRV) = gallons treated per square foot of contactor area per run
- g. Total backwash water volume and total GAC-to-waste water volume.
- h.

3.09 NORMAL GAC OPERATION (GLENVILLE LAKE WTF)

A. Process Overview

- 1. The PLC shall allow each of the contactors to be operated either manually or automatically from the SCADA system during normal operation.

B. Control Equipment

- 1. Control equipment as specified under "GAC Contactors" herein.

C. Control Operations

- 1. During normal operation, contactor valve position shall be as follows:
 - a. Contactor influent valve - open
 - b. Backwash supply valve - closed
 - c. Backwash waste valve - closed
 - d. Contactor effluent isolation valve – open

- e. GAC-to-waste valve - closed
 - f. Contactor flow control modulating valve – open
 - g. Left cell isolation valve - open
 - h. Right cell isolation valve - open
2. The sequence for placing a contactor into service is as follows:
- a. The influent valve shall open, along with the contactor effluent isolation valve and the left and right cell isolation valves.
 - b. The contactor effluent flow control valve shall open and modulate to maintain the effluent flow setpoint.
3. During normal operation, effluent flow control shall be achieved via cascaded PID control loops that maintain a constant level setpoint in the contactor influent channel. The master level controller shall provide identical flow rate setpoints to the contactor rate control loop for each in-service contactor. The individual contactor rate control loops shall modulate the associated rate control valve to maintain that flow setpoint.
- a. If the runtime for any contactor exceeds the alarm setpoint, an alarm shall be triggered in SCADA. The runtime alarm shall be independently adjustable for each contactor. The alarm setpoint shall be initially set at 672 hours.
4. During normal operation, the differential pressure transmitter provided at each contactor cell shall transmit an analog signal proportional to contactor head loss to the PLC.
- a. If the loss of head reaches the high loss of head alarm setpoint, an alarm shall be triggered and displayed in SCADA. The alarm setpoint shall be independently adjustable for each contactor cell. The alarm set point shall be initially set at 8.5 ft of water column and alarm after a 30 second delay.
5. During normal operation, the combined contactor effluent turbidity analyzer shall transmit an analog signal proportional to the effluent turbidity to the PLC.
- a. If the combined effluent turbidity reaches the effluent turbidity alarm setpoint, an alarm shall be triggered and displayed in SCADA.
6. When a contactor is taken out of service, all the contactor valves shall be automatically placed into the closed position. Each time a contactor is taken “out-

of-service”, the remaining contactors shall share the influent flow normally handled by the contactor taken out of service.

7. When combined GAC effluent pH is above or below an operator adjustable threshold, an alarm shall be sent to SCADA.

3.10 GAC BACKWASH (GLENVILLE LAKE WTF)

A. Process Overview

1. Contactor controls will allow each of the contactors to be backwashed from the SCADA system either manually or automatically during normal operation. The PLC shall allow only one contactor cell to be backwashed at a time. The backwash setpoints and sequence durations shall be independently adjustable for each contactor.
2. The PLC shall not allow a contactor and a filter to be backwashed simultaneously. If both a contactor and a filter are called to be backwashed, preference will be given to the filter backwash, however, if a contactor is in the process of being backwashed, the backwash will not be interrupted and the filter will be backwashed upon completion of the contactor backwash sequence.
3. The PLC shall not allow a contactor to be backwashed simultaneously with a sedimentation basin blowdown operation. If a contactor backwash is called for in addition to a sedimentation basin blowdown, preference will be given to the contactor backwash.

B. Control Equipment

1. Control equipment as specified under “GAC Contactors” herein.

C. Control Operations

1. A contactor backwash shall be initiated manually by the operator. High loss of head and an operator-entered elapsed time since the last backwash shall generate an alarm condition.
2. Valve positions shall be confirmed before advancing to the next sequence step.
3. Prior to initiating a contactor backwash the following conditions must be met:
 - a. All valves on the contactor to be backwashed must be in Remote.
 - b. A minimum of one (1) GAC Backwash Supply Pump must be in AUTO.

- c. Backwash cannot be active for any other contactor or filter.
 - d. A prompt shall be provided if clearwell level is below the adjustable low level setpoint (0-8 feet) when operator selects "Initiate Backwash".
 - e. A prompt shall be provided if the Residuals Collection Tank level is above the adjustable high level setpoint (0-10 feet) when operator selects "Initiate Backwash".
4. The operators shall enter the following backwash parameters via SCADA:
- a. Low wash rate/duration (up)
 - b. High wash rate/duration
 - c. Low wash rate/duration (down)
 - d. GAC-to-waste limit (minimum time to terminate GAC-to-waste)
 - e. Maximum elapsed time between backwashes
 - f. Maximum loss of head
5. Initial flow rates and durations for the sequences described above are as follows:

	Flow Rate	Duration
Low-Rate Backwash (Up)	1,300 GPM	400 Seconds
High-Rate Backwash	3,100 GPM	600 Seconds
Low-Rate Backwash (Down)	1,300 GPM	200 Seconds

6. Once a backwash is initiated, the contactor rate-of-flow controller shall no longer respond to the setpoint flowrate. The contactor rate setting shall track the setpoint for the remaining in-service contactors to provide for a "bumpless" return to service. The remaining contactors in service shall adjust their effluent flow rate accordingly to maintain the plant production rate (i.e., Intermediate Pump Station discharge flow rate shall not change).
7. Pump Control
- a. The variable speed pumps and the associated magnetic flow meter (FE/FIT-33145) shall be used for flow setpoint control, in accordance with Paragraph 2.03-C of this Section.

8. Backwash Sequence

- a. Contactor drain down: the contactor backwash sequence shall begin with the closing of the contactor influent valve. Closing the influent valve shall also stop the run (contactor in service) clock for the runtime calculation. The contactor shall continue to process water (effluent flow control valve shall remain in its previous position) until the level is drawn down to approximately 12 inches above the media as measured by the level sensors. An alarm shall occur if the minimum water level is not obtained within 30 minutes. After the water level reaches the setpoint level, the effluent valve shall close.
- b. A button shall be provided within SCADA to allow the operator to skip the "Contactor Drain Down" sequence in the event the operator manually drains down the contactor and desires to Initiate Backwash from this step.
- c. Left Cell Backwash
 - 1) The left cell isolation valve shall remain open while the right cell isolation valve is closed.
 - 2) Low-rate backwash: The backwash supply valve shall open, and its position shall be confirmed. After the backwash supply valve is confirmed to be open, one (1) GAC Backwash Supply Pump shall start. The Backwash Supply Pump shall ramp to meet the low-rate backwash flow setpoint. The low-rate backwash shall continue for the preset time duration.
 - 3) High-rate backwash: The pump shall ramp over the course of 2 minutes (adjustable) to meet the high-rate backwash flow setpoint. The high-rate backwash shall continue for the preset time duration.
 - 4) Final backwash: the GAC Backwash Supply Pump shall ramp over the course of 2 minutes (adjustable) to meet the final backwash flow setpoint. The final backwash shall continue for the preset time duration.
- d. Right Cell Backwash
 - 1) The left cell isolation shall remain open while the right cell isolation valve is also opened. Once the position of the right cell isolation valve is confirmed, the left cell isolation valve shall close.

- 2) Low-rate backwash: The Backwash Supply Pump shall ramp to meet the low-rate backwash flow setpoint. The low-rate backwash shall continue for the preset time duration.
 - 3) High-rate backwash: The pump shall ramp over the course of 2 minutes (adjustable) to meet the high-rate backwash flow setpoint. The high-rate backwash shall continue for the preset time duration.
 - 4) Final backwash: the GAC Backwash Supply Pump shall ramp over the course of 2 minutes (adjustable) to meet the final backwash flow setpoint. The final backwash shall continue for the preset time duration.
- e. At the conclusion of the final backwash cycle, the backwash waste valve shall close, the left cell isolation valve shall open, and the contactor shall be filled to its normal operating level via the GAC Backwash Supply Pump. Once the normal level is reached, the GAC Backwash Supply Pump shall shut down and the backwash supply valve shall close. After a preset (adjustable) time delay, the GAC-to-waste sequence shall be automatically initiated.
 - f. GAC-to-waste: the GAC-to-waste valve shall open and the contactor effluent control valve shall modulate its position to meet the effluent flow setpoint. The GAC-to-waste step shall continue until the minimum GAC-to-waste duration is achieved. After the duration has expired, the contactor may conclude the GAC-to-waste cycle provided that:
 - 1) If the operator selects "Abort Rewash", the GAC-to-waste valve shall close and the contactor shall be marked "offline".
 - g. After the GAC-to-waste sequence has concluded, the GAC-to-waste valve, effluent flow control valve, and contactor influent valve shall close.
 - h. When a contactor is in the automatic backwash mode, any disruption in the backwash cycle such as a valve position failure or power failure shall cause the program to take and mark the contactor offline. The influent, effluent, and GAC-to-waste valves shall be closed. The contactor shall remain marked offline until an operator determines the reason for the disruption in the backwash cycle and manually initiates the backwash sequence.
 - i. The following conditions shall initiate a "Backwash Fail" alarm on the operator workstation and shall be reason for marking the contactor offline:
 - 1) GAC Backwash Supply Pump fail

- 2) Contactor level, backwash flow rate signal in bad quality
- 3) Valve open/close fail
- 4) Backwash flow rate fails to achieve within 5% setpoint within an operator-adjustable allotted time
- 5) Plant power failure during backwash

3.11 GAC CONTACTOR VALVES (GLENVILLE LAKE WTF)

A. Process Overview

1. Butterfly valves with electrically operated actuators shall be provided for all GAC contactors as specified in Division 40 and as shown on the Drawings.

B. Control Equipment

1. Control equipment as specified under "GAC Contactors" herein.

C. Control Operations

1. When the valve actuator selector switch is in the LOCAL position, the valve shall be controlled by the OPEN-CLOSE selector switch at the actuator.
2. When the valve actuator selector switch is in the REMOTE position, the valve position shall be controlled either automatically through the PLC as described herein or in remote manual from the SCADA system.
3. When the valve actuator selector switch is in the OFF position, the valve shall not operate under any condition.

3.12 EMERGENCY BYPASS MODE (GLENVILLE LAKE WTF)

A. Process Overview

1. A butterfly valve with electrically operated actuator shall be provided for emergency bypass of the GAC process as specified in Division 40 and as shown on the Drawings.

B. Control Equipment

1. One (1) new OPEN/CLOSE valve located in the yard for bypass of the GAC process.

2. Six (6) new manual valves located within the Operations Building for alternating the dose point location of the Finished Water chemicals.
3. Other control equipment as specified herein.

C. Control Operations

1. When the "HIGH-HIGH" level setpoint is reached in the Filtered Water Flume while all GAC Feed Pumps are operating at full speed, "Emergency Bypass Mode" shall be automatically triggered in SCADA, accompanied by an alarm at the OWS. At that time:
 - a. The Emergency Bypass Valves (MOV-35121) shall be opened.
 - b. The input signal for flow pacing of the Finished Water chemicals shall be switched to the totalized Filtered Water Flow (from the sum of the individual Filter Effluent Flowmeters). These chemicals shall include the following:
 - 1) ZO
 - 2) HF
 - 3) SH
 - c. The operators shall be directed to change the positions of the corresponding manual Emergency Bypass Chemical Isolation Valves as follows:
 - 1) ZO to static mixer in chemical vault: CLOSED
 - 2) ZO to Filtered Water Flume: OPEN
 - 3) HF to static mixer in chemical vault: CLOSED
 - 4) HF to Filtered Water Flume: OPEN
 - 5) SH to static mixer in chemical vault: CLOSED
 - 6) SH to Filtered Water Flume: OPEN
 - d. All GAC Feed Pumps shall be shut down as specified herein under "Intermediate Pump Station".
2. "Emergency Bypass Mode" shall continue until operations staff initiate "Normal Operating Mode" at the OWS. At that time:
 - a. The Emergency Bypass Valve (MOV-35121) shall be closed.

- b. The input signal for flow pacing of the Finished Water chemicals shall be switched to the totalized GAC Feed Flow (from FE/FIT-35142).
- c. The operators shall be directed to change the positions of the corresponding manual Emergency Bypass Chemical Isolation Valves as follows:
 - 1) ZO to static mixer in chemical vault: OPEN
 - 2) ZO to Filtered Water Flume: CLOSED
 - 3) HF to static mixer in chemical vault: OPEN
 - 4) HF to Filtered Water Flume: CLOSED
 - 5) SH to static mixer in chemical vault: OPEN
 - 6) SH to Filtered Water Flume: CLOSED
- d. The GAC Feed Pumps shall be started as specified herein under "Intermediate Pump Station".

3.13 DRAIN PUMP STATION (P.O. HOFFER WTF)

A. Process Overview

- 1. Two (2) submersible, constant-speed pumps (P-93101 and P-93102) shall be provided under Division 43. The pumps shall be located within the Drain Pump Station wet well to pump drain flows to the waste flume.
- 2. One (1) radar level transmitter (LE/LIT-93143) shall be provided within the Drain Pump Station wet well for level monitoring in SCADA.
- 3. Four (4) level switches (suspended float switch type) shall be provided and installed in the wet well as specified in Division 26 for hardwired shutdown interlock.
 - a. Low-low level switch shall shut both pumps off and signal a Low Water Alarm at the OWS.
 - b. High-high level switch shall signal a High Water Alarm at the OWS.
- 4. A Vendor Control Panel (VCP) shall be provided for the Drain Pump Station under Division 43. The VCP shall be located adjacent to the Drain Pump Station as shown on the Drawings.

B. Control Operations

1. Status indication and alarms from the VCP shall be re-transmitted to SCADA as specified in Section 43 25 13.10.
2. The level in the wet well shall be displayed in SCADA as transmitted by the radar level transmitter.
 - a. A LOW-LOW level reported by LE/LIT-93143 (adjustable with an initial setting of 77.50) shall alarm at the OWS.

END OF SECTION

SECTION 40 62 00
COMPUTER SYSTEM HARDWARE AND ANCILLARIES

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. The process control system is physically and functionally distributed between PLC equipped control panels, motor control panels, field panels, operator workstations and appurtenances.
- B. Although manual control facilities shall be provided adjacent to each final control element or in local control panels, such facilities are for testing, maintenance and local monitoring purposes only and shall not be regarded as backup to the PLC-based control system.
- C. PLCs may be categorized as either “process PLCs” or “integration PLCs” that are provided by the instrumentation subcontractor or “equipment control PLCs” or “vendor PLCs” or “packaged PLCs” provided by equipment manufacturers for the operation of their equipment (blowers, centrifuges, chemical systems, filters, etc.). Unless otherwise specified, all PLCs provided under this Contract shall conform to the requirements specified in this Division.
- D. Major plant control system digital equipment items are described in the Specifications and shown on the Drawings.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 40 63 43 – Programmable Logic Controllers
- B. Section 40 66 00 – Network and Communication Equipment

1.03 DIGITAL HARDWARE CONFIGURATIONS

- A. The digital hardware configuration shown on the Control System Architecture Drawing depicts overall system configuration requirements. System design shall be based upon this concept and shall provide an overall digital system availability of 99.8 percent under the conditions specified in Section 40 61 21.73 – Final Acceptance Test. Unless otherwise specified, designs that vary from this concept will be rejected.
- B. All discrete and analog data acquisition, preprocessing, storage and process control functions shall be performed at the PLC level. Run time and flow accumulations shall be performed at the PLC level. Except for minimal calculations related to report-specific functions such as minimum, maximum, average, etc., operator workstations shall not be used to perform calculation for the process control system. Operator workstations shall

be fully independent devices, individually connected to the plant control system networks.

- C. No other exceptions will be considered.

PART 2 – PRODUCTS

2.01 GENERAL SYSTEM HARDWARE REQUIREMENTS

- A. Unless otherwise specified, all hardware shall be rated for industrial use, resistant to shock, vibration, electromagnetic interference, static discharge, and suitable for the environmental conditions described elsewhere in this Division. Commercial or office grade equipment shall not be accepted.
- B. Unless otherwise specified, modular construction shall be employed to simplify maintenance and to provide for future hardware expansion. Plugin, modular PCB's or modules shall be employed for easy removal to permit exposure of circuit wiring, components and test points. Extender boards shall be provided, if necessary, to permit PCB's to be completely exposed for testing purposes.
- C. Keying schemes shall be used to prevent PCB misplacement.
- D. The temperature inside each enclosure containing digital hardware (i.e., cabinet, panel or console) shall be continuously monitored and shall generate an alarm to the nearest PLC if the temperature rises to an adjustable, preset high temperature.

2.02 DIGITAL SYSTEM FAILURE DETECTION AND FAIL-OVER REQUIREMENTS

- A. No degradation in control system performance shall occur when the system is operating in a partial failure or an equipment failover mode. Likewise, no degradation of system performance shall occur while a backed up system component is undergoing preventive or corrective maintenance.
- B. All devices connected to the plant control system network shall be selfchecking and shall report their operational status to the operator workstations as either "normal" or "failed". A graphic display based on the system architecture drawing shall be furnished with the control and information system showing this information along with current communication status of each device.

PART 3 – EXECUTION

3.01 REQUIREMENTS

- A. Refer to Section 40 61 13 – Process Control System General Provisions, Part 3.

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SECTION 40 63 43
PROGRAMMABLE LOGIC CONTROLLERS (PLC)

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. The Contractor shall furnish, test, install and place in satisfactory operation all programmable logic controllers (PLC), with all spare parts, accessories, and appurtenances as herein specified and as shown on the Drawings.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 40 61 13 – Process Control System General Provisions
- B. Section 40 61 23 – Signal Coordination Requirements
- C. Section 40 62 00 – Control and Information System Hardware - General
- D. Section 40 66 00 – Network and Communication Equipment
- E. Section 40 67 63 – Uninterruptible Power Systems
- F. Section 40 67 00 – Control System Equipment Panels and Racks

1.03 TOOLS, SUPPLIES AND SPARE PARTS

- A. Tools, supplies and spare parts shall be provided as specified in Section 40 61 22 – Tools, Supplies, and Spare Parts. In addition, the following specific spare parts items shall be provided:
 - 1. One of each type and size of module for PLC equipment furnished under this Contract.
 - 2. One of each type and size of PLC and equipment power supply furnished under this Contract.

PART 2 – PRODUCTS

2.01 PROGRAMMABLE LOGIC CONTROLLERS - GENERAL

- A. The instrumentation subcontractor shall furnish programmable controllers (PLCs) as specified herein and as shown on the Drawings. PLCs shall be provided complete with backplane, power supply, I/O cards, special function cards, instructions, memory, input/output capacity, and appurtenances to provide all features and functions as described herein. No substitutions will be permitted.

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- B. All components of the PLC system shall be of the same manufacturer; who shall have fully tested units similar to those being furnished in an industrial environment with associated electrical noise. The PLC system shall have been tested to meet the requirements of NEMA Standard ICS 2-230 (Arc Test) and IEEE C37.90.1 (SWC). The processing unit shall perform the operations functionally described herein based on the program stored in memory and the status of the inputs and outputs.
- C. Programmable controllers shall be designed to operate in an industrial environment. The PLC shall operate in an ambient temperature range of 0°-60°C and a relative humidity of 5-95 percent, non-condensing. The PLC shall operate on supply voltages of 90-132 VAC at 4763 Hz or 24 VDC if provided with a battery backup system. An integral fuse shall be provided on the power supply for short circuit protection and shall be front panel accessible. Integral overcurrent and undervoltage protection shall be provided on the power supply.
- D. Where applicable, the minimum PLC backplane size shall be 7 slots, not including power supply slots.
- E. System configuration shall be as shown on the Control System Architecture Drawing. PLC types shall be designated on the Control System Architecture Drawing and correspond to the specifications herein. Only a single type of processor shall be supplied for all PLCs of a designated type. Memory and processor shall be adequate for all control functions specified. PLCs shall be the following with no substitutions:
 - 1. Allen-Bradley CompactLogix 5370 L3 PAC Series with 1769-L36ERM CPU
 - 2. Allen-Bradley CompactLogix with xxx processor
 - 3. GE RX3i with xxx processor
 - 4. Modicon M580 with xxx processor
 - 5. Modicon M340 with xxx processor

2.02 PROCESSORS

- A. The processor and its associated memory shall be enclosed in a modular enclosure. A multiple-position selector switch or equivalent shall be used to select processor operating mode. LED-type indicating lights shall be provided to indicate processor, memory, and battery status. Errors in memory shall be recognized and shall activate the memory error indicating lights. The PLC processor shall monitor the internal operation of the PLC for failure and provide an alarm output. Nonvolatile memory in the form of a manufacturer supplied industrial CompactFlash card or equivalent technology shall be required to maintain the entire current program and firmware of the controller in the event of power loss. The program shall be updated onto the flash memory each time a program change such as an online edit or tag value is changed. When nonvolatile memory (flash memory) is not available for certain controller models as offered by the PLC manufacturer, lithium batteries shall be used to maintain process RAM memory for

at least one year in the event of power loss. The lithium battery unit shall be an externally mounted battery assembly with the highest available capacity. The PLC shall send an alarm to the plant control system if battery level is low.

- B. The instruction set for the PLC shall conform to the requirements of IEC 61131-3. Each PLC shall have the capability to run all five of the standard IEC 61131-3 languages simultaneously. These five languages shall be:
 - 1. Ladder Diagram
 - 2. Structured Text
 - 3. Instruction List
 - 4. Function Block Diagram
 - 5. Sequential Function Chart
- C. Additional co-processors or modules may be necessary and shall be furnished as required to meet the functions specified herein and in Section 40 61 96 – Process Control Descriptions.
- D. PLC processors shall be provided with substantial user program, data and logic memory to allow for future expansion of the overall system. The total memory used on each processor shall be less than 60% of available memory at project completion.

2.03 COMMUNICATIONS

- A. PLC communications shall be provided as specified in Section 40 66 00 – Network and Communication Equipment and as shown on the Control System Architecture Drawing.
- B. In addition to a communications port for the control system network, communication ports shall be provided for any other devices required (i.e., operator interface unit) plus an additional communication port for connection to a notebook computer.
- C. The PLC shall be able to support various types of fieldbus communication systems for data links to field instruments (where specified) in addition to connected equipment such as power monitors, VFDs, motor protection monitors, etc. As a minimum, Profibus DP, Foundation Fieldbus, Modbus RTU Master and Slave, TCP/IP Ethernet shall be supported. The Contractor shall coordinate the efforts of the necessary parties (instrumentation subcontractor and equipment suppliers) to accomplish the required device and data table addressing between each PLC and the associated connected equipment.
- D. Additional communication modules or protocol gateways may be required to support specific communication protocols required under this Contract and shall be supplied at no extra cost to the Owner.

2.04 INPUT/OUTPUT SUBSYSTEMS

- A. Input/output hardware shall be plug-in modules in associated I/O backplane/chassis or DIN-rail mounting assemblies. Each unit shall handle the required number of process inputs and outputs plus a minimum of 10 percent active pre-wired spares for each I/O type furnished, plus a minimum of 20 percent spare I/O module space for the addition of future circuit cards or modules.
- B. Discrete inputs shall be 24 VDC signals (integral to the PLC) from dry field contacts. Discrete outputs shall be dry relay contacts (2A minimum) as required. Refer to Section 40 61 23 – Signal Coordination Requirements for further details of discrete signal type and voltage requirements. The PLC shall provide momentary and latched outputs as required to interface with motor controls and external devices. Interposing relays shall be provided where required to interface with field equipment. Interposing relays shall be as specified in Section 40 78 00 – Panel Mounted Instruments. Electrical isolation shall be provided where required. Maximum density for discrete I/O modules shall be 32 per input module and 16 per output module.
- C. Analog input circuits shall be isolated, minimum 16-bit resolution type. Analog input hardware shall be provided as required for all types of analog inputs being transmitted to the PLC. In general, analog input modules shall be capable of receiving 4-20 mA signals. Where required, RTD input modules shall have a minimum resolution of 0.15°C and be capable of accepting signals from 100-ohm Platinum RTDs. Analog outputs shall be coordinated with the receivers but shall generally be isolated 24 VDC 4-20 mA outputs powered from the PLC. Each input/output circuit shall have optical isolation to protect the equipment against high voltage transients. Optical isolation shall be rated at not less than 1500 V RMS. Lightning/surge protection shall be provided as specified in Section 40 78 56 – Isolators, Intrinsically-Safe Barriers, and Surge Suppressors. Maximum density for analog I/O modules shall be 8 per module.
- D. Input/output modules shall be configured for ease of wiring and maintenance. The modules shall be connected to wiring arms that can be disconnected to permit removal of a module without disturbing field wiring. Covers shall be provided to prevent operator personnel from inadvertently touching the terminals. The process interface modules shall be provided with screw-type terminal blocks with barriers between adjacent terminals for connection of field inputs. Terminals shall be suitable for accepting up to and including No. 14 AWG wire. All DC output circuits to the field shall include fuses, either integral or at the terminal strip. Output failure mode shall be selectable so that upon station or communication system failure all outputs shall be placed either in the non-conducting mode or remain as were prior to failure. Light-emitting diodes shall be provided for status indication for each input and output point.
- E. External power supplies shall be provided with the PLC as required to meet specified installed I/O power requirements plus spares. Power supplies shall be modular units, shall be fully redundant and shall alarm the PLC upon failure. Power supplies shall have a line regulation of 0.05% and meet the environmental and power requirements specified herein for the PLC.

2.05 REMOTE I/O SUBSYSTEMS

- A. Remote I/O shall be provided as designated on the Control System Architecture Drawing. Remote I/O shall be either PLC backplane type I/O or field modules as manufactured by the PLC manufacturer. Field modules shall meet the requirements of Subsection 2.04, Input/Output Subsystems. Remote I/O processor or communication modules shall be modular and individually replaceable.
- B. Remote I/O shall communicate with the PLC using the PLC manufacturer's standard protocol or an open standard network such as DeviceNet, Ethernet IP, ProfiNet, Foundation Fieldbus, Modbus TCP/IP, or equal.

2.06 INPUT/OUTPUT CIRCUIT ARRANGEMENT

- A. Signal and control circuitry to individual input/output boards shall be arranged such that board failure shall not disable more than one half of the control loops within any group of controlled equipment (e.g., one pump out of a group of three pumps, two pumps out of four, etc.). Where possible, individual control loops and equipment shall be assigned to individual boards such that failure of the board will disable only one loop or piece of equipment.

2.07 PROGRAMMING SOFTWARE

- A. The PLC programming and configuration software shall be Studio 5000 to match the Owner's existing system.
- B. PLC logic shall not use structured text. No exceptions shall be permitted.

PART 3 – EXECUTION

3.01 REQUIREMENTS

- A. PLC programming shall be furnished to perform all functions described in Section 40 61 96 – Process Control Descriptions, including global functions. In addition, PLCs shall be programmed to provide additional functions described in other Sections of this Division.
- B. PLC programming shall make use of the various IEC languages as appropriate to the specific task and shall be performed in a modular style making extensive use of program blocks (subroutines) and program variables to be passed to the program blocks for specific equipment. It is the intent of this requirement to allow for enhanced readability and ease of modification of the program code through the elimination of multiple instances of repeated code for the same function in a "hard-coded" style.
- C. Extensive comments shall be placed in the program code to describe the functions of all elements of the program code. PLC code that does not contain comments shall be rejected.

- D. Refer to Section 40 61 13 – Process Control System General Provisions, Part 3 for additional requirements.

3.02 REQUIREMENTS FOR MANUFACTURER-SUPPLIED PLCS

- A. PLCs that are supplied for equipment local control panels by individual equipment manufacturers or suppliers shall, where so indicated on the Control System Architecture Drawing, be integrated into the plant control system. The manufacturer-supplied PLC shall be furnished, installed and programmed by the manufacturer. The PLC shall continuously monitor and control the associated system and at the same time shall provide all the required alarms, indications of system parameters, equipment status, etc. to the main control system at the plant.
- B. Where required as described above, each manufacturer-supplied PLC shall be connected to the Ethernet process control network for access from the plant control system HMI servers, as specified in Section 40 66 00 – Network and Communication Equipment, and shall contain a fiber optic Ethernet switch identical to those provided for the rest of the network-connected PLCs.
- C. Each equipment manufacturer shall provide all monitoring and control data to be transferred between the PLC and the plant control system in contiguous blocks of PLC registers to facilitate block read and write commands for efficient scanning by the control system SCADA servers. These contiguous registers shall be arranged in a single data transfer area, which shall be divided into eight distinct areas with an emphasis on flexibility and future expansion. The distinct areas shall be arranged by data type (analog or discrete), transfer direction (server to PLC or PLC to server), and, where applicable, implementation schedule (current or future). Where required, peer-to-peer communication between PLCs shall likewise be accomplished using separate blocks of contiguous registers. Where individual equipment PLCs are not required to be connected to the plant control system via the data highway network, they shall provide the individual hardwired signals as specified in the Contract Documents. Data and commands for connection to the control system are described in the Drawings, the Input/Output Schedule, the individual equipment Specification Sections, and in Section 40 61 96 – Process Control Descriptions.
- D. The operator interface for control of each individual system shall be performed by local operator interface units as specified in Section 40 62 63 – Operator Interface Terminals or individual pilot devices on the equipment local control panel, as specified in the associated equipment Specification Section. Additional operator interface functions shall be provided through the plant control system as specified in the respective equipment specifications and in Section 40 61 96 – Process Control Descriptions.
- E. Where operator interface and control functions are required to be provided through the plant control system, the individual system supplier shall be responsible for coordination with the instrumentation subcontractor to provide a complete and working equipment control system. The individual equipment supplier shall also be responsible for limiting the access of the plant control system to the equipment PLC code so as to prevent

malfunctions of the equipment and any failure to continuously perform its intended functions. The equipment supplier shall be responsible for ensuring that no actions by the plant control system can damage or otherwise adversely affect the operation of the associated equipment or the safety of personnel working on or near that equipment. The equipment supplier shall also provide direction in the configuration of the SCADA software's security system by the instrumentation subcontractor to limit access to the control functions of the equipment control system to authorized personnel only. The equipment supplier shall coordinate testing of the completed system with the instrumentation subcontractor, which shall conform to the requirements of Section 40 61 21.72 – Field Testing.

- F. The Contractor, equipment supplier and instrumentation subcontractor shall coordinate testing and startup of the equipment provided by the equipment supplier with the plant control system, including but not limited to the following tasks:
1. Provide assistance with control system testing of inputs, outputs, and control strategies as needed.
 2. Provide support or interface work necessary to perform physical checkout and field testing to the final field devices. The schedule may require the instrumentation subcontractor and equipment manufacturer personnel to perform loop checks simultaneously, as directed by the Engineer.
 3. Coordinate and assist as needed to maintain I/O connectivity throughout the system.
 4. Ensure personnel safety while equipment is exercised via the plant control system.
 5. Ensure that process, instrumentation, and control equipment are not damaged while equipment is exercised via the plant control system.
 6. Provide temporary modifications to field devices and their terminations, if needed.
 7. Providing labor and supervision, which may include, but is not limited to, the following: electricians, instrument technicians, manufacturer's representatives, and individual(s) knowledgeable about process startup and operation.
 8. Operation of process equipment for verification of each plant control system input and output.

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SECTION 40 66 00
NETWORK AND COMMUNICATION EQUIPMENT

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. The Contractor shall furnish, test, install and place in satisfactory operation IEEE 802.3 ethernet local area network(s) for communications among plant devices.
- B. Local area network shall be provided with all spare parts, accessories, and appurtenances as herein specified.
- C. All industrial network switches are to be supplied to the owner prior to installation for configuration by Fayetteville PWC's IT department.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 40 61 13 – Process Control System General Provisions
- B. Section 40 63 43 – Programmable Logic Controllers

1.03 TOOLS, SUPPLIES AND SPARE PARTS

- A. The following specific spare parts items shall be provided:
 - 1. A termination tool kit shall be provided containing all required tools and consumables for up to 25 connections of each connection type furnished. Termination kit shall be as manufactured by Black Box, Corning Cable Systems, Optical Cable Corporation, or equal.
 - 2. One (1) spare switch of each type furnished under this Contract.
 - 3. Two (2) spare patch cables of each type and of the maximum length used.
 - 4. Two (2) spare GBIC or SFP modules for each type used.
 - 5. One (1) spare media converter for each type used.

1.04 SUBMITTALS

- 1. Fiber optic testing results, including signal attenuation for each fiber

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PART 2 – PRODUCTS

2.01 LOCAL AREA NETWORK (LAN)

- A. An IEEE 802.3 ethernet local area network shall be used for communications between plant devices.
- B. Network wiring shall be unshielded, twisted-pair copper cables for connections within buildings. Fiber optic media shall be used for all inter-device communication links extended outside of a building, unless specifically noted. Cables shall be as specified herein.
- C. The Contractor shall provide appurtenances, including but not limited to, all hardware, cables, connectors, adapters, modules, and software, to implement a network as required for a fully functional system even if not explicitly specified or shown.

2.02 INDUSTRIAL ETHERNET NETWORK SWITCHES

- A. Except where specifically allowed on the Control System Architecture Drawing, industrial ethernet network switches shall be provided for each device connected to the process control system network. The switches shall create switched ethernet networks that conform to the IEEE 802.3 and 802.3u standards using copper wires or optical fibers in a bus, tree or ring network topology as shown on the Drawings. Ethernet network switches shall be modular, rack mounted, or standard DIN-rail mounted within the PLC cabinet or in an adjacent communication cabinet, as shown on the Drawings.
- B. Ethernet network switches shall support ring, bus, star, or point-to-point network topologies. On-line signal monitoring shall be provided to detect and locate impending faults. Ethernet network switches shall be replaceable on-line without disrupting the network. The ethernet network switches shall be integrated into the in-plant Ethernet network to form a redundant ring network with self-healing communication recovery. Switches shall support the non-proprietary Media Redundancy Protocol (MRP) and Rapid Spanning Tree Protocol (RSTP) in addition to the switch manufacturer's standard redundant ring network protocol, all of which shall provide self-healing communication recovery.
- C. Ethernet network switches shall meet the following minimum performance requirements:
 - 1. Functions: Modular managed switch with store and forward switching mode, 10 Mbps ethernet, or 100 Mbps Fast-Ethernet, or gigabit Ethernet support, multi-address capability, auto-crossing, auto-negotiation, auto-polarity. Port speed and duplex auto-negotiation shall be configurable.
 - 2. Management: Simple Network Management Protocol (SNMP) (v1/v2/v3) and Common Industrial Protocol (CIP) support; IGMP filtering and snooping.
 - 3. Power Requirements: Redundant 24 VDC power supply

4. Operating Temperature: 0 to 60 degrees C
 5. Relative Humidity: 10 to 95%
 6. Network Size: Up to 50 nodes in ring structure; otherwise unlimited
 7. Port Type & Quantity (at each PLC location): minimum of four (4) 10/100Base-TX, twisted pair cable, RJ-45 sockets, 0-100 meters LAN segment and two (2) 100/1000Base-FX, multimode fiber optic cables (62.5/125 μ m), LC, ST or SC sockets, 0-5000 meters LAN segment
 8. Link Budget: 8 dB @ 1300 nm; 10 dB @ 850 nm
 9. Wavelength: 850 or 1300 nm
- D. Acceptable industrial ethernet network switches shall be Allen Bradley Stratix series current offering.

2.03 FIBER OPTIC MEDIA CONVERTERS

- A. Fiber optic media converters shall be provided to transform the specific PLC network communications protocol into an optical signal suitable for transmission over the fiber optic cable specified herein. Fiber optic media converters shall be modular, rack mounted, or mounted within the PLC rack.
- B. Fiber optic media converters shall meet the following minimum performance requirements:
 1. Input Power: 110/220 VAC or 24 VDC, as required to match power source.
 2. Operating Temperature: 0 to 60 degrees C
 3. Node-to-Node Distance: 6,500 feet
 4. Nominal Wavelengths:
 - a. 850 and 1300 nanometers for multimode fiber
 - b. 1310 and 1550 nanometers for single-mode fiber
 5. Connector Type: SC, LC, or ST
- C. The PLC manufacturer's standard, PLC rack-mounted fiber optic transceiver may also be used, subject to approval by the Engineer.
- D. Port speed and duplex auto-negotiation shall be configurable.

- E. Acceptable fiber optic media converters shall be as manufactured by Black Box, Phoenix Contact, or equal.

2.04 UNSHIELDED TWISTED PAIR CABLE

- A. Unshielded twisted pair cable for drops within buildings shall consist of 4 pair of 24 AWG copper conductors in a flame-retardant jacket. Cable shall be plenum rated (UL 910) and meet EIA/TIA-568 Category 6 (i.e., Cat6) specifications. Unshielded twisted pair cable shall be Hyper Grade Extended Distance cable as manufactured by Berk-Tek, Belden equivalent, or equal. Connectors shall be modular RJ-45 plug.
- B. Solid conductors shall be used for all field wiring and punch-down applications. For patch cable applications and where installed-flexibility is necessary, such as for movable equipment or across enclosure door hinges, conductors shall be stranded.
- C. For use as ethernet, Contractor's conduit/cable routing shall be limited to the maximum ethernet length of 100m. If this cannot be accomplished, Contractor shall design and provide a system utilizing long-range copper extenders or fiber with media conversion or similar to overcome distance limitations, subject to Engineer's approval.
- D. Provide copper patch panels where more than one copper communication cable leaves the enclosure.

2.05 SINGLE-MODE FIBER OPTIC CABLE (OS2)

- A. Fiber optic cable shall conform to ITU-T G.652 and the following specifications:
 - 1. Fiber Type: Graded Index (GI) Single Mode
 - 2. Fiber/Cladding Diameter: 9/125 microns
 - 3. No. Fibers: 24 (color-coded), unless otherwise indicated
 - 4. Cable Construction: Loose Tube w/ Ripcords
 - 5. Filling: Water Swellable Dry Block
 - 6. Armored: No
 - 7. Central Member: Dielectric (Kevlar)
 - 8. Rating: Gigabit ethernet, unless otherwise indicated
 - 9. Maximum Attenuation: 0.5 dB/km
 - 10. Application Type: Direct-burial/Conduit/Aerial

11. Plenum Rated: Where required (e.g., in drop ceilings)
 12. Sheath: UV Resistant
 13. Max. Tensile Load: 600 lb (2700 N) installation; 200 lb (890 N) long term
 14. Minimum Bend Radius: 7 in under maximum tensile load; 4.6 in unloaded (installed)
 15. Operating Temperature: -40 to 70 degrees C
 16. Operating Relative Humidity: 0 to 100%
- B. Fiber optic cable shall utilize mechanically spliced, field installable, SC, LC, or ST compatible connectors. Connections shall have a typical loss of 0.35 dB or better and shall provide stable optical performance after numerous rematings. Heat or UV cured connections shall not be acceptable. Where applicable, field terminations shall use a simple procedure requiring minimal training.
- C. Fiber optic cable shall be ALTOS All Dielectric Loose Tube Optical Cable as manufactured by Corning Cable Systems, the Extended Performance Fiber Optic Cable Series as manufactured by Phoenix Digital, Inc., Belden equivalent, equivalent system by Optical Cable Corporation, or equal.

2.06 FIBER OPTIC PATCH PANELS

- A. Upon entering a cabinet, panel or console, fiber optic cable shall be broken out using fan-out kits and terminated in a fiber optic patch panel. Fan-out kit shall provide mechanical connection to fiber optic cable jacket for strain relief and clean appearance. Where mechanical connection is not made or fan-out kit does not completely cover jacket, rip cords, dry block, material etc., fan-out kit shall be reinforced with short length of properly sized heat shrink tubing. Use of adhesive tape in this application shall not be permitted.
- B. All fiber optic patch panels shall be mounted within a rack or a NEMA rated enclosure. Wall-mounting stand-alone patch panels shall not be permitted unless otherwise indicated.
- C. Rack-mounted patch panels shall be Cabinet-Mounted Interconnect Center (C-MIC) as manufactured by Corning Cable Systems, equivalent by Black Box, Inc., Optical Cable Corporation, or equal.
- D. Stand-alone patch panels shall be Wall-Mountable Interconnect Center (WIC) or Premises Interconnect Center (PIC) as manufactured by Corning Cable Systems, equivalent by Black Box, Inc., Optical Cable Corporation, or equal.

- E. Fiber optic patch cable shall be provided at necessary lengths with a modal bandwidth (OM or OS) rating at least as high as the connected components.

PART 3 – EXECUTION

3.01 GENERAL REQUIREMENTS

- A. The destination of all network data cables (both copper and fiber) leaving an enclosure, patch panel, or building shall be labeled at each end using industry-standard wire markers.
- B. Refer to Section 40 61 13 – Process Control System General Provisions for additional requirements.

3.02 FIBER OPTIC CABLE

- A. Fiber optic cable for installation within buildings shall comply with all applicable fire and building safety codes for such applications.
- B. Fiber optic cable shall be installed in accordance with cable manufacturer's instructions.
- C. Testing
 - 1. Bulk fiber shall be tested on-site to prior to installation to provide a reference for the installed test data.
 - 2. All individual fibers, including spares, shall be terminated and all connections shall be tested after installation.
 - 3. Complete installed fiber optic cable shall be tested for continuity with a visual fault locator or fiber tracer and the connections verified and documented. Cabling shall also be tested for optical/insertion loss in compliance with Tier 1 testing per TIA-568.
 - 4. Submit all test results.

3.03 FIBER OPTIC PATCH PANELS

- A. All patch panels shall be labeled with destination/function of each port, matching terminology from the Contract Documents where possible. Provide printed directory mounted to or adjacent to patch panel with this information where sufficient space is not available.

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SECTION 40 67 00
CONTROL SYSTEM EQUIPMENT PANELS AND RACKS

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. The Contractor shall furnish, test, install and place, in satisfactory operation the control enclosures, with all spare parts, accessories, and appurtenances as specified herein and as shown on the Drawings.
- B. Control enclosures shall be assembled, wired, and tested in the instrumentation subcontractor's own facilities, unless specified otherwise. All components and all necessary accessories such as power supplies, conditioning equipment, mounting hardware, signal input and output terminal blocks, and plug strips that may be required to complete the system shall be provided.
- C. Either manufacturer's standard or custom enclosures may be furnished subject to the requirements of the Contract Documents and favorable review by the Owner.
- D. Due consideration shall be given to installation requirements for enclosures in new and existing structures. The Contractor shall examine plans and field inspect new and existing structures as required to determine installation requirements and shall coordinate the installation of all enclosures with the Owner and all affected contractors. The Contractor shall be responsible for all costs associated with installation of enclosures, including repair of damage to structures (incidental, accidental or unavoidable).
- E. The terms enclosure, cabinet, and panel shall be considered the same product and are used interchangeably.

1.02 SUBMITTALS

- A. Submittals shall be per Section 40 61 15 – Process Control System Submittals.
- B. Thermal calculations.
- C. Proof of circuit breaker selective coordination.

1.03 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 40 61 13 – Process Control System General Provisions
- B. Section 40 62 00 – Computer System Hardware and Ancillaries

- C. Section 40 78 00 – Panel Mounted Instruments
- D. Section 40 78 56 – Isolators, Intrinsically-Safe Barriers, and Surge Suppressors
- E. Section 40 70 00 – Instrumentation for Process Systems
- F. Section 40 61 90 – Schedules and Control Descriptions, General
- G. Refer to Division 26 for additional requirements for conductors, circuit breakers, disconnect switches, etc.

1.04 PANEL LOCATION AND TYPE

- A. For locations inside buildings in areas other than climate controlled (i.e., heated and air conditioned) electrical or control rooms, panel shall be Type 316 stainless steel NEMA 4X construction, or as indicated for hazardous area classification (Class, Division, at a minimum), or submersible, NEMA 6, applications. Epoxy coated cast copper-free aluminum construction shall also be acceptable for NEMA 4, 6 and 7 applications.
- B. For locations in storage/feed areas for chlorine or other applicable corrosive chemicals, panel shall be of non-metallic construction, rated NEMA 4X, and be fully compatible with the associated chemical.
- C. For locations within climate controlled (i.e., heated and air-conditioned) electrical or control rooms, panel shall be a painted steel fully enclosed NEMA 12 units with gasketed doors.
- D. For outdoor locations, panel shall be Type 316L stainless steel NEMA 4X construction unless located in chlorine environments. Chlorine environment shall be nonmetallic NEMA 4X construction.

1.05 TOOLS, SUPPLIES AND SPARE PARTS

- A. Tools, supplies and spare parts shall be provided as specified in Section 40 61 22 – Tools, Supplies and Spare Parts, General.

PART 2 – PRODUCTS

2.01 CABINETS AND PANELS

- A. Cabinets and panels shall be formed or welded construction, reinforced with Unistrut, Powerstrut, or equal to facilitate mounting of internal components or equipment. Sufficient access plates and doors shall be provided to facilitate maintenance and testing of the cabinet's equipment. Doors shall be removable. Cabinets and panels with any dimension 36 inches or greater shall be provided with removable lifting lugs designed to

facilitate safe moving and lifting of the panel during installation. All doors shall be fitted with common-keyed locks.

- B. Cabinets and panels shall be minimum 14 USS gauge. Cabinets and panels with any dimension greater than 36 inches shall be 12 USS gauge.
- C. Cabinets and panels shall have doors on the front and shall be designed for front access. NEMA 12 cabinets shall be fitted with three-point door latches. Doors for NEMA 4X cabinets shall be all stainless steel with three-point latches. Door hardware on NEMA 4X cabinets located in chemical storage/feed areas shall be non-corrosive in that environment.
- D. Panels and cabinets located outside fence-secured areas shall be fitted with padlockable latch kits. Coordinate keying with Owner.
- E. All cabinets and panels shall be provided with drawing pockets for as-built panel drawings. One copy of the appropriate panel as-built drawings shall be furnished and left in the pocket of each panel.
- F. Panels with any dimension greater than 36 inches that contain a programmable controller (PLC) shall be provided with a folding laptop programmer shelf on the inside of the door. When deployed, the laptop shelf shall not be greater than 48 inches above finished floor. Laptop shelf shall be fitted to door with factory applied weld-studs. Weld discoloration and enclosure penetrations will not be accepted.
- G. Unless otherwise noted, panel-mounted control devices (OIUs, hand switches, etc.) requiring operator access shall be mounted between 48 and 60 inches above the floor or work platform.
- H. Cabinets and panels shall be prefabricated cabinets and panels by Hoffman or Saginaw Control and Engineering (SCE). The Contractor may optionally provide cabinets that are custom-fabricated by the instrumentation subcontractor or by a reputable panel fabrication shop acceptable to the Engineer.

2.02 FIELD PANELS

- A. Field panels for outdoor service shall be suitable for wall or pipe mounting. Panels shall have the following features:
 - 1. Hinged and foamed-in-place continuous gasketed door(s). Door material shall match enclosure and shall have piano hinge(s) and three-point latches.
 - 2. Field panels located outside fence-secured areas shall be fitted with staple and hasp. Provide padlock and coordinate keying with Owner.

3. Thermal insulation and thermostatically controlled space heaters where required to prevent condensation or maintain environmental conditions for installed components.
 4. External sun shields or shades constructed of the same materials as the associated enclosure, unless otherwise specified. Sun shield or shade shall be fitted to enclosure supports and not to enclosure. Sun shield or shade shall have a slightly sloped top to shed water and shall extend past the front of the enclosure by at least 6 inches and extend down the side and back of enclosure.
- B. All external sample/process piping, including valves and appurtenances, shall be insulated with weather-proof insulation and heat-taped to prevent freezing. Heat taping shall be thermostatically controlled and self-regulating, and shall adjust its heat output to the temperature of the lines. Heat tape shall be powered from an equipment-safety GFCI circuit from within panel, unless otherwise shown or specified.
 - C. Field panels shall be adequately sized to house instruments, power supplies, surge protection, and appurtenant equipment required for operation. Sufficient space shall be provided for servicing instruments without removal of equipment from the enclosure.
 - D. Field panels shall be as manufactured by Hoffman, Saginaw Control & Engineering (SCE), or equal.

2.03 CABINET AIR CONDITIONING UNITS

- A. Where indicated or required due to ambient conditions and panel component ratings, panel-mounted closed loop air conditioning units and thermostatically controlled space heaters shall be provided.
- B. Air conditioning units shall both cool and dehumidify the cabinet's internal air. Each air conditioner shall be sized to handle current and future (with specified spare capacity filled) heat loadings from all equipment mounted inside the cabinet.
- C. Air conditioners shall be provided with thermostats which operate the centrifugal evaporator blowers continuously to prevent stratification of air within the cabinet. Compressors shall operate as needed to maintain the temperature set at the thermostat. Compressors shall be provided with space heaters to maintain the compressor at a minimum temperature during cold ambient temperatures.
- D. Ambient air shall be completely separated from the air inside the cabinet. All air conditioner components exposed to the atmosphere outside the cabinets shall be coated to prevent corrosion.
- E. Power supply shall be 115VAC, 60 Hz. Units shall be provided with EMI/RFI noise suppressors.

- F. Air conditioner enclosures shall be constructed of stainless steel or cold rolled steel which is phosphatized and finished in baked enamel.
- G. Cabinet air conditioners shall be ProAir CR Series as manufactured by McLean Midwest of Brooklyn Park, MN, or equal.

2.04 TERMINAL BLOCKS

- A. Terminal blocks shall be assembled on non-current carrying galvanized steel DIN mounting rails securely bolted to the cabinet subpanel. Terminals shall be of the screw down pressure plate type as manufactured by Phoenix Contact, Weidmuller, Wieland, Square D, or equal.
- B. Power terminal blocks for both 120 VAC and 24 VDC power shall be single tier with a minimum rating of 600 volts, 30 amps.
- C. Signal terminal blocks shall be single tier with a minimum rating of 600 volts, 20 amps.

2.05 NAMEPLATES

- A. Items of equipment installed in control panels shall be identified with nameplates. Each nameplate shall be located so that it is readable from the normal observation position and is clearly associated with the device or devices it identifies. Nameplates shall be positioned so that removal of the device for maintenance and repair shall not disturb the nameplate. Nameplates shall include, as necessary, the equipment identification number, description, calibrated range, and set point(s). Abbreviations of the description shall be subject to the Engineer's approval.
- B. Nameplates shall be made of 1/16-inch thick machine engraved laminated phenolic plastic having white numbers and letters not less than 3/16-inch high on a black background. Nameplates attached to instruments may be black laser etched 1/8-inch high text on stainless steel with sharp edges made smooth. Stamped text shall not be acceptable.
- C. Nameplates shall be attached to metal equipment by NEMA rated stainless steel screws and to other surfaces by an epoxy-based adhesive that is resistant to oil and moisture. In cases where the label cannot be attached by the above methods, it shall be drilled and attached to the associated device by means of a braided stainless steel wire affixed with a permanent crimp.
- D. Submit sample nameplate of each type.

PART 3 – EXECUTION

3.01 FABRICATION

- A. The cabinet itself and all interior and exterior equipment shall be identified with nameplates. The equipment shall be mounted such that service can occur without removal of other equipment. Face mounted equipment shall be flush or semi-flush mounted with flat black escutcheons. All equipment shall be accessible such that adjustments can be made while the equipment is in service and operating. All enclosures shall fit within the allocated space as shown on the Drawings.
- B. Enclosures shall provide mounting for power supplies, control equipment, input/output subsystems, panel-mounted equipment and appurtenances. Ample space shall be provided between equipment to facilitate servicing and cooling.
- C. Enclosures shall be sized to adequately dissipate heat generated by equipment mounted inside the panel. If required, one or more of the following shall be provided to facilitate cooling:
 - 1. For NEMA 12 cabinets only, louvered openings near the bottom and top or thermostatically controlled, low-noise cooling fans to circulate outside air into the enclosure, exhausting through louvers near the top of the cabinet. Air velocities through the enclosure shall be minimized to assure quiet operation.
 - 2. Thermostatically controlled, low noise internal air blowers to circulate air within the enclosure, maintaining a uniform internal temperature. Initial setpoint shall be 75 degrees F.
 - 3. All intake openings in cabinets and panels shall be fitted with dust filters.
- D. Enclosures shall be constructed so that no screws or bolt heads are visible when viewed from the front. Punch cutouts for instruments and other devices shall be cut, punched, or drilled and smoothly finished with rounded edges.
- E. The temperature inside each enclosure containing digital hardware (e.g., PLC, computer, Ethernet switch) shall be continuously monitored and shall generate an alarm to the nearest PLC if the temperature rises to an adjustable, preset high temperature. This thermostat shall be independent and separate from the thermostat used to control the temperature in the enclosure described above. Enclosure “high interior temperature” alarm shall be displayed on the HMI or OIT.
- F. Intrusion alarm switches shall be provided on all enclosures containing digital hardware and shall generate an alarm to the nearest PLC when any enclosure door is opened. If panel contains a service light, alarm switch shall also be wired to turn light on when door is opened.

- G. Terminals shall be marked with a permanent, continuous marking strip. One side of each terminal shall be reserved exclusively for field incoming conductors. Common connections and jumpers required for internal wiring shall not be made on the field side of the terminal. Subject to the approval of the Engineer, a vendor's pre-engineered and prefabricated wiring termination system will be acceptable.
- H. Wiring within cabinets, panels, and consoles shall be installed neatly and shall comply with accepted standard instrumentation and electrical practices. Power, control and signal wiring shall comply with Division 26 of the Specifications, except that the minimum wire size for discrete signal wiring may be 16 AWG, and for analog wiring may be 18 AWG. For each pair of parallel terminal blocks, the field wiring shall be between the blocks.
- I. Separate terminal strips shall be provided for each type of power and signal used within each cabinet. Where applicable, terminal strips for different voltages of discrete signal wiring shall also be separated. Terminal strips shall be labeled as to voltage and function.
- J. All wiring shall be bundled and run open or enclosed in vented plastic wireway as required. Wireways shall be oversized by a minimum of 10%; overfilled wireways shall not be acceptable. All conductors run open shall be bundled and bound at regular intervals, not exceeding 12 inches, with nylon cable ties. Care shall be taken to separate electronic signal, discrete signal, and power wiring when operating at differing voltages.
- K. Spare field wiring shall be bundled, tied, and labeled as specified above, and shall be neatly coiled in the bottom of the cabinet.
- L. All installed spare I/O hardware shall be wired along with live I/O wiring to the field wiring terminal blocks within the cabinet. Where space for spare I/O modules has been provided with the PLC backplane or DIN-rail mounting system, corresponding space for wiring, surge protection, and terminations shall be furnished within the cabinet.
- M. A copper ground bus shall be installed in each cabinet and shall be connected to the building power ground.
- N. Interior panel wiring shall be tagged at all terminations with machine-printed self-laminating labels. Labeling system shall be Brady TLS 2200 Printer with TLS 2200®/TLS PC Link™ labels, or equivalent system by Seton or Panduit. The wire numbering system and identification tags shall be as specified in Section 26 05 19 – Low-Voltage Conductors and Cables. Field wiring terminating in panels shall be labeled in accordance with the requirements of Section 26 05 19 – Low-Voltage Conductors and Cables. Where applicable, the wire number shall be the ID number listed in the input/output schedules.
- O. Wires shall be color coded as follows:

1. Equipment Ground – GREEN
 2. 120 VAC Power – BLACK
 3. 120 VAC Power Neutral – WHITE
 4. 120 VAC Control (Internally Powered) – RED
 5. 120 VAC Control (Externally Powered) – YELLOW
 6. 24 VAC Control – ORANGE
 7. DC Power (+) – RED
 8. DC Power (-) – BLACK
 9. DC Control – BLUE
 10. Analog Signal – BLACK/WHITE or BLACK/RED
- P. Enclosures shall be provided with a main circuit breaker and a circuit breaker on each individual branch circuit distributed from the panel. Main breaker and branch breaker sizes shall be coordinated such that an overload in a circuit will trip only its immediate breaker and not the upstream breaker.
- Q. Enclosures with any dimension larger than 36 inches shall be provided with 120-volt duplex receptacles for service equipment and LED service lights. Power to these devices shall be independent from the PLC power supply and its associated uninterruptible power system.
- R. Where applicable, enclosures shall be furnished with red laminated plastic warning signs in each section. The sign shall be inscribed "WARNING - This Device Is Connected to Multiple Sources of Power." Letters in the word "WARNING" shall be 0.75 inch high, white.
- S. The interconnection between equipment and panel shall be by means of flexible cables provided to permit withdrawal of the equipment from the cabinet without disconnecting the plugs.

3.02 PAINTING/FINISHING

- A. All steel enclosures shall be free from dirt, grease, and burrs and shall be treated with a phosphatizing metal conditioner before painting. All surfaces shall be filled, sanded, and finish coated by spraying a 1-2 mil epoxy prime coat and smooth, level, high grade textured finish between flat and semi-gloss shine. The colors shall be selected by the Owner from a minimum of six color samples provided. Refer to Division 09 for additional requirements.

- B. Materials and techniques shall be of types specifically designed to produce a finish of superior quality with respect to adherence, as well as impact and corrosion resistance.
- C. Panels fabricated from stainless steel shall not be painted.
- D. Panels fabricated from non-metallic materials (e.g., FRP) shall be gel-coated and shall not be otherwise painted.

3.03 INSTALLATION

- A. Refer to Section 40 61 13 – Process Control System General Provisions for additional requirements.

END OF SECTION

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SECTION 40 67 63
UNINTERRUPTIBLE POWER SYSTEMS

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. The Contractor shall furnish, test, install and place in satisfactory operation all uninterruptible power systems, with all spare parts, accessories, and appurtenances as herein specified and as shown on the Drawings.
- B. One UPS shall be provided for each operator workstation and its peripherals (i.e. printer, network equipment, radio, etc.) provided under this Contract.
- C. One UPS shall be provided for each programmable logic controller (PLC) panel or remote telemetry unit (RTU) and its appurtenant equipment provided under this Contract. However, courtesy receptacles in PLC and RTU cabinets shall not be powered by the UPS.
- D. UPS units shall be mounted in or near enclosures containing digital hardware, unless otherwise specified or shown on the Drawings, as follows:
 - 1. UPS units for operator's consoles shall be mounted within the consoles.
 - 2. UPS units for control panels containing PLCs shall be mounted either within the cabinet or in an adjacent cabinet of suitable environmental rating.
 - 3. UPS units for RTUs shall be mounted within the RTU cabinet.
- E. Where the UPS is mounted within a dedicated enclosure, that enclosure shall be properly sized for heat dissipation and all other applicable requirements as specified in Section 40 67 00 – Control System Equipment Panels and Racks and its subordinate Sections.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 40 61 13 – Process Control System General Provisions
- B. Section 40 62 00 – Computer System Hardware and Ancillaries
- C. Section 40 63 43 – Programmable Logic Controllers

1.03 SUBMITTALS

- A. Sizing calculations, in Watts (W) or Volt-Amps (VA), for all UPS units.

- B. Heat dissipation calculations for all enclosures that contain a UPS unit.
- C. Run time calculation.

PART 2 – EQUIPMENT

2.01 UNINTERRUPTIBLE POWER SYSTEMS

- A. Each UPS shall consist of a freestanding UPS module and battery modules as required to meet backup run time requirements.
- B. UPS units shall be true on-line type. Each UPS shall be sized to match the maximum power requirements of the associated digital equipment, control panel power supplies and accessories. Under normal operation, the AC power shall be converted to DC. The DC power from the battery charger shall supply an inverter and maintain the battery module at full charge. The AC output from the inverter shall be fed to the associated digital equipment power supply unit and/or other equipment power supplies as appropriate. Upon loss of the AC supply, the inverter shall continue to supply normal power to the device, drawing DC from the batteries.
- C. An automatic bypass switch shall be provided with UPS units of greater than 2 kVA capacity. The transfer switch shall be of the solid state, make-before-break type and shall automatically transfer load from the inverter to the AC line in the event of an inverter malfunction. The total transfer time shall be 5 milliseconds or less. The transfer switch shall be provided with a manual override.
- D. A manually operated maintenance bypass switch shall be provided for each UPS installation, other than for computers, to allow the hardware to be powered while the UPS is removed for maintenance. The bypass switch shall be the make-before-break type to ensure continuous power to the load.
- E. Loss of AC power shall be monitored on the line side of the UPS and reported via normally closed (fail safe) unpowered contacts to the associated PLC/RTU.
- F. Each UPS shall meet the following requirements:
 - 1. Input voltage shall be 117 VAC, single phase, 60 Hz.
 - 2. Voltage regulation shall be +/-5 percent for line and load changes.
 - 3. The output frequency shall be phase-locked to the input AC line on AC operation and shall be 60 hertz +/-0.5 percent when on battery operation.
 - 4. The batteries shall be of the sealed, lead acid or lead calcium gelled electrolyte type, or VRLA absorbed glass mat (AGM) type. The battery modules shall have a

minimum full load backup time of 30 minutes for PLC-based control panels, and 45 minutes for remote telemetry units.

5. The UPS capacity shall be sized for 150% of the connected load.
 6. A status monitoring and control panel shall be provided and shall include the following:
 - a. Status indicating lights for both normal and abnormal conditions.
 - b. Individual alarm contacts that shall close upon:
 - 1) Loss of the AC line
 - 2) Low battery level
 - 3) Fault condition.
 - c. Contacts shall be wired to the closest discrete input subsystem. Alternatively, an RS-232 or USB port shall provide UPS status to an operator workstation. All required interface software and hardware shall be provided.
 - d. Circuit breaker for the AC input.
 7. Sound absorbing enclosure.
 8. EMI/RF noise filtering.
 9. Surge protection shall be provided on the AC input circuit, which shall have a UL TVSS clamping voltage rating of 400 V with a <5 ns response time.
- G. UPS systems shall be the 9PX series by Eaton, Vertiv Liebert GXT5, or equal.

PART 3 – EXECUTION

3.01 REQUIREMENTS

- A. Where the UPS is mounted within the PLC or RTU cabinet, it shall not interfere with access to other equipment or wiring within the panel (i.e., it shall not be necessary to move or remove the UPS to remove or service other panel-mounted equipment). For floor-mounted PLC cabinets with bottom wiring access (including those cabinets with legs), the UPS shall be placed on a dedicated shelf within the cabinet.
- B. Refer to Section 40 61 13 – Process Control System General Provisions for additional requirements.

END OF SECTION

SECTION 40 68 00.13
PROCESS CONTROL SOFTWARE (MODIFY EXISTING)

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. The Contractor shall furnish, test, install, and place in satisfactory operation all control and information system software with all required programming and software appurtenances as herein specified and as shown on the Drawings.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 40 61 13 – Process Control System General Provisions
- B. Section 40 61 93 – Control System Input/Output List
- C. Section 40 61 96 – Process Control Descriptions

PART 2 – PRODUCTS - (NOT USED)

PART 3 – EXECUTION

3.01 OVERALL SYSTEM CONFIGURATION

- A. The Owner's existing Human-Machine Interface (HMI) software, including but not limited to all relevant displays, alarm summary pages, data collection, and historical trending/reporting, shall be modified to include all work performed under this Contract.
- B. The Owner's existing control system shall be modified to include the inputs and outputs specified in the Input/Output Schedule and in other Sections of this Division.
- C. Existing platform is VTScada by Trihedral, Inc.

3.02 SOFTWARE MODIFICATIONS

- A. All HMI software configuration performed under this Contract shall be coordinated with the Owner and shall match in all possible respects the "look and feel," in the opinion of the Engineer, of the existing SCADA System. Specified features and functions of this Contract that do not already exist, even if only for "look and feel," shall be provided. Details on how to best implement these features and functions shall be discussed with Owner and Engineer.

- B. Major HMI software scope of work shall include, but shall not be limited to, the following:
1. Create new graphic displays showing the new facilities and functions described herein complete with all associated equipment and instrumentation.
 2. Modify the existing plant overview display(s) for the SCADA system to include the new facilities and equipment, and create links to the new screens.
 3. Modify existing alarm summary pages to incorporate new monitoring data into the alarm displays.
 4. Modify existing reports to include the additional monitoring points specified under this Contract.
 5. Create new real-time and historical trends, and coordinate with the Owner appropriate grouping of the trend charts.
 6. Update the system status display to include new hardware provided under this Contract.
- C. Ladder logic resident in existing PLCs shall be modified to perform the functions described as specified herein and in Section 40 61 96 – Process Control Descriptions. Specifically, the existing PLCs shall be programmed to accept the I/O specified in Section 40 61 93 – Control System Input/Output List and to make this data readily available on the plant network and shall be programmed to execute the logic necessary to implement all control functions associated with the scope of work specified under this Contract.
- D. All discrete and analog data acquisition, pre-processing, storage and process control functions shall be performed at the PLC level. The HMI software shall not be used for this purpose.

END OF SECTION

SECTION 40 70 00
INSTRUMENTATION FOR PROCESS SYSTEMS

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. The instrumentation subcontractor shall furnish, install, test and place in operation instruments as scheduled together with all signal converters, transmitters, isolators, amplifiers, etc. to interface with the process control system as shown on the Drawings and as specified. The Contractor may elect to install sensors on process lines provided that the instrumentation subcontractor provides full on-site supervision during installation. Mounting of associated indicators, sensors, sampling pumps, power supplies, brackets and appurtenances shall be provided as indicated.
- B. It is the intent of the Contract Documents that all process taps, isolation valves, nipples, penetrations, embedded instrumentation supports, conduit, wiring, terminations, and the installation of process instrumentation on process lines shall be provided under this Contract. The Instrumentation Subcontractor shall supervise installation of equipment provided where installation is by other Subcontractors or Contractors.
- C. Tapping and connections for primary process sensors shall be sized to suit each individual installation and the requirements of the instrument served. The Contractor shall ensure that the location, supports, orientation and dimensions of the connections and tapping for instruments are such as to provide the proper bracing, the required accuracy of measurement, protection of the sensor from accidental damage and accessibility for maintenance while the plant is in operation. Isolation valves shall be provided at all process taps.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 40 61 13 – Process Control System General Provisions
- B. Section 40 61 91 – Process Control System Instrument List
- C. Section 40 67 00 – Control System Equipment Panels and Racks
- D. Section 40 79 00 – Miscellaneous Instruments, Valves, and Fittings
- E. Section 40 61 22 – Tools, Supplies, and Spare Parts, General
- F. Instruments furnished with mechanical equipment shall be furnished, installed, tested and calibrated as specified elsewhere in the Contract Documents.

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1.03 TOOLS, SUPPLIES AND SPARE PARTS

- A. Tools, supplies and spare parts shall be provided as specified in Section 40 61 22 -- Tools, Supplies, and Spare Parts, General.
- B. Additional items as recommended by the analytical instrument manufacturers or as described for the specified analytical instrument sections shall be provided.

PART 2 – PRODUCTS

2.01 GENERAL

- A. All instrumentation supplied shall be the manufacturer's latest design. Unless otherwise specified, instruments shall be solid state, electronic, using enclosures to suit specified environmental conditions. Microprocessor-based equipment shall be supplied unless otherwise specified. All instruments shall be provided with mounting hardware and floor stands, wall brackets, or instrument racks as shown on the Drawings, or as required.
- B. Equipment installed in a hazardous area shall meet or exceed Class, Group, and Division requirements as shown on the Drawings, to comply with the National Electrical Code.
- C. All field instrumentation for outdoor service shall be provided with enclosures that are suitable for outdoor service, as follows:
 - 1. Where the manufacturer's enclosures are suitable for outdoor service, they shall be provided with instrument sunshades. Sunshades shall be Style E as manufactured by O'Brien Corporation, or equal. Where possible, these instruments shall be mounted in a north facing direction.
 - 2. Where the manufacturer's standard enclosures are not suitable for outdoor service, instruments shall be mounted in Field Panels in accordance with Section 40 67 00 – Control System Equipment Panels and Racks, or may be furnished with Vipak instrument field enclosures as manufactured by O'Brien Corporation, equivalent by Intertec, or equal. It shall not be necessary to provide the manufacturer's NEMA 4 or 4X enclosures for instruments that will be subsequently mounted in separate field panels.
- D. All instruments shall return to accurate measurement without manual resetting upon restoration of power after a power failure.
- E. Unless otherwise shown or specified, local indicators shall be provided for all instruments. Where instruments are located in inaccessible locations, local indicators shall be provided and shall be mounted as specified in Paragraph 3.01 B herein. All indicator readouts shall be linear in process units. Readouts of 0 to 100% shall not be

acceptable (except for speed and valve position). Isolated outputs shall be provided for all transmitters.

- F. Unless otherwise specified, field instrument and power supply enclosures shall be Type 316 stainless steel, fiberglass (or similar, per Engineer's judgement) or PVC coated copper-free cast aluminum NEMA 4X construction.
- G. Where separate elements and transmitters are required, they shall be fully matched, and unless otherwise noted, installed adjacent to the sensor. Special cables or equipment shall be supplied by the associated equipment manufacturer.
- H. Electronic equipment shall utilize printed circuitry and shall be coated (tropicalized) to prevent contamination by dust, moisture and fungus. Solid state components shall be conservatively rated for long term performance and dependability over ambient atmosphere fluctuations. Ambient conditions shall be -20 to 50 degrees C and 20 to 100 percent relative humidity, unless otherwise specified. Field mounted equipment and system components shall be designed for installation in dusty, humid, and corrosive service conditions.
- I. All devices furnished hereunder shall be heavy duty type, designed for continuous industrial service. The system shall contain products of a single manufacturer, insofar as possible, and shall consist of equipment models that are currently in production. All equipment provided, where applicable, shall be of modular construction and shall be capable of field expansion.
- J. All non-loop-powered instruments and equipment shall be designed to operate on a 60 Hz AC power source at a nominal 117 V, plus or minus 10 percent, except where specifically noted. All regulators and power supplies required for compliance with the above shall be provided. Where equipment requires voltage regulation, constant voltage transformers shall be supplied.
- K. All analog transmitter and controller outputs shall be isolated, 4 to 20 milliamps into a load of 0 to 750 ohms, unless specifically noted otherwise. All switches shall have double pole, double throw contacts rated at a minimum of 600 VA, unless specified otherwise.
- L. Materials and equipment used shall be UL approved wherever such approved equipment and materials are available.

2.02 ANALYTICAL INSTRUMENTATION

- A. Liquid samples shall not pass through housings containing analyzer electronics. Process fluid temperature will be within a range of 40 to 90 degrees F.

- B. Where ambient temperatures will affect accuracy by more than 1 percent of span, a suitable isothermal enclosure with thermostatically controlled space heater shall be provided.
- C. Sample assemblies shall be suitable for submersion or flow-through service as noted and shall be chemically inert to constituents of raw wastewater solids or other chemical environment, as scheduled. Where the sample is drawn prior to filtration, the sample assemblies shall be capable of handling solids and grease.
- D. Each analyzer requiring reagents or other replaceable parts shall be furnished with sufficient chemicals and replaceable parts for startup and acceptance tests and the specified warranty period.
- E. Contractor's submittals on these analyzers shall include information on monthly reagent consumption and a list of replaceable parts required for periodic maintenance and the recommended operating periods between replacements. Installation of analyzers and sample preparation shall be in accordance with the analyzer manufacturer's instructions.
- F. Analysis instrumentation performance, accuracy and reproducibility shall be as prescribed in APHA/AWWA/WEF "Standard Methods for the Examination of Water and Wastewater", latest edition. For those measurements specified herein, for which performance characteristics are not listed in the above, the supplier shall state instrument performance characteristics. The "referee" method shall be as prescribed in EPA Methods for Chemical Analysis of Water and Wastes (1971).

PART 3 – EXECUTION

3.01 INSTALLATION

- A. General
 - 1. Equipment shall be located so that it is accessible for operation and maintenance. The instrumentation subcontractor shall examine the Drawings and shop drawings for various items of equipment in order to determine the best arrangement for the work as a whole and shall supervise the installation of process instrumentation supplied under this Division.
 - 2. Work shall be performed in compliance with all applicable local codes and practices. Where the Contract Documents do not delineate precise installation procedures, the latest version of the American Petroleum Institute (API) Recommended Practice 551 manual (API RP 551) shall be used as a guide to installation procedures.
- B. Equipment Mounting and Support

1. Field equipment shall be wall mounted or mounted on two inch diameter pipe stands welded to a 10 inch square by 1/2 inch thick base plate unless shown adjacent to a wall or otherwise noted. Materials of construction shall be aluminum or 316 stainless steel. Instruments attached directly to concrete shall be spaced out from the mounting surface not less than 1/2 inch by use of phenolic spacers. Expansion anchors in walls shall be used for securing equipment or wall supports to concrete surfaces. Unless otherwise noted, field instruments shall be mounted between 48 and 60 inches above the floor or work platform.
2. Embedded pipe supports and sleeves shall be Schedule 40, Type 316 stainless steel pipe, ASA B 36.19, with stainless steel blind flange for equipment mounting, unless otherwise indicated.
3. Materials for miscellaneous mounting brackets and supports shall be Type 316 stainless steel construction.
4. Pipe stands, miscellaneous mounting brackets and supports shall comply with the requirements of Division 05 of the specifications.
5. Transmitters shall be oriented such that output indicators are readily visible.

C. Control and Signal Wiring

1. Electrical, control and signal wiring connections to transmitters and elements mounted on process piping or equipment shall be made through liquid tight flexible conduit. Conduit seals shall be provided where conduits enter all field instrument enclosures and all cabinetry housing electrical or electronic equipment.

3.02 ADJUSTMENT AND CLEANING

- A. The instrumentation subcontractor shall comply with the requirements of Division 01 of these Specifications and all instrumentation and control system tests, inspection, and calibration requirements for all instrumentation and controls provided under this Contract and specified herein. The Engineer, or his/her designated representative(s), reserves the right to witness any test, inspection, calibration or start up activity. Acceptance by the Engineer of plans, reports, or documentation relating to testing or commissioning activity shall not relieve the Contractor of his/her responsibility for meeting all specified requirements.
- B. The instrumentation subcontractor shall provide the services of factory trained technicians, tools and equipment to field calibrate, test, inspect and adjust each instrument to its specified performance requirement in accordance with manufacturer's specifications and instructions. Instruments which fails to meet Contract requirements, or published manufacturer performance specification for functional and operational parameters, shall be repaired or replaced, at the discretion of the Engineer, at no cost to the Owner. The Contractor shall bear all costs and provide all personnel, equipment and

materials necessary to implement all installation tests and inspection activities for equipment specified herein.

- C. At least 60 days before the anticipated initiation of installation testing, the Contractor shall submit to the Engineer a detailed description of the installation test(s) to be conducted to demonstrate the correct operation of the instrumentation supplied hereunder.
- D. Field instrument calibration shall conform to the following requirements:
 - 1. The instrumentation subcontractor shall provide the services of factory trained instrumentation technicians, tools and equipment to field calibrate or verify factory calibration of each instrument supplied under this Contract and existing instruments shown to its specified accuracy in accordance with the manufacturer's specification and instructions for calibration. Calibration and verification shall take place under actual process conditions. Forcing outputs shall not be acceptable.
 - 2. Each instrument shall be calibrated/verified at 0, 25, 50, 75 and 100 percent of span using test instruments to simulate inputs and read outputs. Test instruments shall be rated to an accuracy of at least five (5) times greater than the specified accuracy of the instrument being calibrated. Where applicable, such test instruments shall have accuracy's as set forth by the National Institute for Standards and Technology (NIST).
 - 3. The instrumentation subcontractor shall provide a written calibration/verification sheet to the Engineer for each instrument, certifying that it has been calibrated to its published specified accuracy. The Contractor shall submit proposed calibration sheets for various types of instruments for Engineer approval prior to the start of calibration. This sheet shall include but not be limited to date, instrument tag numbers, brief description of how the calibration process was performed, calibration data for the various procedures described herein, name of person performing the calibration, a listing of the published specified accuracy, permissible tolerance at each point of calibration, calibration reading as finally adjusted within tolerance, defect noted, corrective action required and corrections made. For electronic or powered instruments, the calibration/verification sheet shall also list all configurable parameters that have been modified from their default factory setting.
 - 4. If doubt exists as to the correct method for calibrating or checking the calibration/verification of an instrument, the manufacturer's printed recommendations shall be used as an acceptable standard, subject to the approval of the Engineer.
 - 5. Upon completion of calibration, devices calibrated hereunder shall not be subjected to adjustments, sudden movements, accelerations, or shocks, and shall

be installed in permanent protected positions not subject to moisture, dirt, and excessive temperature variations. Caution shall be exercised to prevent such devices from being subjected to over-voltages, incorrect voltages, overpressure or incorrect air. Damaged equipment shall be replaced and re-calibrated/verified at no cost to the Owner. Equipment that has been adjusted, modified, or moved or there is evidence of such activity shall be re-calibrated/verified at no cost to the Owner.

6. After completion of instrumentation installation, the instrumentation subcontractor shall perform a loop check. The Contractor shall submit final loop test results with all instruments listed in the loop. Loop test results shall be signed by all representatives involved for each loop test.

END OF SECTION

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SECTION 40 71 13.13
INLINE MAGNETIC FLOW METERS

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. The Contractor shall furnish, test, install and place in satisfactory operation the magnetic flow meters, with all spare parts, accessories, and appurtenances as herein specified and as shown on the Drawings.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 40 61 13 – Process Control System General Provisions
- B. Section 40 70 00 – Instrumentation for Process Systems

1.03 TOOLS, SUPPLIES AND SPARE PARTS

- A. Furnish one spare transmitter.

PART 2 – PRODUCTS

2.01 MAGNETIC FLOW METER SYSTEMS

- A. Magnetic flow meter systems shall include a magnetic flow tube and a microprocessor-based "smart" transmitter that is capable of converting and transmitting a signal from the flow tube. Magnetic flow meters shall utilize the characterized field principle of electromagnetic induction and shall produce DC signals directly proportional to the liquid flow rate.
- B. Each meter shall be furnished with a Type 316 stainless steel or carbon steel metering tube and carbon steel flanges with a polyurethane, ceramic, neoprene, hard rubber, or PTFE liner as required by the application or as specified. Liner shall have a minimum thickness of 0.125 inches. The inside diameter of the liner shall be within 0.125 inches of the inside diameter of the adjoining pipe. Liner protectors shall be provided on all flow tubes.
- C. The flow tube shall be provided with bullet-nose mounted electrodes.
- D. Grounding rings shall be provided for both ends of all meters.

- E. All materials of construction for metallic wetted parts (electrodes, grounding rings, etc.) shall be Type 316 stainless steel, or compatible with the process fluid for each meter in accordance with the recommendations of the manufacturer.
- F. Flow tube shall be rated for pressures up to 1.1 times the flange rating of adjacent piping. System shall be rated for ambient temperatures of 30 to +65°C. Meter and transmitter housings shall meet NEMA 4X/IP66 requirements as a minimum. When meter and transmitter are located in classified explosion hazard areas, the meter and transmitter housings shall be selected with rating to meet the requirements for use in those areas. Where the flow tube is subject to submergence through installation in a meter vault or similar location, the flow tube assembly shall be rated NEMA 6P/IP68 and electronics shall be factory sealed against moisture intrusion. The use of field kits for modifying NEMA 4/4X/IP66 flow tubes to submergence duty shall not be acceptable. The associated transmitter shall be located in an area not subject to submergence.
- G. The transmitter shall provide pulsed DC coil drive current to the flow tube and shall convert the returning signal to a linear, isolated 420 mA DC signal. The transmitter shall utilize "smart" electronics and shall contain automatic, continuous zero correction, signal processing routines for noise rejection, and an integral LCD readout capable of displaying flow rate and totalized flow. The transmitter shall continuously run self-diagnostic routines and report errors via English language messages.
- H. The transmitter's preamplifier input impedance shall be a minimum of 109-1011 ohms which shall make the system suited for the amplification of low-level input signals and capable of operation with a material build up on the electrodes.
- I. The transmitter shall provide an automatic low flow cutoff below a user configurable low flow condition (0-10%). The transmitter's outputs shall also be capable of being forced to zero by an external contact operation.
- J. Each flow tube shall be factory calibrated and assigned a calibration constant or factor to be entered into the associated transmitter as part of the meter configuration parameters. Manual calibration of the flow meter shall not be required. Meter configuration parameters shall be stored in nonvolatile memory in the transmitter. An output hold feature shall be provided to maintain a constant output during configuration changes.
- K. The transmitter shall be capable of communicating digitally with a remote configuration device via a frequencyshiftkeyed, high frequency signal superimposed on the 4-20 mA output signal. The remote configuration device shall be capable of being placed anywhere in the 4-20 mA output loop. The remote configuration device shall be as specified under Section 40 70 00 – Instrumentation for Process Systems. A password-based security lockout feature shall be provided to prevent unauthorized modification of configuration parameters.

- L. Accuracy shall be 0.30% of rate over the flow velocity range of 1.0 to 10.0 m/s (3.0 to 33 ft/sec) and 0.5% between 0.1 m/s and 1.0 m/s (1-3 ft/s). Repeatability shall be + 0.1% of rate; minimum turndown shall be 100:1. Minimum required liquid conductivity shall not be greater than 5 uS/cm. Maximum response time shall be adjustable between 1 and 100 seconds as a minimum. Transmitter ambient temperature operating limits shall be 10 to +50°C. Power supply shall be 115 VAC, 60 Hz.
- M. Flow tubes shall be 150-lb flange mounted unless otherwise noted. The cables for interconnecting the meter and transmitter shall be furnished by the manufacturer. Transmitter shall be mounted integrally on flow tube, wall, or 2-inch pipe mounted as shown or specified.
- N. Magnetic flow meter systems shall be Model 8750W with optional high accuracy as manufactured by Rosemount, equivalent by ABB, equivalent by Endress + Hauser, equivalent by Krohne, equivalent by Siemens, or equal.

PART 3 – EXECUTION

3.01 REQUIREMENTS

- A. Ground magnetic flow meter flow tubes and grounding rings in strict accordance with the manufacturer's recommendations.
- B. Refer to Section 40 70 00 – Instrumentation for Process Systems.

END OF SECTION

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SECTION 40 72 23
RADAR LEVEL METERS

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. The Contractor shall furnish, test, install and place in satisfactory operation the radar liquid level measurement systems, with all spare parts, accessories, and appurtenances as herein specified and as shown on the Drawings.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 40 61 13 – Process Control System General Provisions
- B. Section 40 70 00 – Instrumentation for Process Systems

PART 2 – PRODUCTS

2.01 RADAR LEVEL CONTROLLERS

- A. Each radar level monitoring system shall include one radar level transmitter sensor with microprocessor-based signal conditioning.
- B. Tank mounting applications shall include mounting flange adapter supplied by the manufacturer, which is compatible with the process liquid and the tank flange connection.
- C. The antenna shall be minimum 6-inch horn (cone-shaped) type, 316L stainless steel, with mounting flange (ASME B16.5 Class 150 raised face flange). Flange dimension shall be coordinated with tank supplier or Contractor as required. The radar antenna shall be suitable for operating temperature range of -40 to +374 degrees F and pressure of full vacuum to 155 psi.
- D. The level sensor shall operate on the frequency modulated continuous wave (FMCW) radar signaling technology at approximately 8 to 10 GHz frequency sweep, or pulse time-of-flight (PTOF) microwave method at approximately 6 GHz. Sensor accuracy shall be a minimum of ± 0.8 inches. Resolution shall be at least 0.1 percent of full range or ± 0.02 inch, whichever is greater. The instrument shall be repeatable to ± 0.04 inch.
- E. The transmitter shall include an integral or remote digital display, as scheduled, and operator interface that allows complete field configuration of all settings and control modes of the system. The transmitter shall compensate for temperature and air density. The unit shall provide level monitoring and volumetric calculation. Output level signal shall be linear, isolated 420 mA DC superimposed with a HART digital signal. Power

requirement for the transmitter shall be 24 VDC. The units shall have as a minimum, the required number of programmable set points to perform the functions specified.

- F. The units shall have a NEMA 4X aluminum alloy with polyester-epoxy coated enclosure. All elements shall be Factory Mutual certified for use in Class 1, Division 1, Groups C and D.
- G. Radar level measurement system shall be Krohne BM 70 A; Endress + Hauser Micropilot FMR 30; Siemens/Milltronics Sitrans LR Series; or equivalent by Rosemount.

PART 3 – EXECUTION

3.01 REQUIREMENTS

- A. Refer to Section 40 70 00 – Instrumentation for Process Systems.

END OF SECTION

SECTION 40 72 76.26
LEVEL SWITCHES (FLOATS)

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. The Contractor shall furnish, test, install and place in satisfactory operation the float level switches, with all spare parts, accessories, and appurtenances as herein specified and as shown on the Drawings.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 40 61 13 – Process Control System General Provisions
- B. Section 40 70 00 – Instrumentation for Process Systems

PART 2 – PRODUCTS

2.01 LEVEL SWITCHES (FLOATS)

- A. Level switches of the direct acting float-operated design shall be comprised of a hermetically sealed, approximately 5-inch diameter plastic casing float, containing microswitches and flexibly supported by means of a heavy neoprene or PVC jacket, with three-conductor cable a minimum of 20 feet in length. Unless otherwise specified, media specific gravity is 0.95 to 1.05. Microswitches shall be one normally open and one normally closed, 5A-115V AC capacity. Float hangers and supports shall be provided as shown on the installation detail drawings.
- B. Float switches shall be Model ENM as manufactured by Flygt, or equal.

PART 3 – EXECUTION

3.01 REQUIREMENTS

- A. Refer to Section 40 70 00 – Instrumentation for Process Systems.

END OF SECTION

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SECTION 40 73 13
PRESSURE AND DIFFERENTIAL PRESSURE GAUGES

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. The Contractor shall furnish, test, install and place in satisfactory operation the pressure gauges, with all spare parts, accessories, and appurtenances as herein specified and as shown on the Drawings.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 40 61 13 – Process Control System General Provisions
- B. Section 40 70 00 – Instrumentation for Process Systems
- C. Section 40 79 00 – Miscellaneous Instruments, Valves, and Fittings

PART 2 – PRODUCTS

2.01 PRESSURE GAUGES

- A. All gauges shall be designed in accordance with the ASME B40.1 entitled, "Gauges, Pressure, Indicating Dial Type - Elastic Element".
- B. All gauges shall be direct reading type. Snubbers shall be provided on all gauges. Gauge full-scale pressure range shall be selected such that the maximum operating pressure shall not exceed approximately 75% of the full-scale range.
- C. Features
 - 1. Mounting: ½" NPT, lower stem mount type
 - 2. Accuracy: 0.5% full scale
 - 3. Case: Solid front, black phenolic material
 - 4. Dial: White background and black letters
 - 5. Glass: Shatterproof
 - 6. Blow-out protection: Back
 - 7. Pressure element: stainless steel bourdon tube

- 8. Movement: Stainless steel, Teflon coated pinion gear and segment
- 9. Gaskets: Buna-N
- D. Liquid-filled or equivalent mechanically-damped gauges shall be used if the gauges are installed with pumps, or where gauges are subjected to vibrations or pulsation. Filling fluid shall be silicone unless oxidizing agents such as sodium hypochlorite are present, where halocarbon shall be used.
- E. Gauge size shall be 4-1/2".
- F. Diaphragm seals and isolating ring seals shall be furnished in accordance with the requirements specified under Section 40 79 00 – Miscellaneous Instruments, Valves, and Fittings.
- G. The complete gauge assembly and appurtenances shall be fully assembled and tested prior to field mounting. A 1/2" isolation stainless steel ball valve shall be provided for each gauge assembly.
- H. Pressure and vacuum gauges shall be Ashcroft Duragauge Model 1279, Ametek-U.S. Gauge Division, H.O. Trerice Co., WIKA Instrument Corporation, or equal.

PART 3 – EXECUTION

3.01 REQUIREMENTS

- A. Refer to Section 40 70 00 – Instrumentation for Process Systems.

END OF SECTION

SECTION 40 73 20
PRESSURE TRANSMITTERS

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. The Contractor shall furnish, test, install and place in satisfactory operation the pressure transmitters, with all spare parts, accessories, and appurtenances as specified and as shown on the Drawings.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 40 61 13 – Process Control System General Provisions
- B. Section 40 70 00 – Instrumentation for Process Systems
- C. Section 40 79 00 – Miscellaneous Instruments, Valves, and Fittings

PART 2 – PRODUCTS

2.01 GAUGE PRESSURE INDICATING TRANSMITTERS

- A. Gauge pressure transmitters shall have piezoresistive measuring cells with a metallic or ceramic process isolating diaphragm directly in contact with the process liquid. Silicone oil fill fluid shall be used to transfer the pressure from the process isolating diaphragm to the measuring cell. Calibrated span and zero shall be continuously adjustable externally over the entire range. Span and zero adjustments shall be capable of being disabled internally. The maximum zero elevation and maximum zero suppression shall be adjustable to anywhere within sensor limits. Factory set correction coefficients shall be stored in the sensor's nonvolatile memory for correction and linearization of the sensor output in the electronics section.
- B. Transmitters shall meet the following requirements:
 - 1. Housing: NEMA 4X with low copper, die-cast aluminum body, epoxy coated
 - 2. Wetted Materials: Type 316 stainless steel unless otherwise indicated or required for process fluid compatibility
 - 3. Accuracy: +/- 0.04% of calibrated span
 - 4. Rangeability: 100:1
 - 5. Damping: 0 to 100 seconds, adjustable

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6. Output: Linear and isolated 4-20 mA with HART communication protocol
 7. Power Supply: 24 VDC, 2-wire loop powered
 8. Display: 4-digit (minimum) LCD
 9. Overpressure Protection: Yes
 10. Ambient Conditions: -40 to 85 degrees C; 0 – 100% relative humidity
 11. Operating Temperature: -40 to 100 degrees C
 12. Process Connection: 1/2" FNPT
- C. All mounting flanges, diaphragms, O-rings and materials used in construction shall be non-corroding and compatible with each other and compatible with the liquid being measured.
- D. The piezoresistive silicon pressure sensor shall be mechanically, electrically, and thermally isolated from the process and the environment. Factory set correction coefficients shall be stored in the sensor's nonvolatile memory for correction and linearization of the sensor output in the electronics section. The electronics section shall correct the digital signal from the sensor and convert it into a 4-20 mA analog signal for transmission to receiving devices. The electronics section shall contain configuration parameters and diagnostic data in nonvolatile EEPROM memory and shall be capable of communicating, via a digital signal superimposed on the 4-20 mA output signal, with a remote interface device.
- E. Gauge pressure indicating transmitters shall be furnished with 316 stainless steel two-valve manifold assembly where a block valve provides instrument isolation and a drain/vent valve allows venting, draining, or calibration. Two-valve manifold assembly shall be Model 306 Series as manufactured by Rosemount, or equivalent by instrument manufacturer.
- F. Gauge pressure indicating transmitters shall be Model 3051S as manufactured by Emerson Process Management (Rosemount), Siemens Sitrans P420, Endress + Hauser Model Cerabar S PMP71 Platinum, or equal.

2.02 DIFFERENTIAL PRESSURE INDICATING TRANSMITTERS

- A. Differential pressure indicating transmitters shall be the same as the gauge pressure transmitters except for body specifications. Differential pressure units shall be furnished with close coupled 316 stainless steel five-valve manifold valve assembly complete with drain/vent ports. Integral manifold assembly shall be Model 305 Series as manufactured by Rosemount, or equivalent by instrument manufacturer.
- B. Each differential pressure transmitter shall be furnished with stainless steel mounting brackets and hardware.

- C. The electronics sections of differential pressure transmitters shall contain user selectable square root extractors to provide a linear 420 mA DC output proportional to flow, when activated. Square root extractor circuitry shall be activated only for incompressible fluid flow applications (e.g., water). Flow rates for compressible fluids (e.g., air) shall be calculated externally using line temperature and static pressure corrections as specified elsewhere. In addition, each flow transmitter shall be furnished with laminated flow versus differential pressure curves wall mounted adjacent to the transmitter.
- D. Differential pressure indicating transmitters shall be Model 3051S as manufactured by Emerson Process Management (Rosemount), Siemens Sitrans P420, Endress + Hauser Model Deltabar S PMD75 Platinum, or equal.

PART 3 – EXECUTION

3.01 REQUIREMENTS

- A. Refer to Section 40 70 00 – Instrumentation for Process Systems.

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SECTION 40 73 36
PRESSURE AND DIFFERENTIAL PRESSURE SWITCHES

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. The Contractor shall furnish, test, install and place in satisfactory operation the pressure switches, with all spare parts, accessories, and appurtenances as herein specified and as shown on the Drawings.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 40 61 13 – Process Control System General Provisions
- B. Section 40 70 00 – Instrumentation for Process Systems

PART 2 – PRODUCTS

2.01 PRESSURE SWITCHES

- A. Pressure, vacuum, and differential pressure switches shall be single or dual action with an adjustable setpoint for the process requirement and/or as specified herein. Switches shall be diaphragm or piston operated and activate S.P.D.T. snap action switches on increasing or decreasing pressure. Minimum differential shall be less than 10 percent of the range. Deadband shall be adjustable. Allowable surge pressure shall be a minimum 1.5 times the range. Each pressure switch shall have visible scale.
- B. Pressure switches shall have a contact rating of 10 amperes at 120 volts AC. Pressure switches shall be in NEMA 4X enclosures. Switches shall have a repeatable accuracy of 1 percent of range. Pressure switches shall be isolated from the process fluid by a diaphragm seal or an isolation ring in locations as shown on the Contract Drawings and/or as specified. Wetted parts materials shall be compatible with the process fluid for corrosion resistance. Pressure switches shall be manufactured by ASCO, SOR, Inc., Ashcroft, or equal.

PART 3 – EXECUTION

3.01 REQUIREMENTS

- A. Refer to Section 40 70 00 – Instrumentation for Process Systems.

END OF SECTION

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SECTION 40 75 13
PH/ORP ANALYZERS

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. The Contractor shall furnish, test, install and place in satisfactory operation the pH/ORP analyzers, with all spare parts, accessories, and appurtenances as herein specified and as shown on the Drawings.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 40 61 13 – Process Control System General Provisions
- B. Section 40 70 00 – Instrumentation for Process Systems

PART 2 – PRODUCTS

2.01 PH SENSORS

- A. pH sensors shall be ion selective electrode (ISE) method. The sensors shall have the following features and minimum performance requirements:
 - 1. Integral temperature compensation sensor
 - 2. Measuring range: 0 - 13 pH
 - 3. Maximum pressure: 14 psig at 70 degrees C
 - 4. Resolution: 0.01 pH
 - 5. Operating temperature: -10 to 50 degrees C
 - 6. Housing Material: material shall be compatible with process fluid.
 - 7. Wetted Materials: as required for the process fluid.
 - 8. Sensor cable length: minimum of 10 feet or as required to accommodate locations indicated
- B. Sensor mounting method shall be per Section 40 61 91 – Process Control System Instrument List. Submersion mounted sensors shall be provided with a PVC mounting pipe, PVC electrode protector, and all required appurtenances to facilitate a guard mount. Contractor shall be responsible for coordinating length of mounting pipe. Insertion mounted sensors shall be provided with an isolating ball valve to facilitate

removal while the line is in service. Insertion mount material shall match the piping materials.

- C. Sensors shall be pH sc series pH sensor by Hach, pHX by Cerlic, CPF81D by Endress + Hauser, or equal.

2.02 CONTROLLERS

- A. The microprocessor-based turbidimeter controller shall be fully compatible with the turbidity sensor. The controller shall receive a signal from the sensor, condition it, and amplify the signal for display and transmission.
- B. Controllers shall meet the following minimum functional requirements:
 - 1. Housing: IP66
 - 2. Power Supply: 115 VAC, 60 Hz
 - 3. Operating Temperature: -13 to 149 °F, 10 to 90% relative humidity, non-condensing
- C. The controller shall have three relay contact outputs that can be activated based on the measured process value. Relay outputs shall also be programmable for various alarms and warning conditions that occurred internally within the system or with the process conditions. Relays shall be Form-C SPDT contacts rated at 5A at 115/230 VAC. The control and alarm setpoints for the relays shall be adjustable across the full operating range. LED lights at the controller shall indicate that the relay is energized.
- D. The analyzer shall have two linear, isolated 4 - 20mA assignable outputs.
- E. The controller display shall be backlit LCD display. The controller shall have diagnostic screens for messages, including scrolling lists for failure and warning alarm conditions, calibration records, and hardware tests.
- F. Controllers shall be Swan AMI pH-Redox AC, sc200 Universal Controller as manufactured by Hach, Liquiline CM442 Controller (with Memosens technology) by Endress + Hauser, or equal.

PART 3 – EXECUTION

3.01 REQUIREMENTS

- A. Section 40 70 00 – Instrumentation for Process Systems.

END OF SECTION

**SECTION 40 75 21
CHLORINE ANALYZERS**

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. The Contractor shall furnish, test, install and place in satisfactory operation the chlorine residual analyzers, with all spare parts, accessories, and appurtenances as herein specified and as shown on the Drawings.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 40 61 13 – Process Control System General Provisions
- B. Section 40 70 00 – Instrumentation for Process Systems

1.03 TOOLS, SUPPLIES AND SPARE PARTS

- A. One sample conditioning kit, including self-cleaning Y-strainer, pressure regulators, and Teflon tubing, shall be provided for each analyzer.

PART 2 – PRODUCTS

2.01 CHLORINE ANALYZER

- A. Chlorine analyzers shall reagentless three electrode amperometric method.
- B. Features
 - 1. Range: 0-5 mg/L free
 - 2. Accuracy:
 - 1) 0.00-1.00 ppm $\pm$ 0.01 ppm
 - 2) 1.00-3.00 ppm $\pm$ 0.06 ppm
 - 3) 3.00-5.00 ppm $\pm$ 0.2 ppm
 - 3. Resolution: 0.01 mg/L
 - 4. Sample Flow: 40 l/hr
 - 5. Sample Inlet Pressure: 2-29 psig
 - 6. Sample Temperature Range: 5-45°C

7. Cycle Time: Continuous
8. Outputs:
 - a. Two Selectable for 0-20 or 4-20 mA. (An optional third analog output shall be available)
 - b. 4-20 mA analog shall be isolated. Output span shall be fully programmable
9. Diagnostics: Self-test diagnostics with alarm indication.
10. Alarms:
 - a. Two set point alarms, instrument warning alarm, and system shutdown alarm.
 - b. Alarm shall be SPDT dry contact relay output rated at 5A, 230 VAC SPDT alarm relays.
11. Power Requirements: 115/230 VAC, 50/60 Hz, switch selectable.
12. Enclosure: Sensor and controller enclosures shall be rated NEMA 4X for wall or stanchion mounting.

C. Chlorine analyzer shall be Swan AMI Trides, HACH Model CL17, or equal.

2.02 OPTIONAL (PH + TEMPERATURE PROBE)

- A. Optional pH and temperature sensors shall be provided as a packaged unit with the chlorine analyzer, per Section 40 61 91 – Process Control System Instrument List.
- B. pH Electrode
 1. Range: 2-12
 2. Resolution: 0.01
- C. Temperature Measurement
 1. Range: -30-100°C
 2. Resolution: 0.1°C
- D. Additional 4-20 mA output will be required for all three measurements.

PART 3 – EXECUTION

3.01 REQUIREMENTS

- A. Refer to Section 40 70 00 – Instrumentation for Process Systems.

END OF SECTION

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SECTION 40 75 53
TURBIDITY ANALYZERS

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. The Contractor shall furnish, test, install, and place in satisfactory operation the low range turbidity monitoring systems, with all spare parts, accessories, and appurtenances.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 40 61 13 – Process Control System General Provisions
- B. Section 40 61 15 – Process Control System Submittals
- C. Section 40 61 22 – Tools, Supplies, and Spare Parts, General
- D. Section 40 70 00 – Instrumentation for Process Systems

1.03 TOOLS, SUPPLIES AND SPARE PARTS

- A. Per Section 40 61 22 – Tools, Supplies, and Spare Parts, General
- B. One complete turbidimeter maintenance kit shall be provided and shall include a calibration lid with user manual, lint - free cloths, wire maintenance rack, vial cleaning tool, vial compartment cleaning tool, replacement automatic cleaning module wiper, 20 NTU sealed standard, 600 NTU sealed standard, <0.1 NTU secondary standard glass rod, and vial removal tool.
- C. One complete calibration kit shall be provided and shall include a 1-liter calibration cylinder, auto pipette and 1 pint bottle of 4000 NTU Formazin Standard Solution with instructions for use.

1.04 SUBMITTALS

- A. Per Section 40 61 15 – Process Control System Submittals.

PART 2 – PRODUCTS

2.01 TURBIDITY MONITORS (LOW RANGE)

- A. Sensor

1. Turbidity sensors and controllers shall be microprocessor-based, meeting approved alternative method to US EPA 180.1, and shall provide continuous monitoring.
2. The sensor shall be designed to measure low range turbidity in water by collecting scattered light from a laser light source.
3. Features:
 - a. Measurement range:
 - 1) 0.000 to 100.0 NTU
 - b. Precision
 - 1) 0.003 NTU or 1% of reading whichever is greater
 - c. Resolution
 - 1) 0.001 NTU
 - d. Cycle Time
 - 1) Continuous
4. Operational Criteria
 - a. Sample flow rate
 - 1) 20 – 60 l/hr. or 5 – 16 gal./hr. or $\geq$ 315 - 1000 ml/minute
 - b. Sample pressure
 - 1) 2 to 29 psi (0.15 to 2.0 bar)
 - c. Sample temperature
 - 1) 1 – 40 °C or 34 - 104 °F or $\leq$ 5 °C (9 °F) above ambient temperature
 - d. Operating temperature
 - 1) 14 to 122 °F (-10 to 50 °C)
 - e. Operating humidity
 - 1) 10 to 90% relative non condensing
5. Enclosure

- a. IP66/Nema 4X dust and water ingress protection rating
6. Turbidity sensors shall be Swan Sensor Turbiwell, sc200 Universal Controller as manufactured by Hach, or equal.

B. Controllers

1. The microprocessor-based turbidimeter controller shall be fully compatible with the turbidity sensor. The controller shall receive a signal from the sensor, condition it, and amplify the signal for display and transmission.
2. Controllers shall meet the following minimum functional requirements:
 - a. Housing: NEMA 4X
 - b. Power Supply: 115 VAC, 60 Hz
 - c. Operating Temperature: -13 to 149 °F, 10 to 90% relative humidity, non-condensing
3. The controller shall have three relay contact outputs that can be activated based on the measured process value. Relay outputs shall also be programmable for various alarms and warning conditions that occurred internally within the system or with the process conditions. Relays shall be Form-C SPDT contacts rated at 5A at 115/230 VAC. The control and alarm setpoints for the relays shall be adjustable across the full operating range. LED lights at the controller shall indicate that the relay is energized.
4. The analyzer shall have two linear, isolated 4 - 20mA assignable outputs.
5. The controller display shall be backlit LCD display. The controller shall have diagnostic screens for messages, including scrolling lists for failure and warning alarm conditions, calibration records, and hardware tests.
6. Controllers shall be the Swan AMI Turbiwell AC, Hach Model Surface Scatter 7, or equal.

PART 3 – EXECUTION

3.01 REQUIREMENTS

- A. Refer to Section 40 70 00 – Instrumentation for Process Systems.

END OF SECTION

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SECTION 40 78 00
PANEL MOUNTED INSTRUMENTS

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. The Contractor shall furnish, test, install and place in satisfactory operation the panel mounted instruments, with all spare parts, accessories, and appurtenances as specified herein and as shown on the Drawings.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 40 61 13 – Control and Information System Scope and General Requirements
- B. Section 40 62 00 – Control and Information System Hardware, General
- C. Section 40 67 00 – Control System Equipment Panels and Racks

1.03 GENERAL INFORMATION AND DESCRIPTION

- A. All equipment mounted on the face of a panel shall conform to the same NEMA rating specified for the panel construction.

1.04 TOOLS, SUPPLIES AND SPARE PARTS

- A. Tools, supplies and spare parts shall be provided as specified in Section 40 61 22 – Tools, Supplies, and Spare Parts, General. In addition, the following specific spare parts items shall be provided:
 - 1. One of each type of panel mounted equipment (i.e., indicators, signal converters, etc.) provided under this Contract.
 - 2. Five of each type of interposing control relay provided under this Contract.

PART 2 – PRODUCTS

2.01 OPERATORS

- A. Control operators shall be 30.5 mm, round, heavyduty, oil tight NEMA 4X corrosion resistant. For Hazardous areas, control operators shall be rated NEMA 7.
- B. Pushbuttons shall be non-illuminated, spring release type. Pushbuttons shall include a full guard. Panic stop/alarm pushbuttons shall be red mushroom type with manual-pull

release. Selector switches shall be non-illuminated, maintained contact type, unless otherwise indicated.

- C. Pilot lights shall be of the proper control voltage, push-to-test LED type with lens and LED lamp colors as specified below.
 - 1. Green: stopped, off, or closed
 - 2. Red: running, on, or opened
 - 3. Amber: fault, alarm, or warning
 - 4. White: generic non-alarm status
- D. Control operators shall have legend plates as specified herein, indicated on the Drawings, or otherwise directed by the Engineer. Legend plates shall be plastic, black field (background) with white lettering. Engraved nameplates shall be securely fastened above each control operator. If adequate space is not available, the nameplate shall be mounted below the operator.
- E. Control operators for all equipment under this Contract shall be of the same type and manufacturer unless otherwise indicated. Control operators such as pushbuttons (PB), selector switches (SS), and pilot lights (PL) shall be Cutler-Hammer/Westinghouse Type E34, Square D Company Type SK, or equal

2.02 ELECTRONIC INDICATORS

- A. Electronic indicators shall be 3.5 or 6 digit, as appropriate, with 0.56" high red LED display. Indicators shall be provided with nameplate and scale calibrated to match the calibration of the primary element. The unit shall be designed primarily for use with 4-20 mA current loop signal circuits. Indicator operating voltage shall be 115 VAC 10%, 60 Hz. Indicator controls shall include three (3) front-panel pushbuttons for modifying alarm values and other indicator setup. Two (2) form-C relays shall be provided for each indicator. Relay contact outputs shall be rated 5A, 120/240 VAC, resistive load. Where required, a regulated and isolated 24 V excitation power supply shall be provided. Indicators shall be suitable for indoor or outdoor service as required and shall have the same NEMA enclosure rating as the associated enclosure.
- B. Indicators shall be Red Lion Model IMP or APLCL, Precision Digital, or equal.

2.03 RELAYS

- A. Interposing control relays (CR)
 - 1. Where required to interface between motor control centers, equipment controls, and control panels, interposing relays and associated control wiring circuitry shall

be furnished and installed to provide the monitoring and/or control functions specified herein.

2. Interposing relays shall be small format type, DPDT, minimum 10 amp, 120 VAC contact rating.
3. Relay coils shall be 120 VAC or 24 VDC as required to interface with equipment.
4. Relays shall have a flag indicator to show relay status, a pushbutton to allow manual operation of the relay, and an internal pilot light to indicate power to the coil.
5. Relays shall be as manufactured by Square D, Potter & Brumfield, Allen-Bradley, or equal.

B. Timing Relays (TR)

1. Timing relays shall be electronic type with 120 VAC coils unless otherwise specified or indicated on the Drawings. Timers shall be provided with a minimum of two SPDT timed output contacts and instantaneous contacts where required. Contact ratings shall be the same as for interposing relays.
2. Timing relays shall be the general purpose plug-in type, Type JCK as manufactured by Square D Company, equivalent by Eaton/Cutler-Hammer, equivalent by Allen-Bradley, or equal.

2.04 TOTALIZERS

- A. Totalizing counters shall be provided for flush panel, springclip mounting. Face dimensions of the totalizing counters shall be no larger than 11/8 inches high by 2 inches wide. Totalizing counters shall contain eight digits. Height of the digits shall not be less than 5/32 inch. Numerals shall be white on a black background. The counter shall be nonresettable and shall be totally compatible for operation on the pulses supplied by the associated instrument or integrator. The totalizing counter shall be capable of a maximum count rate of 25 counts/second.
- B. Legend plates shall be provided for each of the totalizing counters with white letters on a black background with legends as specified below.
- C. Totalizing counters shall be manufactured by KesslerEllis, or equal.

2.05 ALARM HORNS

- A. Alarm horns shall be general-purpose type, panel-mounted, and shall be suitable for indoor or weatherproof service, as required. Power supply shall be either 115 VAC or 24

VDC. Horns shall be capable of producing 100 dB at 10 feet and shall have adjustable volume.

- B. Horns shall be Vibratone series as manufactured by Federal Signal Corporation, McMaster-Carr equivalent, Edwards Signaling Company equivalent, or equal.

PART 3 – EXECUTION

3.01 REQUIREMENTS

- A. Refer to Section 40 67 00 – Control System Equipment Panels and Racks, for additional requirements.

END OF SECTION

SECTION 40 78 56
ISOLATORS, INTRINSICALLY-SAFE BARRIERS, AND SURGE SUPPRESSORS

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. The Contractor shall furnish, install, and place in satisfactory operation the isolators, intrinsically-safe barriers, and surge protection devices (SPDs) as specified herein and as shown on the Drawings.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 40 61 13 – Control and Information System Scope and General Requirements
- B. Section 40 62 00 – Control and Information System Hardware, General
- C. Section 40 67 00 – Control System Equipment Panels and Racks
- D. Section 40 78 00 – Panel Mounted Instruments

1.03 TOOLS, SUPPLIES AND SPARE PARTS

- A. Tools, supplies and spare parts shall be provided as specified in Section 40 61 22 – Tools, Supplies, and Spare Parts, General.
- B. In addition, the following specific spare parts items shall be provided:
 - 1. Five of each type of surge protection device provided under this Contract.

PART 2 – PRODUCTS

2.01 SURGE PROTECTION

- A. General
 - 1. All electrical and electronic elements shall be protected against damage due to electrical transients induced in interconnecting lines from lightning discharges and nearby electrical systems.
 - 2. Manufacturer's Requirements: All surge protection devices shall be manufactured by a company that has been engaged in the design, development, and manufacture of such devices for at least 5 years. Acceptable manufacturers shall be Phoenix Contact, Edco, Transtector, Weidmuller, or equal.

3. Surge protection device installations shall comply with UL 94, the National Electric Code (NEC), and all applicable local codes.
4. Surge protection devices shall be installed as close to the equipment to be protected as practically possible.
5. Device Locations: As a minimum, provide surge protection devices at the following locations:
 - a. At connections between AC power and electrical/electronic equipment, including, but not limited to, panels, assemblies, and field mounted analog transmitters.
 - b. At both ends of signal circuits that have any portion of the circuit extending outside of a building.
 - c. At both ends of copper-based communication cables which extend outside of a building, including at field instruments and the field side of analog valve position signals.
 - d. On all external telephone communication lines.

B. AC power protection

1. Surge protection device assemblies for connections to AC power supply circuits shall:
 - a. Be provided with two 3-terminal barrier terminal strips capable of accepting No. 12 AWG solids or stranded copper wire. One terminal strip shall be located on each end of the unit.
 - b. Have a nonflammable enclosure that meets or exceeds UL 94 V0 flammability requirements. The surge protection device shall be provided with provisions for mounting to interior of equipment racks, cabinets, or to the exterior of freestanding equipment.
 - c. Be constructed as multistage devices consisting of gas tube arrestors, high energy metal oxide varistors, or silicon avalanche suppression diodes. Assemblies shall automatically recover from surge events and shall have status indication lights.
 - d. Comply with all requirements of UL 1449, latest edition.
 - e. Be able to withstand a peak surge current of 10,000 amps based on a test surge waveform with an 8-microsecond rise time and a 20-microsecond exponential decay time, as defined in UL 1449.

- f. Have the following characteristics:
 - 1) Maximum Continuous Operating Voltage: 150VAC
 - 2) Maximum Operating Current: 20 amps
 - 3) Ambient Temperature Range: -20 degrees C to +65 degrees C
 - 4) Response Time: 5 nanoseconds

C. Analog signal circuit protection

- 1. Surge protection device assemblies for analog signal circuits shall:
 - a. Have four lead devices with DIN Rail mounting.
 - b. Have a nonflammable enclosure that meets or exceeds UL 94 V0 flammability requirements.
 - c. Be constructed as multistage devices consisting of gas tube arrestors and silicon avalanche suppression diodes. Gas tube arrestors and diodes shall be separated by a series impedance of no more than 20 ohms. Assemblies shall automatically recover from surge events.
 - d. Comply with all requirements of UL 497B.
 - e. Be able to withstand a peak surge current of 10,000 amps based on a test surge waveform with an 8-microsecond rise time and a 20-microsecond exponential decay time, as defined in UL 1449.
 - f. Limit line-to-line voltage to 40 volts on 24VDC circuits.
 - g. Have the following characteristics:
 - 1) Maximum Continuous Operating Voltage: 28VDC
 - 2) Ambient Temperature Range: -20 degrees C to +65 degrees C
 - 3) Response Time (Line-to-Line): 5 ns

D. Communication circuit protection

- 1. Surge protection devices for copper-based data communication circuits shall:
 - a. Be designed for the specific data communication media and protocol to be protected (e.g., telephone, serial, parallel, network, data highway, coax, twinaxial, twisted pair, RF).

- b. Provide protection of equipment to within the equipment's surge withstand levels for applicable standard test wave forms of the following standards:
 - 1) IEC 60-1 / DIN VDE 0432 part 2
 - 2) CCITT K17 / DIN VDE 0845 part 2
 - 3) IEEE C62.31
- c. Have a nonflammable enclosure that meets or exceeds UL 94 V0 flammability requirements.
- d. Provide automatic recovery.

2.02 INTRINSICALLY SAFE BARRIERS AND RELAYS

- A. Intrinsically safe relays and barriers shall be provided where required to interface with equipment located in Classified (i.e., hazardous) areas.
- B. Intrinsically safe relays and barriers shall be FM approved.
- C. Manufacturer shall be
 - 1. Pepperl+Fuchs
 - 2. Crouse Hinds
 - 3. Square D
 - 4. Or equal.

2.03 ISOLATORS AND CONVERTERS

- A. Signal converters shall be provided as required to provide control functions and to interface instrumentation and controls, equipment panels, motor control centers and other instrumentation and controls supplied under other Divisions to the controls provided herein.
- B. General Requirements
 - 1. Converters shall be of the miniature type, utilizing all solid-state circuitry suitable for mounting within new or existing cabinetry. Where sufficient cabinet space is not available, sub panels or supplemental enclosures shall be provided.
 - 2. Power supply shall be 120V, 60 hertz where required by the converter, unless otherwise indicated.

3. Repeatability shall be 0.1% of span, deadband shall be 0.1% span, maximum.
4. Where specific converters are not listed, but are required to interface with the process control system, they shall comply with the general requirements stated herein.

C. Current to Current (I/I) Isolators

1. Current to current isolators shall be furnished where necessary to provide an isolated current loop, calculations or signal amplification between the plant process control system and instrumentation and control loops. Isolators shall be sized such that resistance of existing loops shall not exceed maximum rated resistance.
2. Isolators shall be as manufactured by AGM, Moore Industries, Rochester Instrument Systems (RIS), Phoenix Contact, Weidmuller, Acromag, or equal.

D. Voltage to Current (E/I) Transducers

1. Voltage to current (or current to voltage) transducers shall convert a voltage signal of one magnitude to a 4 20 milliamp DC current signal. The output current shall be directly proportional to the input signal voltage. Transducers shall be sized such that loop resistance does not exceed maximum rated resistance.
2. Transducers shall be as manufactured by AGM, Moore Industries, Rochester Instrument Systems (RIS), Phoenix Contact, Weidmuller, Acromag, or equal.

E. Frequency to Current (F/I) Transducers

1. Frequency to current transducers shall convert pulse rate and pulse duration signals to 4 20 mA, 24 VDC analog signals. Converters shall include field adjustable input frequency range. Converter power shall be 120 VAC, 60 hertz. Transducers shall be sized such that loop resistance does not exceed maximum rated resistance. Transducers shall be suitable for signal transmission via leased telephone lines.
2. Transducers shall be Series 5100 as manufactured by AGM, or equivalent by Moore Industries, Rochester Instrument Systems (RIS), Phoenix Contact, Weidmuller, Acromag, or equal.

F. Current to Frequency (I/F) Transducers

1. Current to frequency transducers shall convert 4 20 mA, 24 VDC analog signals to pulse rate and pulse duration signals. Converters shall include field adjustable output frequency range. Converter power shall be 120 VAC, 60 hertz. Transducers shall be sized such that loop resistance does not exceed maximum rated

resistance. Transducers shall be suitable for signal transmission via leased telephone lines.

2. Transducers shall be Series 5016 as manufactured by AGM, Moore Industries, Rochester Instrument Systems (RIS), Phoenix Contact, Weidmuller, Acromag, or equal.

G. Integrators

1. Integrators shall be provided as interchangeable plug in modules with zero and span adjustment available on the front plate of the units. Output shall range from 0 to 0.1 through 0 to 10 pulses per second. Accuracy shall be + 0.1% of input span. Integrators shall convert linear analog signals to pulse rate and provide a solid state output.
2. Integrators shall be as manufactured by AGM Electronics, Moore Industries, Rochester Instrument Systems (RIS), Phoenix Contact, Weidmuller, Acromag, or equal.

H. Electronic Switches (Alarm Relays)

1. Electronic switches shall be furnished with a calibrated dial for adjusting set points. The input to the switch shall be 4 - 20 mA DC, and the set point shall be adjustable over the full range. Unless otherwise noted, the dead band shall be fixed at less than 2% of span. The set point stability shall be +0.1% per degree F. The repeatability shall be +0.1% of span. The units shall be furnished with SPDT relays rated at 10 amperes at 115 VAC.
2. Electronic switches shall be as manufactured by AGM, Moore Industries, Rochester Instrument Systems (RIS), Phoenix Contact, Weidmuller, Acromag, or equal.

I. RTD to Current Signal Converters

1. RTD to current signal converters shall convert a 3-wire RTD input signal to an isolated 4-20 mADC output signal. Accuracy shall be 0.10% of span or better. Calibrated span of each converter shall be as indicated on the instrument list. The Contractor shall coordinate calibration of the signal converters with existing RTD elements.
2. Signal converters shall be as manufactured by AGM, Moore Industries, Rochester Instrument Systems (RIS), Phoenix Contact, Weidmuller, Acromag, or equal.

PART 3 – EXECUTION

3.01 REQUIREMENTS

- A. See Section 40 78 00 – Panel Instruments and Accessories, for additional requirements.

END OF SECTION

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SECTION 40 79 00
MISCELLANEOUS INSTRUMENTS, VALVES, AND FITTINGS

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. The Contractor shall furnish, test, install and place in satisfactory operation, the instrumentation and control system accessories with all spare parts, and appurtenances as herein specified and as shown on the Drawings.
- B. Accessories include various items of equipment that may be required in the system but are not scheduled. Accessories are shown on details, flow sheets or plans. Accessories are also called out in specifications for scheduled instruments and in the installation specifications. It is not intended, however, that each piece of hardware required will be specifically described herein. This Specification shall be used as a guide to qualify requirements for miscellaneous hardware whether the specific item is described or not.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 40 61 13 – Process Control System General Provisions
- B. Section 40 70 00 – Instrumentation for Process Systems

1.03 SUBMITTALS

- A. Per Section 40 61 15 – Process Control System Submittals
- B. Impulse piping layout and routing drawings
- C. Complete instrument assembly drawings showing orientation to installed process piping.

PART 2 – PRODUCTS

2.01 PROCESS TUBING

- A. Process, impulse, or capillary tubing shall be 1/2 x 0.065-inch seamless, annealed, ASTM A-269 Type 316L stainless steel with 37 degrees Type 316 stainless steel flared fittings or Swagelok or Parker-CPI flareless fittings.
- B. Piping for closely coupling instruments to process seals shall be standard stainless steel NPT threaded piping or NPT tapped mounting blocks.
- C. A nickel-based lubricant shall be used on threaded stainless steel piping connections to prevent galling.

2.02 POWER, CONTROL, AND SIGNAL CABLES

- A. Power, control and signal wiring shall be provided under Division 26 of the Specifications, unless otherwise indicated.

2.03 CHEMICAL DIAPHRAGM SEALS

- A. Diaphragm seals shall be provided for isolation of pressure gauges, switches and transmitters attached to systems containing chemical solutions or corrosive fluids. As a minimum, seals shall be of all 316 stainless steel construction. In general, diaphragms shall be 316L stainless steel for operating pressures at or above 15 psi and elastomers for operating pressures below 15 psi. However, all components shall be non-reactive with the process fluid in all cases. Refer to the Process Control System Instrument Lists for specific materials requirements.
- B. Seal shall have fill connection, 1/4-inch NPT valved flush port and capable of disassembly without loss of filler fluid. Where specified, diaphragm seals shall comply with the above requirements and shall be provided with 316 SS factory filled capillaries.
- C. Seals shall be Helicoid Type 100 HA, Mansfield & Green, Ashcroft, or equal.

2.04 ISOLATING RING SEALS

- A. For solids bearing fluids, line pressure shall be sensed by a flexible cylinder lining and transmitted via a captive sensing liquid to the associated pressure sensing instrument(s).
 - 1. Full Line Size Isolating Ring Seals
 - a. Where indicated, the sensor body shall be full line size wafer design.
 - b. Full line size isolating ring seals shall have 316 stainless steel housing and assembly flanges and Buna N flexible cylinder lining for in line mounting. The wafer shall have through bolt holes or centerline gauge for positive alignment with the associated flanged piping. Gauge or readout shall be oriented for viewing.
 - c. The captive liquid chamber and associated instrument(s) shall be furnished with threaded drain tap and plug. Manufacturer shall furnish seals with a quick-disconnect-type fitting for field disassembly and reassembly, however, seal and instruments shall be factory assembled prior to arriving at the job site
 - d. Isolating ring seals shall be RED Valve Series 40, Ronningen Petter Iso Ring, Moyno RKL Series W, Onyx Isolator Ring, or equal.
 - 2. Tapped Isolating Ring Seals

- a. Where indicated, pressure shall be sensed via a minimum 1-1/2" diameter spool type isolating ring seal mounted on a 1-1/2" pipe nipple at 90 degrees from the process piping.
- b. An isolation ball valve shall be provided between the process piping and the ring seal, and a cleanout ball valve shall be provided between the ring seal and the atmosphere. The factory assembled and filled pressure instrument shall be back or side mounted to the ring seal such that the gauge or readout may be viewed normally.
- c. Tapped isolating ring seals for solids service shall be Red Valve Series 42/742, Ronningen Petter Iso Spool, Onyx Isolator Ring, or equal.

2.05 FILLING MEDIUM:

- A. The filling medium between instruments, isolating ring seals and diaphragm seals shall be a liquid suitable for operation in an ambient temperature ranging from -10 degrees F to +150 degrees F.
- B. Filling medium shall be silicone unless oxidizing agents, such as sodium hypochlorite, are present, then halocarbon shall be used.

2.06 TAMPER EVIDENT PAINT

- A. Piping and screwed/bolted connections of instrumentation containing the filling medium shall be marked with a small continuous tick mark of tamper evident paint over each piping/instrument joint. Tamper evident paint shall be applied prior to instrument assemblies arriving on the job site. Disturbance of the joint shall break the paint.
- B. Instrument assemblies with broken paint or missing paint shall not be accepted and shall be repaired or replaced at no additional cost to Owner. Paint shall be Dykem Cross-Check or equal.

2.07 ISOLATION VALVES

- A. Isolation valves shall be 1/2 inch diameter ball valves, unless otherwise indicated, with a Type 316 stainless steel body, Type 316 stainless steel ball. Where 316 stainless steel is not compatible with the process fluid, materials of construction shall be suitable for the associated process fluid (e.g., PVC for chemical service).

2.08 ALARM ANNUNCIATION DEVICE

- A. Sirens:
 - 1. For Class I, Division 2 areas and non-hazardous areas:

- a. Provide NEMA 4X and Class I, Division 2 rated alarm horn capable of 32 selectable warning tones. Coordinate tone selection with Owner. Volume shall be field adjustable between 0 and 114 dBA measured at 10 feet.
 - b. Alarm horn shall be the SelecTone 302GCX series with UTM tone module as manufactured by Federal Signal Corporation.
2. For Class I, Division 1 areas:
 - a. Provide NEMA 4X and Class I, Division 1 rated alarm horn capable of 32 selectable warning tones. Coordinate tone selection with Owner. Volume shall be field adjustable between 0 and 114 dBA measured at 10 feet.
 - b. Alarm horn shall be the SelecTone 302X series with UTM tone module as manufactured by Federal Signal Corporation.

B. Strobe Lights:

1. Strobes located within the same room, or otherwise visible from any shared frame of view, shall be synchronized per the requirements of NFPA 72. Strobes shall be synchronized by the strobe manufacturer's synchronization module. Strobe circuits shall not exceed the continuous duty current rating of the synchronization module. Synchronization module shall be Federal Signal Model SSM, Edwards Signaling Model EG1M-RM, or equal.
2. For Class I, Division 2 areas and non-hazardous areas:
 - a. Provide red strobe status indicator. Unit shall be rated NEMA 4X and Factory Mutual approved for a Class I, Division 2, Group D area. Unit shall contain a durable polycarbonate housing and be surface mount. Unit shall be UL listed. Strobe shall be powered from 24VDC.
 - b. Alarm strobe shall be Federal Signal Model 225XST, Edwards Signaling Model 116DEGEX-FJ, or equal.
3. For Class I, Division 1 areas:
 - a. Provide red explosion proof dome covered strobe unit rated NEMA 4X and Factory Mutual certified for a Class I, Division 1, Group D area. Unit shall be UL listed. Strobe shall be powered from 24VDC.
 - b. Alarm strobe shall be Federal Signal Model 27XST, Edwards Signaling Model 116DEGEX-FJ, or equal. Compatible mounting hardware by the strobe manufacturer shall be furnished.
4. Lens color shall be as indicated on the Drawings. [Available lens colors are amber, blue, clear, and red]

PART 3 – EXECUTION

3.01 REQUIREMENTS

- A. Refer to Section 40 70 00 – Instrumentation for Process Systems.

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SECTION 41 22 00
CRANES AND HOISTS

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. The Contractor shall furnish, install and make fully operational the crane and hoist systems in the locations and conditions of service, as shown on the Drawings and as specified in the Crane and Hoist Schedule.
- B. These Specifications shall be considered as minimum requirements. The Contractor shall add such additional features as are necessary for satisfactory operation.
- C. Equipment shall be provided in accordance with the requirements of Section 46 00 00 – Equipment General Provisions.
- D. All equipment supplied under this Specification shall comply in all respects with the provisions of the Occupational Safety and Health Act of 1970, including all standards promulgated under the authority of such Act, and shall also meet all applicable industrial codes in the State or Commonwealth in which the project is located.
- E. The manufacturer and ultimately the Contractor shall be totally responsible for structural design of the crane and hoist systems, for the compatibility of all equipment, and for verification of required operating clearances.
- F. All parts of the mechanism furnished shall be amply designed and constructed for the maximum stresses occurring during fabrication, erection and continuous operation. All equipment specified herein shall be designed for the Crane Manufacturer's Association of America Duty Classification as specified herein.
- G. If the Contractor elects to utilize the crane and hoist equipment in any way during the erection of piping and installation of equipment, he shall notify the Owner in writing and shall provide for an inspection by the equipment manufacturer and take any steps necessary to return the equipment to "as new" condition. He shall also obtain recertification by the manufacturer and reinstate all warranties and guarantees.

1.02 CAPACITY AND DESIGN LOADS

- A. The crane shall be designed to withstand the dead load (caused by the weight of the crane and components themselves), the live load and hoist load, and the inertia forces caused by movement of the crane, components, and loads during standard operation.

- B. Standard capacity ratings shall represent the net rated load at the hook of any type of trolley hoist with the same load rating installed on the crane having a trolley hoist weight within the established limits.
- C. All design loads shall meet CMAA requirements. The design load for stress calculations shall be based upon the capacity plus 15% for the weight of the hoist and trolley and an additional 25% for impact (capacity x 1.4). Design load for deflection calculations shall be based upon the capacity plus 15% for the weight of the trolley hoist (capacity x 1.15).
- D. The rated load capacity of each crane shall be clearly labeled on each crane using a label size easily read from the floor level and/or loading position.

1.03 PORTABLE DAVIT CRANE SCHEDULE

Location	GAC Facility – PO Hoffer	GAC Facility – Glenville Lake	
General			
Crane ID	1	2	3
Indoor/Outdoor	Indoor/Outdoor	Indoor/Outdoor	Indoor
Capacity, tons	1	1	1
Radius(span), feet	7	7	7
Crane			
Mounting Type	Flush-mounted/Pedestal-mounted	Flush-mounted/Pedestal-mounted	Pedestal-mounted
Number of Mounts	See Drawings	See Drawings	See Drawings
Winch Type	Spur gear hand winch	Spur gear hand winch	Spur gear hand winch
Lift			
Mount Elevation	119.67	150.33	121.67
Min Hook Elevation	91.00	124.67	121.67
Max Hook Elevation	127.67	158.33	129.67

1.04 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

- A. Without limiting the generality of other requirements of the Specifications, all work herein shall conform to the applicable requirements of the following documents. All referenced Specifications, codes and standards refer to the most current issue available at the time of the Bid.
 1. CMAA – Crane Manufacturers Association of America
 2. AISC – “Manual of Steel Construction”
 3. ASTM A48 – Standard Specifications for Gray Iron Castings
 4. ANSI B30.11 – Safety Code for Underhung Cranes and Monorail Systems
 5. ANSI B30.16 – Safety Code for Overhead Hoists
 6. MMA MH27.1 – Monorail Manufacturers Association

7. OSHA 1910-179 – Occupation Safety and Health Administration

1.05 SUBMITTALS

- A. The following items shall be submitted in accordance with, or in addition to the submittal requirements specified in Section 01 33 00 – Submittal Procedures and Section 46 00 00 – Equipment General Provisions:
1. Shop Drawings
 2. O&M Manuals
 3. Certification that the systems have been designed to resist all loads implied herein and loadings stipulated in the applicable building codes of the State/Commonwealth in which the project is located. The Certification shall also state that the design has been performed and signed and sealed by a Professional Engineer registered in the State or Commonwealth in which the project is located.
- B. Certification that the equipment has been field tested and passed.
- C. Details and design calculations shall be submitted, signed, and sealed by a Professional Engineer registered in the State or Commonwealth in which the project is located for any of the following components furnished by the Manufacturer:
1. Runway beams.
 2. Monorail patented track.
 3. Monorail suspension systems.
 4. Freestanding bridge crane systems.
 5. End stops and connections.

PART 2 – PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. The equipment covered by these Specifications are intended to be standard equipment of proven reliability and as manufactured by reputable manufacturers having experience in the production of such equipment.

2.02 GENERAL

- A. The crane system shall be constructed of structural steel, in accordance with current AISC (American Institute of Steel Construction) and ASTM (American Society for Testing and Materials) A-36 specifications minimum.
- B. All crane components will have properly finished ends and surfaces.
- C. Welding shall follow the current recommended practices of the AWS (American Welding Society) D14.1 specifications.
- D. Moving members of the crane shall be separated by a clearance of at least 3 inches vertically from any overhead obstruction, and 2 inches horizontally from any lateral obstruction.

2.03 PORTABLE DAVIT CRANE

- A. Davit crane assemblies shall be as manufactured by Thern, Inc., Commander Series, or equal.
- B. The crane base shall allow for removal of the mast. The davit crane shall break down into portable components with no single component weighing more than 100 pounds. Carrying handles shall be welded to mast and boom.
- C. Davit crane assemblies shall include adjustable boom, sheave clevis pin, rotation handle, mast cap, two-year standard warranty, manual spur gear hand winch with brake, and shall be capable of 360° of continuous rotation. The crane shall be designed for manual rotation. The crane's boom shall not drift when at rest yet will rotate easily when manually pushed or pulled.
- D. The davit crane boom shall telescope up to 4 different lengths allowing a maximum hook reach of at least 84 inches measured from mast center to hook center. The minimum height of the boom shall be 36 inches between mounting surface and the underside of the boom in all base configurations.
- E. The davit crane shall have a variable lift capacity based on boom length, to vary between 2000 pounds lift capacity with the boom in the shortest length, and 1000 pounds with the boom fully extended. Wire rope shall be of appropriate thickness and rated for 2000 pounds.
- F. Cranes for indoor use shall have powder coat finishes and galvanized wire rope.
- G. Cranes for outdoor use shall have a 304 stainless steel finish, 304 stainless baseplates, stainless steel winch, 304 stainless steel wire rope, and 316 stainless steel fasteners.

- H. Davit crane shall be labeled with a non-corrosive metal identification plate labeled or imprinted with the manufacturer's name, model number, serial number, capacity rating, and other essential information.

PART 3 – EXECUTION

3.01 MANUFACTURER'S FIELD SERVICES

- A. The services of a qualified manufacturer's technical representative shall be provided in accordance with Section 46 00 00 – Equipment General Provisions and shall include the following site visits for each crane and hoist system:

Service	Number of Trips	Number of Days/Trip
Field Testing	1	1
Startup and Training	1	1

3.02 INSTALLATION

- A. All crane equipment shall be installed in accordance with the applicable sections of Division 05 – Metals, Division 26 – Electrical, and the manufacturer's instructions and recommendations.

3.03 FIELD TESTS

- A. Field tests shall be conducted in accordance with Section 46 00 00 – Equipment General Provisions and the manufacturer's instructions and recommendations. Prior to initial use, all cranes shall be proof-tested at 125% of their rated load in accordance with all OSHA requirements.

3.04 PAINTING

- A. A wire-brushing and/or solvent wipe shall be performed prior to painting to clean and remove debris, mill scale, dirt, and oils.
- B. At least one quart of matching color paint shall be shipped with each crane for field touch-ups.
- C. The crane shall be properly banded and skidded prior to shipment. Any paint damage, scratches, blemishes to the finish of the crane, caused by shipping, transportation via common carrier, etc., shall be repaired by the Contractor.
- D. Rated capacity of crane system shall be painted with stencil in black on all components of crane system as specified herein.

END OF SECTION

SECTION 43 20 00
PUMPS – GENERAL

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. Comply with the requirements of Section 46 00 00 – Equipment General Provisions.
- B. Pumps shall be provided complete with all accessories, special tools, spare parts, mountings, shims, sheaves, couplings, and other appurtenances as specified, and as may be required for a complete and operating installation.
- C. The provisions of this section shall apply to all pumps and pumping equipment specified except where specifically noted otherwise in the Contract Documents.
- D. All pumps provided under an individual specification section shall be by the same manufacturer unless otherwise indicated in the specification.
- E. All equipment for the pumps, including but not limited to motors, cans and bases, shall be provided as a complete unit by the pump Manufacturer.
- F. The pump supplier shall have unit responsibility for coordinating the proper pump mounting system with the Contractor to ensure stable pump operation free from abnormal vibration.
- G. The pump supplier shall include, in their bid, time, labor, materials and tools required for installation assistance, testing and start-up with the Contractor.

1.02 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

- A. All equipment, materials, and installations shall conform to the requirements of the most recent editions with latest revisions, supplements, and amendments of the specifications, codes, and standards listed in Section 01 42 00 – References.
- B. Pumping system equipment, installation and testing shall be in accordance with the following applicable codes, standards and guidelines. All codes, standards and guidelines shall be the latest version as of the date of project bidding.
 - 1. American National Standards Institute / Hydraulic Institute (ANSI/HI)
 - a. ANSI/HI 3.1-3.5 Rotary Pumps for Nomenclature, Definitions, Application and Operation
 - b. ANSI/HI 3.6 Rotary Pump Test

- c. ANSI/HI 9.6.1 Rotodynamic Pumps – Guideline for NPSH Margin
 - d. ANSI/HI 9.6.2 Rotodynamic Pumps for Assessment of Applied Nozzle Loads
 - e. ANSI/HI 9.6.3 Rotodynamic Pumps – Guideline for Operating Regions
 - f. ANSI/HI 9.6.4 Rotodynamic Pumps for Vibration Measurements and Allowable Values
 - g. ANSI/HI 9.6.5 Rotodynamic Pumps Guideline for Condition Monitoring
 - h. ANSI/HI 9.6.6 Rotodynamic Pumps for Pump Piping
 - i. ANSI/HI 9.6.8 Rotodynamic Pumps - Guideline for Dynamics of Pumping Machinery. Guidelines and recommendations included in ANSI/HI 9.6.8 shall constitute the minimum requirements for acceptance.
 - j. ANSI/HI 9.8 Rotodynamic Pumps for Pump Intake Design
 - k. ANSI/HI 11.6 Rotodynamic Submersible Pumps for Hydraulic Performance, Hydrostatic Pressure, Mechanical and Electrical Tests
 - l. ANSI/HI 12.1-12.6 Rotodynamic Slurry Pump for Nomenclature, Definitions, Applications and Operation
 - m. ANSI/HI 14.1-14.2 Rotodynamic Pumps for Nomenclature and Definitions
 - n. ANSI/HI 14.3 Rotodynamic Pumps for Design and Application
 - o. ANSI/HI 14.6 Rotodynamic Pumps for Hydraulic Performance Acceptance Tests
- 2. American Society of Mechanical Engineers (ASME)
 - a. ANSI/ASME B73.1 Specifications for Horizontal End Suction Centrifugal Pumps for Chemical Process
- 3. American Petroleum Institute (API)
 - a. ANSI/API Standard 610 Centrifugal Pumps for Petroleum, Petrochemical and Natural Gas Industries
- 4. American Water Works Association (AWWA)
 - a. ANSI/AWWA E103 Standard for Horizontal and Vertical Line-Shaft Pumps
- 5. American Society for Testing and Materials (ASTM)

- a. A36 Specification for Structural Steel
- b. A48 Specification for Gray Iron Castings
- c. A53 Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
- d. A148 Specification for Steel Castings, High Strength, for Structural Purposes
- e. A193 Specification for Alloy Steel and Stainless Steel Bolting Materials for High Temperature Service
- f. A276 Specification for Stainless Steel Hot/Cold-Finished Bars
- g. A322 Specification for Steel Bars, Alloy, Standard Grades
- h. A514 Specification for High Yield Strength, Quenched and Tempered alloy Steel Plate, Suitable for Welding
- i. A532 Specification for Abrasion-Resistant Cast Irons
- j. A536 Specification for Ductile Iron Castings
- k. A565 Specification for Martensitic Stainless Steel Bars
- l. A582 Specification for Free-Machining Stainless and Heat-Resisting Steel Bar, Hot-Rolled and Cold-Rolled
- m. A743 Specification for Castings, Iron-Chromium, Iron-Chromium-Nickel and Nickel-Base, Corrosion-Resistant for General Application
- n. B148 Specification for Aluminum-Bronze Sand Castings
- o. B584 Specification for Copper Alloy Sand Castings for General Application
- 6. American National Standards Institute (ANSI)
 - a. B16.1 Standard for Cast Iron Pipe Flanges and Flanged Fittings
 - b. B16.5 Standard for Pipe Flanges and Flanged Fittings
- 7. American National Standards Institute / National Fire Protection Association (ANSI/NFPA) 70 National Electric Code
- 8. Society of Automotive Engineers (SAE) J404 Chemical Compositions of SAE Alloy Steels

9. International Organization for Standardization (ISO), Standard, ISO 1940 – Mechanical Vibration – Balance quality requirements for rotors balance quality grade for rotors in a constant rigid state.
10. Comply with the requirements of Section 46 00 00 – Equipment General Provisions.

C. Related contract specification sections:

1. Section 01 33 00 – Submittal Procedures
2. Section 46 00 00 – Equipment General Provisions
3. Division 15 – Mechanical
4. Division 26 – Electrical
5. Section 26 05 60 – Low Voltage Electric Motors
6. Section 26 05 61 – Medium Voltage Electric Motors
7. Division 40 – Process Interconnections

1.03 ACTION/INFORMATIONAL SUBMITTALS

A. Product Data:

1. Comply with Section 01 33 00 – Submittals.
2. Fabrication information.

B. Provide submittals identified in Specification Section 46 00 00 – Equipment General Provisions in addition to the submittals identified herein and in addition to the submittals identified in the individual pumping specification sections.

C. Shop Drawings shall include the following information in addition to the requirements of Section 01 33 00 – Submittal Procedures and shall include the following information in addition to the requirements of Section 01 33 00 – Submittal Procedures:

1. Pump name, identification number and specification number.
2. Performance characteristics and descriptive data, including but not limited to:
 - a. Pump performance curves at rated speed and reduced speeds (if reduced speeds are specified).

- b. Pump performance data shall be provided for the proposed impeller diameter and for the maximum impeller diameter possible with the proposed pump.
- c. Curves shall indicate:
 - 1) Information specified elsewhere
 - 2) Impeller diameter
 - 3) Minimum continuous stable flow (minimum flow to avoid suction recirculation)
 - 4) Preferred operating region (POR) per ANSI/HI 9.6.3
 - 5) Allowable operating region (AOR) per the latest version of ANSI/HI 9.6.3.
 - 6) Performance curves submitted shall be for the entire pump assembly, including efficiency corrections and losses.
 - 7) Pump performance curves shall be submitted both in the form of performance data cut sheets and in tabular format. Tabular data shall include the following:
 - a) Flow
 - b) Pump head (pressure for positive displacement type pumps)
 - c) NPSH required (net positive inlet pressure, NPIP, for positive displacement type pumps)
 - d) Pump efficiency
 - e) Rated driver horsepower
 - f) Brake horsepower
 - g) A minimum of 10 data points shall define rotodynamic pump performance curves listed above. Performance curve data points shall include the following:
 - i. best efficiency point
 - ii. all specified operating points
 - iii. preferred operating region minimum and maximum

- iv. allowable operating region minimum and maximum
 - v. shutoff condition
 - vi. runout
 - vii. The remainder of the points shall be distributed evenly to clearly define the shape of each of the curves.
 - viii. Each data point shall be reported to a minimum of three (3) significant figures.
 - ix. The curve data shall align with the HI acceptance grade (1B, 2B, 1U, etc.) as specified in the individual pump specification and shall explicitly state the applicable tolerance band, as defined by the Hydraulic Institute Standards, associated with each value.
3. Minimum submergence requirements shall be provided for vertically suspended pumps and submersible pumps.
 4. Detailed dimensional drawings, data and setting plans including but not limited to:
 - a. General cutaway sections
 - b. Materials
 - c. Dimension of shaft projections
 - d. Shaft and keyway dimensions
 - e. Shaft diameter
 - f. Shaft-impeller connection details
 - g. Dimension between bearings
 - h. General dimensions of pump
 - i. Suction head bolt orientation
 - j. Anchor bolt locations
 - k. Forces: Itemized forces shall be determined at specified operating points and at pump shutoff condition.
 - l. Assembly views

- m. Exploded parts view
 - n. Cutaway images
 - o. Provide weight of entire pump assembly, including motor and base weight of individual major subassemblies. Indicate the weight of each component, and total static and dynamic loads imparted by the equipment to the supporting structure. Itemized loads shall be determined at specified operating points and at pump shutoff condition.
 - p. Impeller
 - q. Drawings shall identify each component by tag number to which the catalog data and detail sheets pertain.
 - r. Mass of rotating assembly
 - s. Mass of coupling(s)
5. Drive and motor data as required by Division 26 – Electrical. Complete motor data shall include but not be limited to:
- a. Size
 - b. Make
 - c. Mass of motor
 - d. Inertia of driver
 - e. Motor enclosure type
 - f. Characteristics
 - g. Wiring diagrams
 - h. Variable speed drive information and data: Where pump and motor speeds are to be regulated by variable speed drives, the CONTRACTOR shall coordinate, furnish and exchange all necessary requirements with the respective equipment manufacturers to ensure compatibility and shall submit pump, motor and variable speed drive shop drawings together as a complete system.
6. Information on pumps and motor bearings, including but not limited to:
- a. Bearing types

- b. Rated bearing life
 - c. Bearing life calculations for the specified operating points.
 - d. Bearing arrangement
- 7. Gear box design and performance criteria and AGMA service factor.
- 8. Equipment protective device details and connection diagrams.
- 9. Details of shaft sealing system including seal/packing type, seal water control devices, and seal water piping schematic.
- 10. Information on pump appurtenances including but not limited to:
 - a. Couplings
 - b. Shaft guards
 - c. V-belt drive systems
- 11. Submersible pump submittals shall also include:
 - a. Product data sheets for power and control cables, length of cables and cable support system.
 - b. Details on pump guide rail system and mounting requirements.
 - c. Details on submersible pump's retrieval system.
- 12. Any additional information required to demonstrate compliance with the specifications.
- D. Results of structural, lateral, and torsional dynamic analyses as required herein and in the individual specification sections.
- E. Manufacturers literature and brochures
- F. Lubrication Information: Complete lubrication instructions and lubricant schedule, including manufacturer's recommended lubricant. All lubricants shall be food grade, NSF 61 approved. Schedule shall include frequency of lubricant application, type of lubricant, and instructions regarding lubricant application. Comply with Section 46 00 00 – Equipment General.
- G. Materials of construction data and associated specifications (such as AISI, ASTM, SAE, etc.), including but not limited to:

1. Grade
 2. Type
 3. Elemental makeup, by percent elemental constituent
 4. Mechanical properties, including but not limited to:
 - a. Brinell hardness number
 - b. Galling resistance
- H. Coatings: Coating system data and description of coating system, surface preparation and shop painting, including certification that the shop paint is compatible with the finish paint.

1.04 CLOSEOUT SUBMITTALS

- A. Submit warranty documentation in compliance with:
1. Section 01 33 00 – Submittals
 2. Section 01 61 00 – Product Requirements and Options
 3. Section 01 75 00 – Checkout and Startup Procedures
- B. Operation and Maintenance (O&M) manuals shall be submitted in accordance with Section 01 33 00 – Submittal Procedures and Section 01 78 23 – Operation and Maintenance Data.

1.05 MAINTENANCE MATERIALS SUBMITTALS

- A. Operation and Maintenance (O&M) manuals shall be submitted in accordance with:
1. Section 01 33 00 – Submittal Procedures.
 2. Section 01 78 23 – Operation and Maintenance Data.
- B. Comply with Section 01 78 43 – Spare Parts and Extra Materials.
- C. Comply with Section 01 79 00 – Instructions to Owner's Personnel.
- D. Comply with Section 46 00 00 – Equipment General.

1.06 QUALITY ASSURANCE SUBMITTALS

- A. Dynamic Analysis Submittals:

1. Dynamic analysis entity qualifications: Qualifications shall be submitted in advance of dynamic analysis calculations, models and analyses. Qualifications shall include but not be limited to:
 - a. Detailed tabulation of relevant projects with descriptions and data to clearly substantiate that the qualifications specified herein this section are satisfied by the dynamic analysis firm and individuals. For each project, tabulation shall include:
 - 1) Proposed personnel who worked on project experience item.
 - 2) Resumes of proposed personnel including which project experience items they have experience working on.
 - 3) Pump end user point of contact including name and email address.
2. Dynamic analysis input data requirements as defined in ANSI/HI 9.6.8, Appendix B.
3. Dynamic analysis results as required herein and as follows:
 - a. For vertical motors, where dynamic analysis is specified, submit the following additional information:
 - 1) Expected/Proposed reed critical frequency (RCF) data:
 - a) Motor reed critical frequency (RCF)
 - b) Force due to the weight of the motor
 - c) Center of gravity location (the distance to the motor center of gravity from the motor flange face)
 - d) The static deflection of the motor center of gravity, y_{static}
 - e) Expected and proposed values shall be provided by the motor manufacturer to the pump manufacturer, to the Engineer, and to the dynamic analysis entity.
 - 2) Report of post-manufacture/pre-shipment motor reed critical frequency (RCF) factory impact verification test: Post-manufacture/pre-shipment motor impact test results (per HI 9.6.8, Appendix D) (for vertical pumps where a dynamic analysis is specified), including but not limited to the following information:
 - a) Mounting plate structure natural frequency (without motor)

- b) RCF in two perpendicular planes:
 - i) In-line with the conduit box;
 - ii) Perpendicular to the conduit box.
- c) Motor weight
- d) Motor center of gravity location (the distance to the motor center of gravity from the motor flange face).
- e) Photo of the motor test set-up with the motor in place
- f) Vibration instrument used
- g) Impact device used
- h) Weight scale information
- i) Description of method used to determine motor center of gravity location
- j) Post-manufacture, pre-shipment motor reed critical frequency (RCF)

4. Report shall include model mesh sizes.

B. Factory testing plan. Wherever factory tests are specified, testing plan shall include but not be limited to the following:

- 1. Testing procedures
- 2. Testing equipment
- 3. Test arrangement
- 4. Test conditions
- 5. Speed of rotation of test
- 6. Test facility systems and equipment, including but not limited to:
 - a. Test facility electrical single line diagram
 - b. Calibrated factory motor (where applicable) with calibrated efficiency curves
 - c. Calibrated factory drive (where applicable) with calibrated efficiency curves

- C. Factory Test Results shall be submitted and approved prior to shipment of equipment.
- D. Shipment, Delivery, Handling and Storage instructions
- E. Installation instructions
- F. Field testing plan
- G. Comply with Section 01 75 00 – Check Out and Start Up Procedures
- H. Preliminary field test data
- I. System field quality control testing
- J. Final field test data
- K. Certified test reports
- L. Startup report including data substantiation of successful completion of 30-day operational demonstration performance data.

1.07 GENERAL INFORMATION AND DESCRIPTION

- A. Comply with Section 46 00 00 – Equipment – General Provisions.

1.08 DYNAMIC ANALYSIS

- A. Dynamic analyses shall be performed to determine the potential for a critical natural frequency (lateral, torsional, or structural) occurring within the application's operating speed range of the pumps. All dynamic analyses shall be performed in accordance with the latest edition of ANSI/HI 9.6.8 – Rotodynamic Pumps Guideline for Dynamics of Pumping Machinery, as supplemented in these specifications.
 - 1. Types of analyses, level of analysis, and minimum frequency separation margins required for each pump service is indicated in the individual pump specification sections. If no specific dynamic analysis requirements are included in the individual pump specification section, the shop drawing submittal shall include a certification that no critical speeds fall below 125% of the pump operating speed and/or within 25% +/- of the vane pass frequency ranges.
 - 2. The analyses shall identify natural frequencies (critical speeds) of the equipment and demonstrate that these natural frequencies are above of the pump operating speed range and outside of associated excitation frequencies by the specified frequency separation margin. As a minimum, excitation frequencies to be considered in the analyses shall include 1x running speed, 2x running speed, and vane pass frequency. Torsional analyses shall also consider 1x line frequency, 2x

line frequency, and VFD/VSD excitations. Critical speed calculations provided shall include, but not be limited to, the first and second critical speed calculations.

3. Pump operating speed range used in the dynamic analyses shall extend from the minimum to the maximum operating speeds required by the manufacturer to satisfy the full range of the specified pump operating conditions.
4. All foundations shall be assumed to be flexible unless proven via calculations and/or models to be rigid per the requirements of HI 9.6.8.

B. Where Level 1 analyses are required in the individual pump specifications:

1. The following dynamic analyses shall be performed by the manufacturer:
 - a. Level 1: Comply with Schedule 43 20 00 – 01 Dynamic Analysis Requirements. Analyses performed shall include but not be limited to the level of analysis specified in the individual specification section for the type of pump (VS, OH, BB).

C. Where Level 2/3 analyses are required in the individual pump specifications:

1. Dynamic analysis shall be performed by:
 - a. a pre-qualified third-party entity or
 - b. a qualified and Engineer approved equal third party entity that satisfies all the requirements specified herein.
2. Pre-qualified third-party entities include the following:
 - a. Mechanical Solutions, Inc of Whippany, NJ
 - b. Engineering Dynamics Inc of San Antonio, TX.
 - c. Kelm Engineering LLC of Friendswood, TX.
3. Third party qualified dynamic analysis professional who is in responsible charge (and signs and seal the analysis) shall meet the following criteria:
 - 1) Project List Experience:
 - a) Number of years of firm experience performing dynamic analysis: 15 years, minimum.
 - b) Number of level 2 dynamic analysis projects completed in accordance with ANSI/HI 9.6.8: 20, minimum.

- c) Number of level 3 dynamic analysis projects completed in accordance with ANSI/HI 9.6.8: 5, minimum.
 - d) Pump dynamic analysis experience shall be for complete mechanical and structural systems and shall clearly indicate inclusion of pump, motor, foundation, and suction/discharge piping to the first restraint or expansion joint in accordance with ANSI/HI 9.6.8.
 - e) Calibration of models using field test data.
 - f) Names of personnel who performed each project. Resumes of personnel proposed to perform dynamic analysis for this project.
 - g) Requirements specified elsewhere.
- 2) Firm's staff shall include:
- a) Years of experience: At least one employee shall have a minimum of 10 years' experience.
 - b) Pump field troubleshooting personnel: One (1), minimum.
 - c) Field data collection personnel: One (1), minimum.
 - d) Number of licensed professional engineers: One (1) minimum.
- 3) Dynamic analysis entity shall be capable of proving model assumption capabilities based on models that are calibrated based on field test data.
- 4) Dynamic analysis analyst shall not be performed by the equipment manufacturer.
4. To comply with the following "pump-system" dynamics requirements, the pump Manufacturer will provide the independent third party entity firm conducting the analysis with all necessary pump components through 2D drawings and/or 3D solid models so that the natural frequencies and critical speeds of the combined pump-system can be accurately predicted. Solid models shall be utilized for this effort.
5. Motor weight, center of gravity, reed frequency information, as well and motor rotating shaft dimensions and polar moment of inertia will be required to be submitted by the selected motor manufacturer. Solid models shall be utilized for this effort.

6. The following analyses shall be performed:

- a. Level 2: Comply with Schedule 43 20 00 – 01 Dynamic Analysis Requirements. Analyses performed shall include but not be limited to the level of analysis specified in the individual specification section for the type of pump (VS, OH, BB).
- b. If natural frequencies fall within the specified ranges and separation margins, and if reasonable modifications cannot adequately shift the natural frequencies above the separation margins, then the subject equipment shall be rejected from further consideration.
- c. If compliance with the acceptance criteria cannot be demonstrated, the pump manufacturer shall coordinate the dynamic analysis with the Engineer and make recommendations to the Engineer for reasonable changes (e.g., changes to the design of the concrete pump base/pedestal, discharge head design, connectors, supports, motor to discharge head interface mounting) as needed to achieve the required margins. The dynamic analysis shall be repeated with the modified design, and the process shall be repeated as necessary until a compliant pump and pedestal design is achieved. The pump manufacturer, not the Engineer, is responsible for the coordination and successful vibration performance of the complete system. Any related analysis shall be at no additional cost the Owner.
- d. Post-manufacture, pre-shipment, confirmation: Where the Dynamic Analysis is based on equipment and structure assumptions for weight, strength, rigidity, reed critical frequency, or any variable or input into the calculation specific to the pump equipment, the assumptions used are to be confirmed following equipment manufacture by a manufacturer's certification of Dynamic Analysis assumptions, signed by both the Manufacturer and the entity which performed the submitted Dynamic Analysis.
 - 1) This certification shall state that the values used in the model are reflective of the actual equipment such that they would not result in the adjusted critical speeds falling within the critical speed limits, plus specified margin of separation, specified for that equipment.
 - 2) Alternately, a revised analysis can be prepared and submitted with the actual post-manufacture/pre-shipment values.
 - 3) Any post-manufacture, pre-shipment analysis shall be at no additional cost the Owner.

D. Reporting of Results

1. Prior to manufacture, a submittal shall be provided to the Engineer demonstrating that the required dynamic analyses have been performed and that the specified requirements will be met. Reports shall be in accordance with ANSI/HI 9.6.8. Reports for Level 1 or Level 2 dynamic analyses shall be signed and sealed by a professional engineer. The report shall include the following:
 - a. A Level 1 lateral, structural, or torsional dynamic analysis report shall include:
 - 1) A statement that the analyses were performed in accordance with the requirements of ANSI/HI 9.6.8.
 - 2) Equations used, with references.
 - 3) Equation input values used.
 - 4) Results obtained.
 - 5) margin of separation from rated speed(s).
 - b. A level 2 lateral, structural, or torsional dynamic analysis report shall include:
 - 1) All the items that are required for a Level 1 report.
 - 2) A statement that the analyses were performed in accordance with the requirements of ANSI/HI 9.6.8.
 - 3) Computer program used.
 - 4) Assumptions made in order to model the system.
 - 5) Schematic diagram of the model depicting nodes and elements.
 - 6) Input data consisting of node coordinates, element types, material properties, element characteristics, element connectivity presented graphically, and specified displacements and/or excitation force spectra.
 - 7) A statement that models have a minimum of a two (2) element node thickness for all bodies.
 - 8) Supporting calculations and data.
 - 9) Unless otherwise approved in writing by the Engineer, the report shall include a written statement that models have been developed using the original equipment manufacturer solid models.

- 10) Motor or other drive reed frequency data (or dynamic analysis, if recommended) (for structural or lateral analysis).
 - 11) Motor or other drive critical speed data, by the manufacturer (for structural or lateral analysis).
 - 12) Motor ISO 1940 balance level. Pump ISO 1940 balance level.
 - 13) Shafting critical speed data, by the manufacturer (structural or lateral analysis).
 - 14) Pump and drive equipment torsional data by the respective vendors (for torsional analysis).
 - 15) Shafting and coupling torsional data by respective vendors (for torsional analysis).
 - 16) Anticipated excitation frequencies.
 - 17) Analysis results, including all significant natural frequencies and a description of the corresponding mode shapes.
 - 18) A Campbell diagram depicting a plot of excitation frequency versus operating speed, with the following information:
 - a) A plot of all excitation sources that are multiples of the operating speed, properly labeled.
 - b) A plot of natural frequencies versus operating speed.
 - c) Areas of interference of 1) and 2) described above clearly identified, or the lack of likely resonance indicated.
- c. Interpretation of the results and recommendations, including recommendations for appropriate corrective action.

1.09 WARRANTY

- A. Warranty requirements shall be as specified in Section 01 61 00 – Product Requirements and Options. Warranty requirements are supplementary to the individual equipment specifications.
- B. Comply with the Equipment Warranties requirements specified in Section 46 00 00 – Equipment General Provisions.

1.10 OPERATING CONDITIONS AND PERFORMANCE REQUIREMENTS:

- A. When operating at the maximum output speed each pump shall have a characteristic performance curve which meets the conditions listed in the pump schedule. The pumps and drive motors shall be capable of operating satisfactorily under the full-range of speed, flow and pressure conditions as defined by the pump schedule. Pump efficiency as defined herein shall include all mechanical losses from bearings and shaft seals.
- B. The impeller diameter required for the specified operating conditions shall not exceed 95% of the maximum impeller diameter of the pump provided to allow increased duty for future conditions.
- C. Each pumping unit and its driving equipment shall be designed and constructed to withstand the maximum turbine run-away speed of the unit due to backflow, including but not limited to back spinning from a dead stop and/or via a flow reversal condition that occurs immediately subsequent to a forward flow condition, through the pump with the primary TDH specified available at the pump discharge flange. Maximum reverse run-away speed shall not exceed 130 percent of the design operating speed.
- D. Pump manufacture shall certify a Minimum Continuous Stable Flow (MCSF) rating at maximum speed that is lower than the specified minimum operating flow. Where a reduced speed operating condition is specified, the manufacturer shall also certify MCSF at the pump speed required to meet this condition.
- E. Factory test acceptance grade for rating point shall be as specified herein, except where superseded via specification and/or scheduled values in the individual pump specifications, however power required shall not exceed the rated motor horsepower.
- F. Pump Operating Conditions: Refer to respective individual pump specifications for specific performance requirements.

PART 2 – PRODUCTS

2.01 GENERAL

- A. Performance Curves: All centrifugal pumps shall have a continuously rising curve. In no case shall the required horsepower at any point on the performance curve exceed the rated horsepower of the motor or drive. Safety factors will not be considered in determining compliance with this requirement.
- B. Suction and discharge flanges shall conform to ASME B16.1 or B16.5 dimensions.
- C. For pumps in raw sewage service and as required by individual pump specifications, handholes shall be provided on the pump suction nozzle and the pump volute and shall be shaped to follow the contours of the casing or adjoining piping to avoid any obstructions in the water passage.

- D. The minimum ABMA L10 bearing life for all pump, motor and drive bearings shall be 60,000 hours unless otherwise specified in the individual pump specification sections.

2.02 ANCHORS AND SUPPORTS

- A. Comply with the following Specification Sections:
1. Specification Section 05 05 23 – Metal Fastening.
 2. Specification Section 46 00 00 – Equipment General Provisions.
 3. Comply with individual pump specifications.
- C. [Specification Section 01 73 23 – Anchorage and Bracing of Non-Structural Components (applies to all states except Florida)]

2.03 DEFAULT MATERIALS

- A. Pumps shall be constructed out of the materials specified in respective individual pumping specification sections. Material not specifically called for shall be high-grade, standard commercial quality, free from all defects and imperfection that might affect the serviceability of the product for the purpose for which it is intended, and shall conform to the following requirements unless otherwise specified in individual pumping equipment Specifications:

Component	Materials of Construction
Casings and Bowls	Close-grained gray cast iron, conforming to ASTM A 48, or equal
Impellers	Water: ASTM B 148, aluminum bronze Wastewater: ASTM A 536, Hard Iron
Shafts, wetted	Type 400 series stainless steel
Shafts, non-wetted	AISI 4140 steel
Miscellaneous stainless steel parts	Type 316 series stainless steel
Anchor Bolts and Fasteners	Type 316 stainless steel

2.04 COMPONENTS:

- A. Refer to individual specification sections for specific requirements.
- B. Pump Shaft:
1. The shaft shall be heat treated, turned, ground, and polished over its entire length and shall be provided with keyways on both ends.

2. The shaft shall be sufficiently large in diameter to safely transmit the maximum torque developed by the drive unit and provide a rigid support for the impeller to prevent excessive vibration.

C. Bearings:

1. Bearings shall be designed for continuous heavy duty loads and for both axial and radial thrust loads.
2. The specified ABMA L-10 life for bearings shall be under worst possible operating conditions.
3. Bearings shall support the shaft and the complete rotating elements.

D. Wear Rings:

1. Wear rings shall meet or exceed the requirements of API 610, including but not limited to the following features:
 - a. Brinell hardness and Brinell hardness difference between adjacent wear parts.
 - b. Wear ring clearances
2. Adjacent wear ring material combinations shall be non-galling.

2.05 STRUCTURAL STEEL

- A. Structural steel used for fabricating equipment supports, etc. shall conform to the requirements of Section 05 12 00 – Structural Steel.
- B. All materials shall conform to applicable provisions of the AISC Specifications for the design and fabrication of structural steel, and to pertinent ASTM Standard Specifications.

2.06 DISSIMILAR METALS

- A. All dissimilar metals shall be isolated in accordance with Section 05 10 00 – Metal Materials and to the satisfaction of the Engineer.

2.07 GALVANIZING

- A. Where required by the equipment specifications, galvanizing shall be performed in accordance with Section 05 05 13 – Galvanizing.

2.08 STANDARDIZATION OF GREASE FITTINGS

- A. Grease Fittings: Comply with Section 46 00 00 – Equipment General Provisions.

2.09 APPURTENANCES

- A. Seals:

1. Mechanical seals shall be furnished as specified in individual pumping equipment sections.
2. If the pump manufacturer recommends a better seal or alternate flushing arrangement for a specific application, it may be submitted to the Engineer for approval in accordance with the requirements of Section 01 25 00 – Substitution Procedures.

- B. Pressure Gauges:

1. Contractor shall supply all pressure gauges for all pumps by one manufacturer.
2. Gauges shall be provided through the instrumentation subcontractor to match other gauges on the project.
3. Gauges shall be as specified in Section 40 73 13 – Pressure and Differential Pressure Gauges.
4. All gauges shall be provided with diaphragm seals or isolating ring seals as specified in Section 40 79 00 – Miscellaneous Instruments, Valves and Fittings.
5. The Contractor shall furnish and install pressure gauges as shown on the Drawings, but the following gauges shall be provided as a minimum:
 - a. On the suction and discharge of each pump, except wet-pit submersible pumps and vertical turbine pumps.
 - b. On the discharge piping of each wet-pit submersible pump and vertical turbine pump in the locations shown on the Drawings or as directed by the Engineer.
6. Gauge ranges shall be coordinated with the pump manufacturer and shall meet the following requirements, except where otherwise specified:

Location	Type	Graduation	Suction Range	Discharge Range
Suction	Single Scale, Compound	FT H20	-34-FT	+34-FT
Discharge	Single Scale	FT H20	0-FT	Greatest of the following: - Shutoff + 5-FT - 130% of Maximum

C. Shaft Couplings:

1. Except as otherwise specified in individual pump specification sections, flexible couplings for direct driven pumps shall provided between the pump shaft and driver and keyed to pump and driver shafts. Flexible couplings shall be internal metal grid type couplings with a metal flange on both shafts with a metal cage in between, as manufactured by Falk, or equal.
2. Spacer couplings shall be provided where necessary to allow removal of the pump rotating element without disturbing the driver.
3. Comply with Section 46 00 00 – Equipment General Provisions protective guard requirements.

D. Equipment Guards: Provide guards in accordance with OSHA requirements for all rotating assemblies that would otherwise be exposed at the operating deck level.

E. Provide access to:

1. Couplings
2. Oil drains

2.10 ELECTRICAL REQUIREMENTS

- A. All electrical equipment and appurtenances, including but not limited to motors, panels, conduit and wiring, etc., specified in the equipment specifications shall comply with the applicable requirements of the Division 26 - Electrical specifications and the latest National Electric Code.
- B. All pumps shall be furnished with motors such that the motor shall not be overloaded throughout the full range of the pump operation. The use of service factor will not be allowed in determining overloaded condition.
- C. In the individual pump specifications, specified motor horsepower is intended to be the maximum size motor to be provided. If a larger motor is required to meet the specified operating conditions and performance requirements, the Contractor shall furnish the

larger sized motor and shall upgrade the electrical service (conduit, wires, starters, etc.) at no additional cost to the Owner.

- D. Where variable frequency drives (VFDs) and/or variable speed drives (VSDs) are specified, the Contractor shall be responsible for coordinating between pump supplier and VFD/VSD supplier to ensure a complete and operational system. VFDs/VSDs shall be furnished under Division 26 - Electrical unless otherwise specified in the pump specification.
- E. Motor starters and controls shall be furnished and installed under Division 26 - Electrical and Division 40 - Process Interconnections unless otherwise specified in the individual pump specifications.

2.11 SPARE PARTS AND SPECIAL TOOLS

- A. Accessories, spare parts, and special tools shall be provided in accordance with Section 01 78 43 – Spare Parts and Extra Materials.
- B. Spare parts for equipment shall be furnished where indicated in the equipment Specifications and/or where recommended by the equipment manufacturer.
- C. Spare parts shall be identical and interchangeable with original parts.
- D. The Contractor shall furnish a one-year supply of all recommended lubricating oils and greases.
- E. Comply with Section 01 78 43 – Spare Parts and Extra Material.

2.12 EQUIPMENT IDENTIFICATION

- A. Comply with the requirements of Section 46 00 00 – Equipment General Provisions.
- B. All pumps shall be provided with a stainless steel nameplate, mechanically fastened with stainless steel hardware in a conspicuous place, and clearly inscribed with:
 - 1. the manufacturer's name
 - 2. year of manufacture
 - 3. model number
 - 4. serial number
 - 5. principal rating data including the following at the primary design point:
 - a. Capacity in gallons per minute

- b. rated total dynamic head
 - c. speed in rotations per minute
 - d. efficiency at the primary design point.
- C. Each pump shall also be identified as to name and number by a suitable laminated plastic or stainless steel nameplate mechanically fastened with stainless steel hardware; for example, "Raw Water Pump – 1 (RWP-1)". Coordinate name and number with same on remotely located controls, control panel, and other related equipment.
- D. Nameplates shall not be painted over.

PART 3 – EXECUTION

3.01 SHOP TESTING

- A. The terms Shop Testing and Factory Testing shall be considered to be interchangeable.
- B. Perform Shop Testing in conformance with Section 46 00 00 – Equipment General Provisions.
- C. The CONTRACTOR shall be responsible for the coordination of factory testing of each pump, variable speed drive, and motor. Unless required as indicated by the individual pump specification sections, manufacturer provided factory test motors and factory variable speed controllers (as necessary) shall be used for factory performance testing.
- D. Except as otherwise specified, factory testing shall be conducted in accordance with the latest version of
 - 1. ANSI/HI 14.6.
 - 2. For submersible pumps, testing shall be conducted in accordance with the latest version of ANSI/HI 14.6 and ANSI/HI 11.6.
 - 3. For rotary pumps, testing shall be conducted in accordance with the latest version of ANSI/HI 3.6.
 - 4. Pumps shall be tested within plus or minus 3 percent of the pump design speed. Affinity laws shall be used to adjust performance within this range to the design condition hydraulics.
- E. Hydraulic Performance Acceptance Tests

1. The testing procedure shall be submitted to the Engineer for review and approval before scheduling the testing. The Owner/Engineer shall be given at least 2 weeks advanced notice of the scheduled testing date.
2. Notification and payment of expenses for witness testing shall be as described in Section 46 00 00 – Equipment General Provisions wherever individual pump specifications call for witness testing.
3. Specified hydraulic operating condition tolerances for rotodynamic pumps shall be as follows unless otherwise specified in the individual pump specifications:
 - a. The design or rated pump operating point shall be within the tolerances specified for Acceptance Grade 1U as defined by ANSI/HI 14.6.
 - b. The specified low flow pump operating point shall have a unilateral positive head tolerance; no negative head tolerance is allowed at the defined flow condition.
 - c. The specified high flow pump operating condition shall have a unilateral positive flow tolerance; no negative flow tolerance is allowed at the defined head condition.
4. Factory performance test shall include a minimum of seven test points between shutoff and runout.
5. Where required by the individual equipment specification sections, NPSH (NPIP for rotary pumps) tests shall be conducted to demonstrate compliance with the specified NPSH (NPIP for rotary pumps) requirements.
6. Net Positive Suction Head Testing for rotodynamic pumps shall be as follows unless otherwise specified in the individual pump specifications:
 - a. An NPSH test for a single operating condition shall be executed. The test flow shall be greater than the specified high flow operating condition and shall be identified by increasing the flow until a 3% drop in head occurs relative to the expected head if sufficient NPSH were available.
 - b. If during the NPSH test the pump's maximum flow condition is reached prior to identification of the NPSH3 value (i.e., control valve is fully open or the pump is operating at the edge of the AOR), the NPSHa at that operating condition shall be documented as the maximum NPSH3 value.
7. Certified test curves shall be provided for all centrifugal pumps unless otherwise specified in the individual pump specifications.

- a. Certified tests will not be required for submersible sump pumps (as specified in Section 43 25 17 – Submersible Sump Pump and Section 43 25 18 – Submersible Chemical Sump Pumps) with motors less than 5 hp.
 - b. Certified curves shall identify minimum continuous stable flow and preferred operating region (POR) and allowable operating region (AOR) per the latest version of ANSI/HI 9.6.3.
 - c. Certified performance curves shall include the NPSH3 value identified during testing. An NPSH3 curve shall be calculated over the pump's AOR based on the documented test value(s). A clear designation shall be provided on the certified performance curve indicating calculated portions of the NPSH curve.
- 8. For wet pit submersible pumps and vertical turbine pumps, all tests shall be run at minimum pump submergence specified in the individual pump specifications.
- 9. All instruments shall be calibrated as required by ANSI/HI 14.6, 11.6, or 3.6 as applicable.
- F. Where required in the individual pump specifications, a certified hydrostatic test shall be completed on each pumping unit in accordance with ANSI/HI 14.6 or 11.6 as applicable. Hydrostatic test pressure shall be 1.5 times maximum operating head or 1.25 times shutoff head, whichever is greater.
- G. Where required in the individual pump specifications, each individual casting shall be Brinell tested in a minimum of two places, in an area of representative casting thickness to ASTM Method E-10. Results shall be certified by a registered professional engineer.
- H. Shop testing of electric motors shall conform to:
 - 1. Section 46 00 00 – Equipment General Provisions
 - 2. Section 26 05 60 – Low-Voltage Electric Motors
 - 3. Section 26 05 61 – Medium Voltage Electric Motors
 - 4. Section 26 05 00 – Basic Electrical Requirements
 - 5. Post-manufacture, pre-shipment motor impact test results (per HI 9.6.8, Appendix D) (for vertical pumps where a dynamic analysis is specified). Motor Reed critical frequency (RCF) mass and center of gravity properties shall be verified at the motor manufacturer's facility via motor impact testing. Before shipment of motor from motor factory, submit report of impact test results.

6. The accuracy of post-manufacture, pre-shipment motor impact test RCF shall be within 10% +/- of the expected/proposed values obtained from the motor manufacturer during the motor proposal phase. If/where values are out of tolerance, dynamic analyses and forced response analyses shall be repeated and adjustments to equipment made until a result that conforms with HI 9.6.8 and this specification is demonstrated via submitted data and accepted via the submittal process.
- I. Shop testing of pumping trains - The right is reserved to require factory impact tests pre-shipment.
 1. Post-manufacture, pre-shipment impact test results (per HI 9.6.8, Appendix D) (for pumps where a dynamic analysis is specified). Natural frequencies shall be verified at the manufacturer's facility via impact testing. Before shipment of equipment from the point of manufacturer, submit report of impact test results.
 2. The accuracy of post-manufacture, pre-shipment impact test shall be within 10% +/- of the expected/proposed values obtained from the manufacturer during the proposal phase. If/where values are out of tolerance, dynamic analyses and forced response analyses shall be repeated and adjustments to equipment made until a result that conforms with HI 9.6.8 and this specification is demonstrated via submitted data and accepted via the submittal process.

3.02 SHIPMENT, DELIVERY, HANDLING AND STORAGE

- A. Shipment, delivery and handling of equipment and materials shall be in accordance with Section 01 65 00 – Product Delivery Requirements.
- B. Storage of equipment shall be in accordance with Section 01 66 00 – Product Storage and Protection Requirements.
- C. Factory assembled parts and components shall not be dismantled for shipment unless permission is received in writing from the Engineer.
- D. Machined surfaces of all exposed pump openings or other exposed unpainted surfaces shall be protected by wooden blanks or Cosmoline, as appropriate, strongly built and securely bolted thereto.
- E. After hydrostatic or other tests, all entrapped water shall be drained prior to shipment, and proper care shall be taken to protect parts from the entrance of water during shipment, storage and handling.

3.03 MANUFACTURER'S FIELD SERVICES

- A. Manufacturer's field services shall be in accordance with:

1. Section 01 75 00 - Checkout and Startup Procedures
 2. Section 46 00 00 - Equipment General Provisions
 3. Section 01 79 00 – Instruction of Owner Personnel
- B. Unless otherwise referenced in the individual pump specification section, as a minimum the services of the manufacturer's representative shall be provided for as stated in the following schedule:

Service	Number of Trips	Number of Days/Trip
Installation and Testing	1	2
Startup and Training	1	2
Services after Startup	1	1

- C. Any additional time required to achieve successful installation and operation shall be at the expense of the CONTRACTOR.

3.04 INSTALLATION

- A. Pumping equipment shall be installed in accordance with Section 46 00 00 – Equipment General Provisions, the manufacturer's recommendations, accepted procedures submitted with the shop drawings and as indicated on the Drawings, unless otherwise accepted by the ENGINEER.
- B. Level pump and motor and grout feet or baseplate with grout in accordance with Section 03 60 00 – Grout and in accordance with Section 46 00 00 – Equipment General. Ensure minimum grout depth is obtained as recommended by the pump and grout manufacturers.
- C. Drains: All gland seals, air valves, and drains shall be piped to the nearest floor drain or trench drain with stainless steel pipe or copper tube (as appropriate for the environment), properly supported with brackets.
- D. Contractor shall have unit responsibility for the proper coordination, sizing, and installation of the pump foundation/mounting requirements based on the manufacturer's recommendations, subject to Engineer's review and comment.

3.05 ALIGNMENT

- A. Pumping equipment shall be aligned in accordance with Section 46 00 00 – Equipment General Provisions, the manufacturer's recommendations, accepted procedures submitted with the shop drawings and as indicated on the Drawings.
- B. Equipment shall be aligned and free from binding, scraping, excessive vibration, shaft runout, or other defects. Pump drive shafts shall be measured just prior to assembly to ensure correct alignment without forcing.
- C. As a minimum, comply with International Standard, ISO 1940 – Mechanical Vibration – Balance quality requirements for rotors balance quality grade for rotors in a constant rigid state.

3.06 FIELD TESTING

- A. Comply with Section 46 00 00 – Equipment General Provisions for applicable preliminary and final field testing requirements supplementary to those described in this specification.
- B. Comply with Section 01 75 00 – Checkout and Startup Procedures.
- C. All pumping units shall be field tested after installation, in accordance with the Contract Documents, to demonstrate satisfactory operation over the full operating speed range, without excessive noise, vibration, cavitation, and overheating of the bearings. The field testing shall be performed in the presence of an experienced field representative of the manufacturer of each major item of equipment, who shall supervise the following tasks and shall certify in writing that the equipment and controls have been properly installed, aligned, lubricated, adjusted, and readied for operation:
 - 1. Pumps shall be tested for vibration over the full specified speed range. Unless otherwise required by individual specification sections, vibration shall be within the limits identified in the latest version of ANSI/HI 9.6.4 (or ANSI/HI 11.6 for submersible pumps), or manufacturer's limits if more stringent. If vibration is greater than 80% of the limits identified in ANSI/HI 9.6.4, follow-up vibration testing shall be completed after a 90-day break-in period to ensure that vibration remains within ANSI/HI 9.6.4 allowable limits. If vibration exceeds the allowable limits during the follow up testing, modifications shall be made as a warranty repair.
 - 2. Bearing temperatures shall be determined. A running time of at least 20 minutes shall be maintained for this test, unless liquid volume available is insufficient for a complete test.
 - 3. In addition to dynamic analysis requirements specified and defined in HI 9.6.8, where Level 2 or Level 3 analysis is specified or otherwise specified in the individual pump specifications, the natural frequencies of each installed pump shall

be determined using the “bump test” method. Field natural frequency testing shall demonstrate a minimum of 10% field separation from the 1x running speed, 2x running speed and vane pass frequencies. Field test information shall be incorporated into the models developed for this facility for confirmation purposes. In addition, pump train coast down testing shall be performed for comparison purposes to bump testing results.

4. Pump performance shall be documented by obtaining concurrent readings, showing motor voltage, amperage, motor power, flow, pump suction head, and pump discharge head, for at least five (5) pumping conditions at full speed. One of the points shall be within -5% and 0%, and one being within 0% and +5% of the rated condition point flow rate; the remaining three points shall be spaced over the allowable operating region of the pump performance curve with points taken at or near the maximum allowable (shutoff) head region and at or near the maximum allowable flow (runout). Additional reduced speed testing shall be performed to demonstrate that pumps can achieve performance at turndown conditions where specified in individual pump specification sections. Each power lead to the motor shall be checked for proper current balance. Flow shall be measured to the extent possible by permanently installed instrumentation or drawdown measurement. The rated motor nameplate current shall not be exceeded at any point. Pumps with drive motors rated at less than five horsepower shall only be tested for overcurrent when overheating or other malfunction becomes evident in general testing. Field performance testing shall meet HI 14.6 pump acceptance test grade tolerance band grade 3B for all required test points.
- D. The field testing shall be witnessed by the Owner or its representative. The CONTRACTOR shall submit to the ENGINEER a written notification of all pump field tests a minimum of one (1) week prior to testing. In the event of failure of any pump to meet any of the above requirements, the CONTRACTOR shall make all necessary modifications, repairs, or replacements to conform to the requirements of the Contract Documents and the pump shall be re-tested at no additional compensation, until found satisfactory. The CONTRACTOR shall then certify in writing that the equipment has been satisfactorily tested, and that all final adjustments thereto have been made. Certification shall include date of final acceptance test, as well as a listing of all persons present during tests, and resulting test data. The costs of all Work performed in this Paragraph by factory-trained representatives shall be borne by the CONTRACTOR.

3.07 FAILURE OF EQUIPMENT TO PERFORM

- A. Comply with Section 46 00 00 – Equipment General Provisions.

3.08 PAINTING

- A. Comply with Section 46 00 00 – Equipment General Provisions.

B. Comply with Section 09 90 00 – Painting.

END OF SECTION

Schedule 43 20 00 – 01 Dynamic Analysis Requirements

Calculation Title		Purpose	Minimum Components of Analysis	Level 1 Simple Calculations			Level 2 Intermediate Methods				Level 3 (Note 1) Advanced Methods					
				-- VS, Vert OH BB, Vert OH OH, BB, Vert OH			--		OH, BB Stages, Vert OH		(Note 3, 7)	--		OH, BB Hydrodynamic Bearing	OH, BB ≤ 2 Stages, Antifriction Bearing	BB ≥ 3 Stages
							VS, Vert OH	Vert BB, Vert OH				Vert BB, Vert OH	OH, BB, Vert OH			
Lateral Analysis Calculations																
Critical lateral frequency (standard established equations)		First transverse (lateral) critical speed of the rotor	Rotor and structure	X	X	X										
First dry critical speed analysis		Critical lateral frequency occurring within operating speed range				X					X					
Lateral forced response analysis		Critical lateral frequency occurring within operating speed range	Combined structural analysis								X		X			
Undamped natural frequency analysis		Critical lateral frequency occurring within operating speed range	Pump, motor, shafting					X	X (anti-friction bearing)	X				X		X
Damped natural frequency analysis		Critical lateral frequency occurring within operating speed range	Pump, motor, shafting						X (hydro-dynamic bearing)	X		X	X	X		X
Torsional Analysis																
Critical Torsional Frequency (standard established equations)		Torsional critical speed	Pump, motor, rotor	X	X	X										
Undamped torsional natural frequency analysis		Critical torsional frequency occurring within speed range	entire motor-coupling-shafting drive train				X	X	X	X (Note 3)	X	X (Note 3)	X	X		X

Schedule 43 20 00 – 01 Dynamic Analysis Requirements

Calculation Title	Purpose	Minimum Components of Analysis	Level 1 Simple Calculations			Level 2 Intermediate Methods				Level 3 (Note 1) Advanced Methods						
			--			VS, Vert OH	OH, BB, Vert OH	--		OH, BB ≥ 3 Stages	(Note 3, 7)	--		OH, BB Hydrodynamic Bearing	OH, BB ≤ 2 Stages, Antifriction Bearing	BB ≥ 3 Stages
			VS, Vert OH	Vert BB, Vert OH	OH, BB, Vert OH			Vert BB, Vert OH	OH, BB, Vert OH			Vert BB, Vert OH	OH, BB, Vert OH			
Structural Analysis																
Structural reed critical frequency (RCF)	Critical structural natural frequency within operating speed range	pump-motor-rotor structure	X	X	X			X				X				
Shaft end deflection analysis (static structural finite element analysis, FEA)	Critical structural natural frequency occurring within operating speed range	Combination pump and supporting structure (baseplate)						X (Note 4,5)	X (Note 4,5)				X			
Modal FEA	Natural frequency analysis	Combined pump-motor-baseplate structural system (including pump column and bowl assembly)						X (Note 4, 5)	X			X (Note 4, 5, 2)	X (Note 2)			
Motor Reed Critical Frequency (RCF) - Expected/Proposed (Note 6)	Expected/proposed RCF, mass of motor, and location of center of gravity of the motor.	motor	X	X	X		X	X				X	X			
Motor Reed Critical Frequency (RCF) Factory Impact Verification Test - Post-manufacture/pre-shipment (Note 6)	Post-manufacture/pre-shipment RCF, mass of the motor, and as-built center of gravity location of motor.	motor	X	X	X		X	X				X	X			

Notes

- (1) Where forced response analyses are expressly specified and allowed and analysis indicates that natural frequency falls within specified separation margins, and if reasonable modifications cannot adequately shift the natural frequencies outside of the separation margins, then the pump rotor and surrounding structure shall be subject to a forced response analysis performed as a combined structural analysis (per HI 9.6.8.7.2.1.2, 9.6.8.7.2.3.2, 9.6.8.7.2.1.1 and 9.6.8.2.3.1). The forced response analysis shall demonstrate that the pump will function properly over its entire speed range.
- (2) Analysis shall include concrete supports and elevated slab.
- (3) Torsional forced damped response analysis shall demonstrate that infinite service life shall be achieved.
- (4) Analysis shall include piping to the first pipe support or expansion joint, including water mass.
- (5) If pump is located on concrete pedestal or an elevated slab, the analysis shall include the nearby foundation in accordance with ANSI/HI 9.6.8. Any concrete foundation features included in the analysis shall be based on a final design for these items based on the equipment provided.
- (6) RCF applies to non-submersible vertical pump-motor structures
- (7) The level 3 structural analysis for VS pumps shall include foundation mass and stiffness within a radial distance (measured from the center of the pump base) at least equal to the height of the top of the motor relative to the level of attachment of the baseplate to the floor and piping details pertinent to modal mass and stiffness (including enclosed fluid) within a spherical zone of radius (relative to centerline) equal to twice the height of the top of the motor relative to the level of attachment of the baseplate to the floor.

SECTION 43 20 00.01

PUMP FIELD TESTING SCHEDULE

PART 1 - GENERAL

1.01 THE REQUIREMENT

- A. Reference Section 43 20 00 - Pumps General.

1.02 PUMP FIELD TESTING SCHEDULE

- A. Pumping requirements for this Section are outlined on the Drawings, in Equipment General, in Pumps General and in the individual pump specifications and schedules. Where individual pump specifications require field testing, all pumps provided in response to that specification section shall be tested as Scheduled herein.
- B. The Contractor shall provide the services of a third party testing entity to independently perform all field testing.

1.03 INSTRUMENTATION

- A. The contractor shall provide any supplemental instrumentation necessary to collect the data required by the pump field testing schedules.

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43 20 00.01 - PUMP FIELD TESTING SCHEDULE

FACTORY ACCEPTANCE TESTED GUARANTEED VALUES

PUMP		MOTOR	
PUMP TYPE:	[XXXXXX]	MOTOR TYPE:	[XXXXXX]
PUMP EQUIP. ID NO.:	[XXXXXX]	MOTOR EQUIP. ID	[XXXXXX]
PUMP MANUFACTURER:	[XXXXXX]	MOTOR	[XXXXXX]
PUMP MODEL:	[XXXXXX]	MOTOR MODEL:	[XXXXXX]
PUMP EQUIP. SERIAL NO.:	[XXXXXX]	MOTOR EQUIP.	[XXXXXX]
PUMP IMPELLER DIA.:	[XXXXXX]	MOTOR HP:	[XXXXXX]
BRAKE HP:	[XXXXXX]	VOLTAGE:	[XXXXXX]
DATE OF TEST:	[XXXXXX]	MOTOR SPEED:	[XXXXXX]
TEST FLUID:	[XXXXXX]	NUMBER OF PHASES:	[XXXXXX]
TEST DATUM ELEVATION (EL FT):	[XXXXXX]	HZ:	[XXXXXX]
		CURRENT (FLA):	[XXXXXX]
			[XXXXXX]

MEASURING METHODOLOGY:	
RATE OF FLOW:	[XXXXXX]
INLET HEAD:	[XXXXXX]
OUTLET HEAD:	[XXXXXX]
BRAKE HP:	[XXXXXX]
SPEED OF ROT.:	[Tachometer]

MEASUREMENT INTERVAL	PARAMETER TIME	UNITS (HR:MIN)	1	2	3	4	5	6	7	8	9	10	11	12
TEST POINTS			EXAMPLE	RUNOUT	MAX POR	100-105% RATED	95-99% RATED							
	VFD FREQUENCY	(HZ)	60	60	60	60	60							
	% OF MAX	(%)	100%	100%	100%	100%	100%							
SPEED	RPM	(RPM)												
	PUMP BEARING - Inboard	(Deg F)												
	PUMP BEARING - Outboard	(Deg F)												
TEMPERATURE	MOTOR INBOARD BEARING	(Deg F)												
	MOTOR OUTBOARD BEARING	(Deg F)												
	SOUND PRESSURE AT 3-FT	(DBA)												

NOTES:

- (1) Design Head is as measured from the gate invert to the maximum WSEL.
- (2) Per HI 9.6.4 for speeds 600 RPM and below, in addition to velocity measurements, the peak-to-peak displacement on bearing housings(s) shall be measured
- (3) This item pertains to between bearing (BB) type pumps only.
- (4) If field vibration values exceed the HI 9.6.4 field testing vibration values, the Contractor shall hire a third party specialist vibration company to investigate utilizing Fast Fourier Transform (FFT) full spectrum analysis, enhanced motion video, and modal analysis to
- (5) Contractor shall submit completed form following each test.

END OF SECTION

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SECTION 43 23 17
SAMPLE PUMPS

PART 1 – GENERAL

1.01 WORK INCLUDED

- A. Furnish and install sample pumps as specified herein and as shown on the Contract Drawings. The sample pumps shall be provided by one manufacturer with sole responsibility for the satisfactory manufacture and performance of the systems.
- B. The following is a list of pumping equipment to be provided under this Section:

Facility	Pump Service	Sample Location	Pump Location	Suction Condition
GLWTF	GAC Influent	Operations Building (see drawings)	Sample Pump above Filter Effluent Flume	20 ft Suction Lift
GLWTF	GAC Effluent (Pre-Chemical)	Operations Building (see drawings)	Sample Pump above Filter Effluent Flume	20 ft Suction Lift
POHWTF	GAC Influent	Filtered Water Flume (see drawings)	Sample Pump above Filter Effluent Flume	20 ft Suction lift
POHWTF	GAC Effluent (Pre-Chemical)	Filtered Water Flume (see drawings)	Sample Pump above Filter Effluent Flume	20 ft Suction Lift

- C. The Contractor shall provide a Hubbell Hot Box, or Equal – Flip Top, Heated, Vented, Fiberglass, Insulated Enclosure for all exposed sample pumps as indicated in the Drawings.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 01 33 00 – Submittal Procedures
- B. Section 46 00 00 – Equipment General Provisions
- C. Section 43 20 00 – Pumps General
- D. Section 40 05 00 – Basic Mechanical Requirements
- E. Division 26 – Electrical
- F. Division 40 – Process Interconnections

1.03 SUBMITTALS

- A. Submit in accordance with Section 01 33 00 – Submittals and Section 46 00 00 – Equipment General Provisions.

1.04 QUALITY ASSURANCE

- A. The sample pumps shall be in accordance with Section 46 00 00 – Equipment General Provisions and Section 43 20 00 – Pumps General.

1.05 OPERATION AND MAINTENANCE

- A. Comply with the requirements of Section 46 00 00 – Equipment General Provisions and Section 43 20 00 – Pumps General.

1.06 WARRANTY

- A. Comply with the requirements of Section 46 00 00 – Equipment General Provisions and Section 43 20 00 – Pumps General.

PART 2 – PRODUCTS

2.01 SAMPLE PUMPS

- A. Type of Pump: Fully integrated, self-priming booster pump, continuous duty.
- B. Performance Requirements:

Number of Units	8 (4 installed, 4 spares)
Total Design Capacity (gpm)	5 gpm at 110 feet of total head
Discharge Pressure (psi)	40
Maximum Motor Horsepower	1/2
Temperature of Liquid Pumped	Ambient
Minimum Suction Port Diameter (inch)	1-1/4"
Minimum Discharge Port Diameter (inch)	1"
Self-Priming Capacity (ft)	20

- C. Materials: Pumps body housing and integral components such as impeller, control box cover, pump cover, chamber stack, non-return valves, tank, drain plug, and thread shall be constructed of composite Noryl. The shaft seal shall be constructed of ceramic.

2.02 MANUFACTURERS

- A. Pump shall be Model STA-RITE ProJet SNC-HF25L as manufactured by Pentair, or Engineer approved equal. Pump motor shall be provided with the pump.
- B. Motor: The pump motors shall be designed for 115 volt, 60 hertz, single phase electrical power. All pumps shall be plug-in. Motor shall have NEMA 3 enclosure rating, shall be U.L. approved, and shall be designed for continuous duty operation.
- C. Accessories

1. Provide universal mounting bracket and 316 stainless steel mounting hardware. Contractor shall provide any additional accessories required for a complete installation. A 316 stainless steel wall mounting bracket shall be provided where indicated on the drawings.
2. Provide foot valve for pump installations that do not have a flooded suction condition. Foot valves shall be NSF/ANSI 61 certified as directed in Section 40 05 00 – Basic Mechanical Requirements.

2.03 SPARE PARTS

- A. Spare parts shall be provided in accordance with Section 46 00 00 – Equipment General Provisions and shall include the following:
 1. One (1) spare pump per application for nine (9) total
 2. One (1) – spare foot valve

PART 3 – EXECUTION

3.01 GENERAL

- A. Pumps shall be installed and adjusted in such a manner that connecting piping will not impose any strain on any pump.
- B. Pump installation shall be as indicated on the drawings. All wall mounting brackets or pump support tables shall be provided as shown on the Drawings.

3.02 SHIPPING AND HANDLING

- A. Comply with requirements of Section 46 00 00 – Equipment General Provisions and Section 43 20 00 – Pumps General.

3.03 EQUIPMENT SHOP TESTS

- A. Perform under provisions of Section 46 00 00 – Equipment General Provisions and Section 43 20 00 – Pumps General.

3.04 FIELD TESTS

- A. Perform under provisions of Section 46 00 00 – Equipment General Provisions and Section 43 20 00 – Pumps General.

3.05 INSTALLATION AND STARTUP

- A. The Contractor shall install the equipment in accordance with the manufacturers' recommendations, shop drawings, and under provisions of Section 46 00 00 – Equipment General Provisions and Section 43 20 00 – Pumps General.

END OF SECTION

SECTION 43 24 10
VERTICAL TURBINE PUMPS

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. Provide all labor, materials, equipment, motors, anchorage systems, and incidentals necessary for the installation, testing, and placing into operation open-lineshaft vertical turbine pumps and appurtenances at the locations shown on the Drawings and as specified herein. All pumps specified herein shall be supplied by the same manufacturer.
- B. Equipment shall be provided in accordance with the requirements of Section 43 20 00 – Pumps General.
- C. For the purposes of this Section, “Manufacturer” shall mean the designer, manufacturer, supplier and tester of the pump equipment, including selection and assembly of motor. The Manufacturer shall be responsible for the design, coordination, testing, and satisfactory performance of all the components. Inclusion of a specific manufacturer's name in the Specifications does not mean that the specific manufacturer's standard product will be acceptable. Specified manufacturer's or other manufacturer's standard product shall be modified as required to meet the Specifications.
- D. The Manufacturer shall have unit responsibility for coordinating the proper pump mounting system with the Contractor to ensure stable pump operation. The Contractor shall install, anchor, test, and align the equipment such that vibration levels are within Manufacturer's recommended tolerances. The Contractor shall provide all supports, stiffeners, etc., that may be required to provide systems that operate reliably and within vibration limits specified by the Manufacturer.
- E. All equipment shall be suitable for continuous operation (24 hours per day, 365 days per year). Pumps shall be NSF 61 rated.

1.02 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

- A. Comply with Section 43 20 00 – Pumps General.
- B. Add Requirements specific to this pump type, if any.

1.03 ACTION/INFORMATIONAL SUBMITTALS

- A. Product Data: Comply with Section 01 33 00 – Submittal Procedures.

- B. Provide submittals identified in Section 46 00 00 – Equipment General Provisions in addition to the submittals identified herein and in addition to the submittals identified in the individual pumping specification sections.
- C. Provide submittals identified in Section 43 20 00 – Pumps General.
- D. Dynamic Analysis Results Report
- E. Shaft critical speed analysis, bearing spacing calculations, and shaft stretch (impeller end-play) analysis with recommended installation lateral adjustment.

1.04 CLOSEOUT SUBMITTALS

- A. Submit warranty documentation in compliance with:
 - 1. Section 01 33 00 – Submittal Procedures
 - 2. Section 01 61 00 - Product Requirements and Options
- B. Operation and Maintenance (O&M) manuals shall be submitted in accordance with Section 01 33 00 – Submittal Procedures and Section 01 78 23 – Operation and Maintenance Data.
- C. Comply with Section 43 20 00 – Pumps General.

1.05 MAINTENANCE MATERIALS SUBMITTALS

- A. Operation and Maintenance (O&M) manuals shall be submitted in accordance with:
 - 1. Section 01 33 00 – Submittal Procedures
 - 2. Section 01 78 23 Operation and Maintenance Data
- B. Comply with Section 01 78 43 – Spare Parts and Extra Materials.
- C. Comply with Section 01 79 00 – Instructions to Owner’s Personnel.
- D. Comply with Section 46 00 00 – Equipment General.
- E. Comply with Section 43 20 00 – Pumps General.

1.06 QUALITY ASSURANCE SUBMITTALS

- A. Comply with Section 43 20 00 – Pumps General.
- B. Comply with Section 01 75 00 – Check Out and Start Up Procedures.

- C. Installation list demonstrating years of experience producing substantially similar equipment and demonstrating evidence of the number of installations in satisfactory operation for at least five years in the continental United States. At least three installations in the last five years shall be of similar size or larger than specified application.

1.07 GENERAL INFORMATION AND DESCRIPTION

- A. Comply with Section 46 00 00 – Equipment – General Provisions.

1.08 DYNAMIC ANALYSIS

- A. Dynamic analyses shall be performed to determine the potential for a critical natural frequency (lateral, torsional, or structural) occurring within the normal operating speed range of the pumps. All dynamic analyses shall be performed in accordance with the latest edition of ANSI/HI 9.6.8 – Rotodynamic Pumps Guideline for Dynamics of Pumping Machinery and as specified in Section 43 20 00 – Pumps General.
- B. Level of analysis required, minimum frequency separation margin, and other parameters of the analyses shall be as follows:

Schedule 43 24 10 - 01

	GLWTF		POHWTF	
	GAC Feed	Backwash	GAC Feed	Backwash
Lateral Analysis				
Level of Analysis	Level 2	Level 2	Level 2	Level 2
Separation Margin	20%	20%	20%	20%
Torsional Analysis				
Level of Analysis	Level 2	Level 2	Level 2	Level 2
Separation Margin	20%	20%	20%	20%
Structural Analysis				
Level of Analysis	Level 2	Level 2	Level 2	Level 2
Separation Margin	20%	20%	20%	20%
Include Concrete Base/Pedestal in FEA Model (Level 2/3 analysis only)	N/A	N/A	N/A	N/A
Include Elevated Slab in FEA model (Level 2/3 analysis only)	Yes	Yes	Yes	Yes

1.09 WARRANTY

- A. Warranty requirements shall be as specified in Section 01 61 00 – Product Requirements and Options. Warranty requirements are supplementary to the individual equipment specifications.
- B. Comply with the Equipment Warranties requirements specified in Section 46 00 00 – Equipment General Provisions.

1.10 OPERATING CONDITIONS AND PERFORMANCE REQUIREMENTS

Vertical Turbine Pump Performance Criteria

Schedule 43 24 10 - 02

	GLWTF		POHWTF	
	GAC Feed	Backwash	GAC Feed	Backwash
Pump Identification Numbers	P-35101 P-35102 P-35103	P-36101 P-36102	P-35101 P-35102 P-35103 P-35104	P-36101 P-36102 P-36103
Number of Units	3	2	4	3
Maximum Nominal Speed (rpm)	1,800	1,800	1,800	1,800
Minimum Pump Operating Speed (Hz)	30	30	30	30
Number of Stages	As Required	As Required	As Required	As Required
Primary Operating Point (at maximum pump speed)				
Flow (gpm)	8,333	3,100	8,333	4,000
Total Head (ft)	53	64	36	46
Minimum Bowl Efficiency (%)	80%	80%	80%	79%
Rating Point shall be within the following range as % of BEP Flow	80% to 120%	70% to 120%	80% to 120%	70% to 120%
Secondary Operating Point (at reduced pump speed)				
Flow (gpm)	3,819	1,033	5,555	2,430
Total Head (ft)	38	41	23	24
Minimum Bowl Efficiency (%)	70%	50%	75%	80%
Rating Point shall be within the following region (AOR/POR)	AOR	AOR	AOR	AOR
Maximum NPSH Required at Primary Operating Point at centerline of impeller of first stage (feet)	18	17	17	25

Vertical Turbine Pump Performance Criteria

Schedule 43 24 10 - 02

	GLWTF		POHWTF	
	GAC Feed	Backwash	GAC Feed	Backwash
Minimum NSPH Available at Primary Operating Point at centerline of impeller of first stage (feet)	51	52	57	44
Maximum Shut Off Head (feet)	110	120	105	90
Fluid Pumped	Filtered Water	Finished Water	Filtered Water	Finished Water
Fluid Temperature (degrees F)	Ambient	Ambient	Ambient	Ambient
Fluid Specific Gravity	1.0	1.0	1.0	1.0
Fluid pH range	6.5 – 8.5	6.5 -8.5	6.5 – 8.5	6.5 – 8.5
Fluid Viscosity (absolute centipoise at 60-deg F.)	1.12	1.12	1.12	1.12
Pump Can Diameter (inches)	42	30	42	30
Maximum Bell Outer Diameter (in)	31.5	24.5	31.5	22.5
Minimum Bell Inner Diameter (in)	20.6	16	20.6	18
Pump Can Suction Pipe diameter (inches)	30	18	30	24
Minimum Pump Column Diameter (inches)	20	12	20	14
Minimum Discharge Diameter (inches)	20	12	20	14
Minimum Lineshaft Diameter (inches)	1 11/16	1 1/4	1 11/16	1 1/4
Can Flange to Vortex Suppression Basket Length (inches)	304	286	255	173
Minimum Can Flange to Floor Length (inches)	308	290	259	177
Factory Test Acceptance Grade	1U	1U	1U	1U

- A. When operating at the maximum output speed each pump shall have a characteristic performance curve which meets all the minimum conditions listed in the pump schedule. The pumps and drive motors shall be capable of operating satisfactorily under the full-range of speed, flow and pressure conditions as defined by the pump schedule. Pump efficiency as defined herein shall include all losses from the pump intake suction bell to the pump discharge flange. Losses through blank bowls (if any) for initial conditions shall also be considered.

1.11 DEFINITIONS

- A. Terms shall be as defined in ANSI / AWWA E103 Standard for Horizontal and Vertical Line-Shaft Pumps.
- B. Additional terms are defined below:

1. Submergence: Vertical distance in feet between the pumping water level and the bottom of the first stage impeller.

PART 2 – PRODUCTS

2.01 GENERAL

- A. Comply with Section 43 20 00 – Pumps General, except where superseded in this specification section.
- B. Anchor bolts and baseplates shall be provided and set per the requirements of the Manufacturer. The Manufacturer shall supply templates for setting the anchor bolt layout

2.02 ACCEPTABLE MANUFACTURERS

- A. Manufacturer shall have a minimum of 10 years of experience of producing substantially similar equipment and shall be able to show evidence of at least 5 installations in satisfactory operation for at least 5 years in the continental United States.
- B. Pump Manufacturer:
 1. Peerless
 2. Floway
 3. Flowserve
 4. Or equal
- C. The electric motor shall be provided by the pump manufacturer and shall be one of the named manufacturers specified in Section 26 05 60 – Low-Voltage Electric Motors.
- D. All equipment for the pumps, including motors and bases, shall be provided as a complete unit by the pump manufacturer.

2.03 ANCHORS AND SUPPORTS

- A. Comply with the following Specification Sections:
 1. Section 05 05 23 – Metal Fastening
 2. Section 46 00 00 – Equipment General Provisions
 3. Comply with individual pump specifications.
- B. Comply with Section 43 20 00 – Pumps General

2.04 MATERIALS OF CONSTRUCTION

A. Materials of construction shall conform to the requirements listed below.

Schedule 43 24 10 – 03R

Component	GLWTF		POHWTF	
	GAC Feed	Backwash	GAC Feed	Backwash
Pump shafts and line shafts	Stainless steel, Type 416	Stainless steel, Type 416	Stainless steel, Type 416	Stainless steel, Type 416
Line shaft couplings	Stainless Steel, Type 316	Stainless Steel, Type 316	Stainless Steel, Type 316	Stainless Steel, Type 316
Bowl wear rings	Stainless Steel, Type 420	Stainless Steel, Type 420	Stainless Steel, Type 420	Stainless Steel, Type 420
Bowl impellers	Nickel Aluminum Bronze or Stainless Steel, Type 316	Nickel Aluminum Bronze or Stainless Steel, Type 316	Nickel Aluminum Bronze or Stainless Steel, Type 316	Nickel Aluminum Bronze or Stainless Steel, Type 316
Pump bowls, discharge case, and suction bell	Cast Iron or Ductile Iron	Cast Iron or Ductile Iron	Cast Iron or Ductile Iron	Cast Iron or Ductile Iron
Impeller keys and thrust rings	Stainless steel, Type 416	Stainless steel, Type 416	Stainless steel, Type 416	Stainless steel, Type 416
Pump columns	Carbon Steel Pipe, ASTM A53, Sch 30*	Carbon Steel Pipe, ASTM A53, Sch 30*	Carbon Steel Pipe, ASTM A53, Sch 30*	Carbon Steel Pipe, ASTM A53, Sch 30*
Enclosing Tube	NA	NA	NA	NA
Tube centering spider	NA	NA	NA	NA
Pump can	Carbon Steel Pipe, ASTM A53, Sch 30*	Carbon Steel Pipe, ASTM A53, Sch 30*	Carbon Steel Pipe, ASTM A53, Sch 30*	Carbon Steel Pipe, ASTM A53, Sch 30*
Discharge heads	Carbon Steel, ASTM A53 or A36	Carbon Steel, ASTM A53 or A36	Carbon Steel, ASTM A53 or A36	Carbon Steel, ASTM A53 or A36
Sole plate	Carbon Steel, ASTM A36	Carbon Steel, ASTM A36	Carbon Steel, ASTM A36	Carbon Steel, ASTM A36
Base Plate	Match discharge head	Match discharge head	Match discharge head	Match discharge head
Sleeve bearings	Bronze	Bronze	Bronze	Bronze
Lineshaft bearings	Rubber	Rubber	Rubber	Rubber
Bearing Retainers	Bronze	Bronze	Bronze	Bronze
Vortex Suppression Basket	Stainless Steel, Type 316L	Stainless Steel, Type 316L	Stainless Steel, Type 316L	Stainless Steel, Type 316L

Schedule 43 24 10 – 03R

	GLWTF		POHWTF	
Component	GAC Feed	Backwash	GAC Feed	Backwash
Bolts and nuts	Stainless Steel	Stainless Steel	Stainless Steel	Stainless Steel
Tube Tension Bearings	NA	NA	NA	NA
Oiler Assembly tubing	NA	NA	NA	NA

* Or higher schedule if required to meet vibration criteria.

- B. The impeller and bowl wearing rings shall not be constructed of the same material. Impeller and bowl wearing rings materials shall have a minimum Brinell hardness difference of 50.

2.05 COMPONENTS

A. DISCHARGE HEAD

1. The discharge head shall have bolted register or rabbet-fit connections for the motor. Discharge head shall have connections for the pump column and shall support the loadings that it imposes as well as hydrostatic and hydrodynamic heads.
2. Design columns and discharge heads for 100% of the pump discharge pressure (suction pressure plus pump differential pressure) at shutoff. Hydrostatically test columns and discharge heads at 130% of design pressure.
3. Access to the stuffing box shall be through windows placed 90 degrees from the discharge. Fit handholes or windows with stainless steel, expanded or perforated metal guards in stainless steel frames to protect the exposed shaft and coupling.
4. Design columns and discharge heads for 100% of the pump discharge pressure (suction pressure plus pump differential pressure) at shutoff. Hydrostatically test columns and discharge heads at 130% of design pressure.
5. Provide the following connections on the discharge head in addition to discharge nozzle:

Schedule 43 24 10 – 04

	GLWTF		POHWTF	
	GAC Feed	Backwash	GAC Feed	Backwash
Configuration	Above Grade	Above Grade	Above Grade	Above Grade
Flange	ANSI B16.5 Class 150	ANSI B16.5 Class 150	ANSI B16.5 Class 150	ANSI B16.5 Class 150
Suction Vent ¹	1 – inch NPT	1 – inch NPT	1 – inch NPT	1 – inch NPT
Seal Drain	1/2 – inch NPT	1/2 – inch NPT	1/2 – inch NPT	1/2 – inch NPT
Discharge Gauge	1/2 – inch NPT	1/2 – inch NPT	1/2 – inch NPT	1/2 – inch NPT
Pressure Switch	1/2 – inch NPT	1/2 – inch NPT	1/2 – inch NPT	1/2 – inch NPT
Air Line	NA	NA	NA	NA
Prelube	NA	NA	NA	NA

¹Located on can flange – refer to drawings

6. Base Plate:
 - a. The pump manufacturer shall supply the pump base plate as an integral part of the discharge head assembly.
 - b. The pump base plate shape: as shown on the drawings.
 - c. Base plate thickness: 1.5-inch minimum.
7. Sole Plate:
 - a. The pump manufacturer shall supply the pump sole plate for which the pump base plate shall rest upon.
 - b. Sole Plate Shape: Square
 - c. Sole plate thickness: 1.25-inch minimum for plates up to 36" square and 1.5-inch minimum for plates up to 54" square.
 - d. There shall be a gasket or o-ring installed between the base plate and sole plate, and between the sole plate and column assembly to ensure and provide a watertight seal.
 - e. Flatness: 0.15% of the nominal can diameter
 - f. Plumbness shall be specified in 46 00 00 – Equipment General Provisions

g. [Install, set to the most stringent of the following requirements for levelness, plumbness, flatness, coplanarity and coplanar surface deviation:

- 1) ASA-ANSI S2.75, Shaft Alignment Methodology.
- 2) Manufacturer's pre-printed written requirements.
- 3) Comply with Section 46 00 00 – Equipment General Provisions.
- 4) For can/barrel pump (VTP 6 or 7) with non-replaceable cans/barrels
Install, set to the following requirements for levelness, plumbness, flatness and coplanar surface deviation:

Levelness	Foot Flatness	Coplanar Surface Deviation
5 mils/ft	4 mils/ft	<= 2 mils

- 5) The Contractor shall be responsible for all costs associated with field machining installed barrel sole plates to meet stated tolerances for levelness, flatness, and coplanar surface deviation.

B. SHAFTS

1. Support the shafting by bearings at intervals so that the first natural frequency complies with Section 43 20 00 – Pumps – General. Calculate the shaft diameter using the formulas given in AWWA E103 for the pump shutoff head, and shaft elongation limitations of the pump bowl.
2. Shaft shall be provided in interchangeable sections not exceeding 5 feet in length and shall be butt fit.
3. For open lineshaft pumps, shafts shall be supported by no fewer than three bearings (not including stuffing box bushing). Lineshaft bearings shall be supported by bearing retainers of the material listed in this Specification Section's Paragraph "Pump Materials of Construction" and clamped between column pipe flanges for open lineshaft pumps.
4. Shaft couplings for shaft diameters 2 inches or larger shall be of the key and thrust-ring types or other nonthreaded design.
5. Shaft diameter and bearing spacing shall be designed to ensure that the entire pump operating speed range is at least 25% away from the shaft critical speeds.

6. Shaft elongation shall not cause the impeller to contact the bowl at any point along the rated pump curve when impeller is set to manufacturer recommended running clearance at design point.
7. The pump shaft shall be coupled to the motor shaft by a four piece adjustable spacer coupling that allows axial adjustment and removal of the complete seal assembly without disturbing the driver. An adjusting plate shall be part of the coupling.
8. Hollow shaft motors shall be provided with a shaft adjusting nut.
9. Total eccentricity between pump shaft and motor shaft (for solid shaft motors) and angular misalignment shall not exceed the values established in AWWA E103:
 - a. Butting faces shall be machined with center relief and square to the axis of the shaft. The maximum permissible error in the axial alignment of the thread axis with the axis of the shaft shall be 0.002 in. per 6 in.
 - b. Shaft diameter 3 inches or less: misalignment ≤ 0.0005 in./ft with a maximum runout of 0.005 in. in any one length of shafting for 10 ft and longer.
 - c. Shaft diameter greater than 3 inches: misalignment ≤ 0.001 in./ft with a maximum runout of 0.010 in. in any one length of shafting for 10 ft and longer.

C. Column Assembly:

1. The column assembly sections shall be connected as follows:
 - a. 14-inch diameter and smaller: flanged.
 - b. Greater than 14-inch diameter: flanged.
2. Column pipe section shall not exceed 5 feet for short set open-lineshaft pumps ; top and bottom sections shall not exceed 5 feet for open line-shaft pumps and 20 feet for enclosed-lineshaft pumps.
3. Pump manufacturer shall supply a coupling adaptor to connect the column piping to the discharge head and to the bowl assembly. The connection shall be made per the pump manufacturer's instructions.

D. BOWL ASSEMBLY

1. Each bowl assembly shall consist of the discharge bowl, impeller, impeller shafting, and a bearing above the impeller. A bearing below the first stage impeller shall be located in the suction case or bell.

2. Pump bowls shall be of the material listed under this Section's Paragraph "Pump Materials of Construction".
3. Bowls shall be sufficiently rigid to prevent adverse changes in bearing alignment and to maintain the running clearances of seal rings.
4. Bowls shall be flanged with male and female rabbets for joining to the suction bell and the discharge column.
5. Waterways and the diffusion vanes shall be smooth and free from nodules, bumps, and dips.
6. Provide the bowls with a renewable wear ring adjacent to the impeller, made of materials as indicated under this Section's Paragraph "Pump Materials of Construction".

E. SUCTION BELL

1. Vanes and bottom bearing hub: The suction bell shall have, as an integral part, vanes supporting a central hub in which the bottom bearing is carried below the impeller.
2. Suction bell diameter:
 - a. The outer suction bell entrance shall be at least the size of the maximum pump bowl dimension and as much larger as is practical.
 - b. Maximum entrance velocity shall not exceed 5 fps based on the outside diameter of the suction bell.
3. The contour between the outer edge and the impeller suction eye shall be smooth, continuous, and bell shaped.

F. IMPELLERS

1. Type: Enclosed.
2. Material: Material shall be as listed in this Section's Paragraph "Pump Materials of Construction", cast in one piece.
3. Impellers shall incorporate a close-fitting annular clearance with the case at the suction eye.
4. Impellers shall be equipped with replaceable wearing rings.
5. Impeller-shaft connection:

- a. Impellers shall be positively secured to the shaft in such a manner that they cannot become loose under any operating condition or under reverse rotation or torque.
 - b. For pumps having shaft diameters greater than 2 inches and all pumps with stainless steel impellers and shafts, impellers shall be keyed to the shaft and positively secured against axial movement.
6. Balance Grade: Dynamically balance impellers to the tolerances specified by ISO 1940-1, grade G-6.3.
7. Provide for adjustment of the axial position of the impellers at the pump shaft connection to the motor shaft to obtain proper clearance between bowls and impellers.

G. DISCHARGE HEAD, AND COLUMN FABRICATION

1. Welding shall conform to the following:
 - a. Welding procedures and performance qualifications shall be in accordance with AWWA Standards with written certification from the manufacturer.
 - b. The minimum number of passes for welded joints shall be as follows:

Schedule 43 24 10 - 05

Steel Cylinder Thickness (inch)	Minimum Number of Passes for Welds
Less than 0.1875	1
0.1875 through 0.25	2
Greater than 0.25	3

- c. Welds shall be full circumferential.
2. Beveled ends for butt welding shall conform to ANSI B16.25. Remove slag by chipping or grinding. Surfaces shall be clean of paint, oil, rust, scale, slag, and other material detrimental to welding.
3. Test the seams by the dye-penetrant method per ASTM E 165, Method B.
4. Welded stainless steel components shall be pickled and passivated following fabrication. All surfaces shall be free of heat tint, scale and slag. Manufacturer shall provide written certification that passivation has been completed prior to shipment of equipment.

H. FLOW CONDITIONING / VORTEX SUPPRESION BASKET

1. For all new pumps, a fabricated flow conditioning / vortex suppression basket shall be provided by the Manufacturer. The basket shall be of vaned design. The basket shall be installed directly onto the pump suction bell. Performance of the basket shall be the responsibility of the pump manufacturer. Fastening of the basket shall be per the pump manufacturer's recommendations. See 'Materials of Construction' Table for pumps requiring a vortex suppression basket.
2. Vortex suppression basket shall conform to ANSI/HI 9.8.A.6 and Figure A.13. Radial vane spacing and number of vanes shall be as follows:

Schedule 43 24 10 – 06

Suction Bell Diameter (inch)	Radial Vane Spacing (Degree)	Total Number of Vanes
13 – 16	18	20
16 – 20	15	24
20 – 24	12	30
24 – 32	10	36

2.06 VIBRATION

1. The maximum vibration level measured on the top of the discharge head for any speed and operating point within the Preferred Operating Region shall not exceed that shown in Figure 9.6.4.2.5.16 of the Hydraulic Institute Standards as measured on the installed pump during field testing.
2. The pump and motor assembly shall be designed so that structural, rotor lateral and torsional natural frequencies meet the requirements of 1.08 DYNAMIC ANALYSIS.
3. The CONTRACTOR shall coordinate pump installation requirements with the pump supplier to ensure a stable installation free of abnormal vibration.
4. The pump supplier shall have unit responsibility for coordinating and fabricating the proper pump mounting design for the layout shown on the drawings. If, in the opinion of the pump supplier, the openings or other aspects of the pump mounting design must be revised to allow for acceptable vibration and stable pump operation, the Contractor shall submit said revisions to the Engineer for review, comment and acceptance. The Contractor shall then be responsible for implementing such revisions at no additional cost.

B. PUMP CAN

1. Pump can shall be fabricated of the material listed in the Paragraph "Pump Materials of Construction" in this Section. Cans shall be designed for the maximum

suction pressure specified and the maximum pressure of bearing or seal water connected to the pump, if any. Cans shall also be designed to withstand full vacuum. The pressure design of the can shall meet ASME Code for Pressure Piping or Code for Unfired Pressure Vessels. The wall thickness of steel cans shall be standard weight, and 10S for stainless steel cans, respectively, and shall not be less than that of Schedule S or Schedule 10S pipe of equivalent diameter.

2. Provide a flange at the top of the pump can so the pump discharge head can be bolted onto the can. Pressure rating of the pump can top flange shall be the same as the suction flange. Flanges shall have an O-ring groove and an EPDM O-ring. Flange face shall be flat within 0.15% of the nominal can diameter after installation to allow a tight seal with the discharge head.
3. Can shall be equipped with straightening vanes in accordance with the Hydraulic Institute Standard ANSI/HI 9.8 for Pump Intake Design.

2.07 DISCHARGE HEAD, STRUCTURAL STEEL

- A. Comply with Section 43 20 00 – Pumps General.

2.08 DISSIMILAR METALS

- A. Comply with Section 43 20 00 – Pumps General.

2.09 GALVANIZING

- A. Where applicable, galvanizing shall be performed in accordance with Section 05 05 13 – Galvanizing.

2.10 STANDARDIZATION OF GREASE FITTINGS

- A. Grease Fittings: Comply with Section 46 00 00 – Equipment General Provisions.

2.11 APPURTENANCES

- A. Shaft Seals: Shaft sealing shall be accomplished by one of the following methods as identified in the schedule below.

1. PACKING WITH LANTERN RING

- a. The discharge head shall include a cast iron lineshaft stuffing box. Lineshaft stuffing box housing shall contain a bronze bearing, bypass water passage to the bearing terminating in a lantern ring or an annular port for relieving pressure on the stuffing box. The lantern ring shall be opposite a grease fitting for lubricating the packing. The bypass line shall contain a throttling valve for adjusting the leakage rate at the gland. The stuffing box shall be

equipped with a minimum of five (5) rings of packing. Packing shall be braided with synthetic non-asbestos fiber impregnated with PTFE. The top shaft shall be equipped with a renewable shaft sleeve of Type 316 stainless steel where it passes through the stuffing box.

- b. Packing gland shall be Type 316 Stainless Steel, split type secured using at least two stainless steel bolts.

2. Shaft Seal Schedule 43 24 10 – 06:

Shaft Seal Schedule 43 24 10 - 07

	GLWTF		POHWTF	
	GAC Feed	Backwash	GAC Feed	Backwash
Shaft Sealing Arrangement	Packing	Packing	Packing	Packing
Seal Flush Source / API Flush Plan	Product / Plan 13	Product / Plan 13	Product / Plan 13	Product / Plan 13
Seal Face Material	NA	NA	NA	NA
Metallic Components	316 SST	316 SST	316 SST	316 SST
Flexible Components	EPDM	EPDM	EPDM	EPDM
Seal Flush Rate (GPM)	NA	NA	NA	NA
Seal Flush Pressure (PSIG above pump discharge pressure)	NA	NA	NA	NA

- B. Pressure Gages: Provide pressure gages as indicated on the drawings and as specified under Section 43 20 00 – Pumps General.
- C. The motor for the pump shall be of the vertical hollow shaft fan cooled squirrel cage induction type in accordance with Section 26 05 60 – Low Voltage Electric Motors and/or Section 26 05 61 – Medium Voltage Electric Motors. The motor shall be designed to accept all downthrust and upthrust loads imposed by the pump during starting and running. The maximum speed and horsepower of each motor shall be as specified. The rated horsepower shall be such that the motors will not be overloaded nor the motor nameplate horsepower exceeded when the pumps are operated at any point on the pump performance curve.
- D. Motors shall be specifically designed for operation with variable frequency drive speed controls as specified in Section 26 05 60 – Low Voltage Electric Motors and Section 26 29 23 – Low Voltage Variable Frequency Motor Controllers.
- E. Motor Data

Electrical and Instrumentation Requirements

Schedule 43 24 10 - 08

	GLWTF		POHWTF	
Motor Data	GAC Feed	Backwash	GAC Feed	Backwash
Type	Direct Coupled – Vertical	Direct Coupled – Vertical	Direct Coupled – Vertical	Direct Coupled – Vertical
Voltage	460v	460v	460v	460v
Phase	3	3	3	3
Frequency	60 Hz	60 Hz	60 Hz	60 Hz
Max Horsepower	200	75	200	75
Maximum Nominal Speed, rpm	1,800	1,800	1,800	1,800
Minimum Reduced Speed	50%	50%	50%	50%
Enclosure Type	TEFC	TEFC	WP1	WP1
Insulation	Class H	Class H	Class H	Class H
Inverter Duty*	Yes	Yes	Yes	Yes
Service Factor	1.0	1.0	1.0	1.0
Motor Speed Control	Variable Frequency Drive	Variable Frequency Drive	Variable Frequency Drive	Variable Frequency Drive
Maximum Sound at 3 feet	85 dBA	85 dBA	85 dBA	85 dBA
Space Heater	Yes, 120 V, single phase	Yes, 120 V, single phase	Yes, 120 V, single phase	Yes, 120 V, single phase
Motor Winding Temperature Protection	RTDs	RTDs	RTDs	RTDs
Non-reverse ratchet	Yes	Yes	Yes	Yes
Shaft Grounding Rings	Yes	Yes	Yes	Yes
Insulated Bearings	Yes	Yes	Yes	Yes
Steady Bushing	Yes	Yes	Yes	Yes
Miscellaneous	See Note	See Note	See Note	See Note

NOTE: [Provide oversized Terminal Box..] [Provide breathers and drains for TEFC enclosures.] [Provide motor shaft brushes.]

* Manufacturer shall coordinate the settings of the variable frequency drive with the pump and motor to ensure proper operation. A written transmittal of the drive settings shall be sent to the Contractor prior to start-up of the equipment.

- F. Thrust bearings and guide bearings shall be anti-friction type and grease or oil lubricated. Thrust bearings for motors of 125 hp and larger and guide bearings for

motors of 250 hp and larger shall be oil lubricated. Bearings shall have a minimum ABMA L10 life of 100,000 hours. Water cooling of thrust bearings shall not be used.

- G. Non-reverse ratchet shall not engage above the minimum motor speed in Motor Data Table. The manufacturer shall certify that the proposed non-reverse ratchets are able to withstand reverse torques in excess of the maximum possible reverse torque in the application in order to ensure that the proposed non-reverse ratchets is/are able to withstand the worst case torques that have the potential to result.
- H. Non-reversing ratchet type: Ball type

2.12 SPECIAL TOOLS AND SPARE PARTS

- A. Comply with Section 43 20 00 – Pumps General.
- B. Spare parts shall be provided in accordance with Section 46 00 00 – Equipment General Provisions and shall include the following for each series of pumps.
- C. Provide the following spare parts for each pump:

Spare Parts Schedule 43 24 10 – 09

Component	Quantity
Impeller wear rings	1 set
Bowl wear rings	1 set
Bowl Bearings	2 sets
Shaft Bearings	2 sets
Shaft Coupling	1
Impellers	1 set
Gaskets and O-rings	2 sets
Packing Assemblies	2

2.13 EQUIPMENT IDENTIFICATION

- A. Comply with Section 43 20 00 – Pumps General.

PART 3 – EXECUTION

3.01 SHOP TESTING

- A. Factory testing shall be in accordance with Section 43 20 00 – Pumps General, and shall include:

Shop Testing Schedule 43 24 10 - 10

	GLWTF		POHWTF	
	GAC Feed	Backwash	GAC Feed	Backwash
Hydraulic Performance Testing	Yes	Yes	Yes	Yes
Witnessed Performance Testing	No	No	No	No
Certified Performance Curves ¹	Yes	Yes	Yes	Yes
Mechanical Test	Yes	No	Yes	No
String Test	No	No	No	No
NPSH Test	No	No	No	No
Hydrostatic Test	Yes	Yes	Yes	Yes
Casing Hardness Test	No	No	No	No

- B. Pump performance test acceptance grade shall be as scheduled in Part 1 of this specification as defined by HI Standards; however, required power shall not exceed motor horsepower rating at any point on the rated pump curve.

3.02 SHIPMENT, DELIVERY, HANDLING AND STORAGE

- A. Shipment, delivery and handling of equipment and materials shall be in accordance with Section 01 65 00 – Product Delivery Requirements.
- B. Storage of equipment shall be in accordance with Section 01 66 00 – Product Storage and Protection Requirements.

3.03 MANUFACTURER’S FIELD SERVICES

- A. The services of a qualified manufacturer's technical representative shall be provided in accordance with Section 43 20 00 – Pumps General. For each series of pumps, field services shall include the following Site Visits Schedule 43 23 18 – 07:

Site Visits Schedule 43 23 18 - 11

Service	Number of Trips	Number of Days/Trip
Installation and Testing	1	1
Startup and Training	1	1
Services after Startup	1	1

3.04 INSTALLATION

- A. Install pump in strict accordance with manufacturer's recommendations and Section 43 20 00 – Pumps General.
- B. Manufacturer's technical representative shall perform or supervise the following activities prior to starting each pump:
 - 1. Installation of mechanical seals
 - 2. Alignment of pump and motor shafts
 - 3. Impeller end clearance adjustment
- C. After installation and until substantial completion, all pump shafts shall be rotated weekly in the presence of the Engineer.

3.05 ALIGNMENT

- A. Comply with Section 43 20 00 – Pumps General.

3.06 FIELD TESTING

- A. Field testing shall be in accordance with Section 43 20 00 – Pumps General, and shall include the following Field Testing Schedule 43 23 18 - 08:

Field Testing Schedule 43 23 18 - 12

	GLWTF		POHWTF	
	GAC Feed	Backwash	GAC Feed	Backwash
Field Performance Testing	Yes	Yes	Yes	Yes
Vibration Testing	Yes	Yes	Yes	Yes
Natural Frequency "Bump" Test	Yes	Yes	Yes	Yes

- B. Field vibration and alignment tests shall be performed on all pumps. In addition, natural resonance testing shall be conducted on each pump assembly utilizing the standard "Bump Test" method. The Contractor shall procure the services of an independent predictive/preventive maintenance laboratory service to perform baseline vibration tests on the subject equipment. The testing laboratory shall be independent from the Contractor and Supplier. Testing shall be conducted at maximum, intermediate and minimum pump operating speeds for the assembled pumping units in place after installation. Vibration tests will be conducted in the presence of the Engineer in accordance with the procedures outlined in the applicable standards of the Hydraulic Institute and maximum vibration shall be within the limits set forth therein. In the event vibration exceeds the specified limits, the pump manufacturer shall make all required

balancing and frame adjustments to bring the equipment within the Hydraulic Institute limits and re-perform the baseline vibration testing until the system complies prior to acceptance of any pumping equipment. The results of the final baseline analysis will be delivered to the OWNER.

- C. Noise measurements shall be taken in the field and shall comply with Hydraulic Institute Standards and as specified herein.
- D. After the pump manufacturer's representative has determined the pump installation is correct and the pumps are ready for continuous use, Contractor shall test operate the pumps under actual operating conditions for the next twenty-one days.

3.07 FAILURE OF EQUIPMENT TO PERFORM

- A. Comply with Section 46 00 00 – Equipment General Provisions.

3.08 PAINTING

- A. Comply with Section 46 00 00 – Equipment General Provisions.
- B. Comply with Section 09 90 00 – Painting.
- C. Mating surfaces of mounting flanges and sole plates shall not be coated.
- D. Bowl Assembly:
 - 1. Internal Lining of Cast or Ductile Iron Bowls: vitreous enamel or fusion bonded epoxy, 12 mils (minimum total thickness)
 - 2. Externally Coating: Fusion bonded epoxy, 12 mils (minimum total thickness).
 - 3. All fusion bonded epoxy shall be heat-cured.
- E. Typical Coating System:
 - 1. Ferrous surfaces including interior and exterior, wetted and non-wetted surfaces of cans, column assembly, base plate, discharge head, [and] sole plate, [and enclosing tube] shall be coated in accordance Section 09 90 00 – Painting. [The coatings shall be listed by ANSI/NSF International to be in compliance with NSF 61.
- F. Specialized Coating System:
 - 1. Comply with typical coating system except as described hereafter:
 - 2. Column Assembly: Interior and exterior of the column pipe shall be fusion epoxy coated with Scotchkote 134, or approved equal.

3. Base Plate and Discharge Head: Provide fusion epoxy coating
4. Sole Plate: Hot-dip galvanized coating.

END OF SECTION

SECTION 43 25 13.10
SUBMERSIBLE SOLIDS-HANDLING PUMPS (WET PIT)

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. The Contractor shall furnish, install, and place into satisfactory operation submersible solids-handling pumps at the locations shown on the Drawings and as specified herein. All pumps specified herein shall be supplied by the same manufacturer.
- B. Equipment shall be provided in accordance with the requirements of Section 43 20 00 – Pumps General.
- C. The pump and all related equipment shall be designed for the wastewater applications specified herein and shall be suitable for continuous or intermittent operation. The pump shall be bottom/end suction, side discharge construction and shall be supplied with a foot mounted discharge connection elbow and integral sliding rail removal system of the pump manufacturer's design matched to the pumps being supplied.
- D. Orientation of Installation: Vertical.

1.02 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

- A. Comply with Section 43 20 00 – Pumps General

1.03 ACTION/INFORMATIONAL SUBMITTALS

- A. Product Data: Comply with Section 01 33 00 – Submittal Procedures.
- B. Provide submittals identified in Section 46 00 00 – Equipment General Provisions in addition to the submittals identified herein and in addition to the submittals identified in other referenced specification sections.
- C. Provide submittals identified in Section 43 20 00 – Pumps General.

1.04 CLOSEOUT SUBMITTALS

- A. Submit warranty documentation in compliance with:
 - 1. Section 01 33 00 – Submittal Procedures
 - 2. Section 01 61 00 - Product Requirements and Options

- B. Operation and Maintenance (O&M) manuals shall be submitted in accordance with Section 01 33 00 – Submittal Procedures and Section 01 78 23 – Operation and Maintenance Data.
- C. Comply with Section 43 20 00 – Pumps General.

1.05 MAINTENANCE MATERIALS SUBMITTALS

- A. Operation and Maintenance (O&M) manuals shall be submitted in accordance with:
 - 1. Section 01 33 00 – Submittal Procedures
 - 2. Section 01 78 23 Operation and Maintenance Data
- B. Comply with Section 01 78 43 – Spare Parts and Extra Materials.
- C. Comply with Section 01 79 00 – Instructions to Owner's Personnel.
- D. Comply with Section 46 00 00 – Equipment General.
- E. Comply with Section 43 20 00 – Pumps General.

1.06 QUALITY ASSURANCE SUBMITTALS

- A. Comply with Section 43 20 00 – Pumps General.
- B. Comply with Section 01 75 00 – Check Out and Start Up Procedures.

1.07 GENERAL INFORMATION AND DESCRIPTION

- A. Comply with Section 46 00 00 – Equipment – General Provisions.

1.08 DYNAMIC ANALYSIS (NOT USED)

1.09 WARRANTY

- A. Warranty requirements shall be as specified in Section 01 61 00 – Product Requirements and Options. Warranty requirements are supplementary to the individual equipment specifications.
- B. Comply with the Equipment Warranties requirements specified in Section 46 00 00 – Equipment General Provisions.

1.10 OPERATING CONDITIONS AND PERFORMANCE REQUIREMENTS

Submersible Pump Performance Criteria Schedule – 43 25 13 - 02

	POHWTF Drain Pumps No. 1-2
Number of Units	2
Pump Identification Numbers	P-93101 P-93102
Pump Shutoff Head (Allowable Range) (ft)	40 - 60
Rating Point (at Full Speed)	
Flow (gpm)	200
Total Head (ft)	36
Minimum Pump Efficiency (%)	50%
NPSH Required shall not exceed (ft)	14
Maximum Flow Operating Point (at Full Speed)	
Flow (gpm)	300
Total Head Range (ft)	26 - 32
NPSH Required shall not exceed (ft)	15
Operating Point shall be within (AOR/POR)	POR
Minimum Flow Operating Point (at Full Speed)	
Flow (gpm)	100
Total Head Range (ft)	35 - 50
Operating Point shall be within (AOR/POR)	AOR
Maximum Brake Horsepower for all operating points	5.0
Maximum Pump Operating Speed (rpm)	1,780
Fluid Pumped	Water
Fluid Temperature (degrees F)	Ambient
Fluid Specific Gravity	1.0
Fluid Percent Solids (%)	<0.5%
Fluid pH range	6 - 9
Minimum Solids Passing Size (in)	2
Minimum Discharge Diameter (in)	3

	POHWTF Drain Pumps No. 1-2
Drive configuration	Close Coupled
Minimum ABMA L-10 bearing life along the full length of the operating curve (hours)	50,000
Factory test acceptance	In accordance with HI 14.6.3.4.1
Rated Starts Per Hour, Minimum	10
Area Classification	Unclassified

PART 2 – PRODUCTS

2.01 GENERAL

- A. Comply with Section 43 20 00 – Pumps General, except where superseded in this specification section.
- B. Pump Type: Non-clog, wet pit submersible, centrifugal pump.

2.02 ACCEPTABLE MANUFACTURERS

- A. Pump Manufacturer:
 - 1. Pentair/Fairbanks
 - 2. Xylem/Flygt
 - 3. KSB
- B. All equipment for the pumps, including motors and bases, shall be provided as a complete unit by the pump manufacturer.

2.03 ANCHORS AND SUPPORTS

- A. Comply with the following Specification Sections:
 - 1. Section 05 05 23 – Metal Fastening
 - 2. Section 46 00 00 – Equipment General Provisions
 - 3. Comply with individual pump specifications.
- B. Comply with Section 43 20 00 – Pumps General

2.04 MATERIALS OF CONSTRUCTION

Materials of Construction Schedule – 43 25 13 - 03

Component	POHWTF Drain Pumps No. 1-2
Casing	Cast Iron, ASTM A48, CL30-40 or Ductile Iron A536
Suction Cover	Cast Iron, ASTM A48, CL30-40 or Ductile Iron A536
Seal Chamber	Cast Iron, ASTM A48, CL30-40 or Ductile Iron A536
Bearing Housing	Cast Iron, ASTM A48, CL30-40 or Ductile Iron A536
Shaft	AISI 329 SS or 400 Series SS
Impeller	Gray Cast Iron, ASTM A48, CL30-40 or Ductile Iron A536 or Cast Stainless Steel CF8M or ASTM A-532 Alloy IIIA 25% Chrome Cast Iron
Impeller Wear Ring	Stainless Steel 400 Series, BHN 300-350
Casing Wear Ring	Stainless Steel 400 Series, BHN 400-450
Fasteners	AISI Type 316L SS
O-Rings	Nitrile or Viton
Control Panel	316 SS or FRP
Control Panel Rating	NEMA 4X
Foot mounted discharge connection elbow	Cast Iron conforming to ASTM A48 Class 30 or 35
Guide Bars and Brackets	316L Stainless Steel

2.05 COMPONENTS

A. Impeller

1. Impeller Type: One-piece, single-suction, enclosed or semi-open, non-clogging, multiple-vane, solids-handling, mixed flow type.
2. Impeller Construction:
 - a. Solids Passage:
 - 1) Shall be designed with smooth flow passages to pass a spherical solid of the specified size and to prevent clogging by stringy materials.

- 2) Impeller shall handle: solids of the specified sphere size, fibrous materials, heavy sludge, and other matter found in normal wastewater applications.
- b. The impeller shall be bolted, keyed and locked to the pump shaft at the factory. Adhesive or friction type fits are not acceptable.
- c. Impeller shall be coated with the same system applied to the interior of the casing as applicable.
- d. Impeller Balancing: Dynamically balanced.

B. Casing/Volute

- 1. Casing/Volute Type:
 - a. End suction, side discharge construction.
- 2. Casing/Volute Construction:
 - a. The volute shall be single piece, non-concentric design.
 - b. Shall be designed with a pullout assembly so that the impeller can be withdrawn
 - c. Casing shall be equipped with removable suction cover which can be removed for access to the impeller.
 - d. All non-stainless steel metal surfaces coming in contact with the pumped media shall be protected by a factory applied spray coating.
- 3. Mounting:
 - a. Side discharge shall be equipped with foot mounted discharge connection elbow and integral sliding rail system.
- 4. Solids Passage:
 - a. Passages shall have smooth unobstructed passages for solids. Volute shall have smooth fluid passages large enough at all points to pass any size solids which can pass through the impeller.
 - b. Passage Size: Large enough to pass a spherical solid of the specified size.
 - c. Cleanouts (as applicable):

- 1) Pump volute shall be provided with a cleanout port to allow for removal of any foreign material blocking or impeding performance of the pump.
 - 2) Provide cleanout handhole near cutwater.
 - 3) Cleanout cover shall be removable.
 - 4) The inner contours of the handhole cover shall match the contours of the casing in which it fits.
- d. Flanges: Integrally cast ANSI Standard flat faced flange with 125-lb drilling.
5. Lifting: Casing/Volute shall be provided with lifting bolts and eye lugs for installation and maintenance of the pumps.

C. Wearing Rings (as applicable):

1. Shall be provided on casing and impeller.
2. Wearing rings and fasteners shall be galvanically compatible with casing and impeller materials and resistant to corrosion and erosion by the pumped fluid.
3. Impeller wearing ring shall be approximately 50 Brinell softer than casing wearing ring.
4. A wear ring system shall provide efficient sealing between the volute and impeller.
5. Rings shall be drive fitted to the volute inlet and heat-shrink fitted to the impeller.

D. Shaft

1. Diameter: Shall be sufficiently large in diameter to safely transmit the maximum torque developed by the drive unit and of such design as to provide a rigid support for the impeller and to prevent excessive vibration.
2. Construction: The shaft shall be heat treated, turned, ground, and polished over its entire length and shall be provided with keyways on both ends.

E. Bearing Housing & Bearings

1. Type: Permanently lubricated, radial and thrust bearing anti-friction ball or tapered roller.
2. ABMA L-10 Bearing Life: Comply with scheduled herein.
3. Quantity: Two (2) per pump.

4. Construction:

- a. Bearing housing shall fully enclose the bearings to prevent entrance of contaminants and shall be designed to provide for axial adjustment of rotating assembly.
- b. Bearing housing shall be designed with a machined self-centering fit with the housing.
- c. Bearing Lubrication: Bearings shall be permanently lubricated.
- d. Comply with Section 46 00 00 – Equipment General Provisions.

F. Sealing of Mating Surfaces:

1. All mating surfaces where watertight sealing is required shall be machined and fitted with O-rings.
2. Fitting shall be such that sealing is accomplished by metal-to-metal contact between machined surfaces. This will result in controlled compression of the O-rings without the requirement of a specific torque limit.
3. Secondary sealing compounds, rectangular gaskets, elliptical O-rings, grease or other devices shall not be acceptable.

G. Lifting System and Discharge Connection:

1. For wet pit installations, provide permanently installed slide rail mounting systems for each pump as shown on the drawings and as specified herein.
2. Slide rail system shall facilitate pump removal from the wet pit for inspection or service without entering the pit or disconnecting piping.
3. The pump shall be provided with a foot mounted discharge connection elbow permanently installed in the wet well along with the discharge piping.
4. The discharge connection elbow shall be constructed with a 125 lb. ANSI standard flat faced flange.
5. The pump shall be automatically connected to the discharge connection elbow when lowered into place and shall be easily removed for inspection or service. Sealing of the pumping unit to the discharge connection elbow shall be accomplished by a simple downward motion of the pump.
6. A sliding guide bracket shall be an integral part of the pump unit. The entire weight of the pump unit shall be guided by the guide bar(s) and pressed tightly against the discharge connection elbow to provide positive sealing under all conditions.

7. The entire sliding rail system shall be designed to safely withstand all stresses imposed thereon by vibration, torque, shock and all possible direct and eccentric loads. No portion of the pump shall bear directly on the floor of the sump.
8. Lower guide bar holders shall be integral with the discharge connection. Guide bars shall be of a conservative size adequate for the intended use. The guide bars shall not support any portion of the weight of the pump.
9. All anchor bolts, lifting bolts, eye lugs and lifting cable, etc. necessary for a complete installation and maintenance of the pump shall be constructed of the scheduled material and shall be adequately designed for its intended use.
10. All metal to metal interfaces where movement might occur shall be non-sparking in classified areas as indicated in the Sump Pump Schedule.

2.06 STRUCTURAL STEEL

- A. Comply with Section 43 20 00 – Pumps General.

2.07 DISSIMILAR METALS

- A. Comply with Section 43 20 00 – Pumps General.

2.08 GALVANIZING

- A. Where applicable, galvanizing shall be performed in accordance with Section 05 05 13 – Galvanizing.

2.09 APPURTENANCES

- A. Shaft Seals: Shaft sealing shall be accomplished by one of the methods schedule below.
 1. Seal Chamber:
 - a. Mechanical seals shall run in a lubricant-filled chamber to provide constant lubrication.
 - b. The lubricant chamber shall be designed to prevent overfilling and to provide lubricant expansion capacity.
 - c. The drain and inspection plug, with positive anti-leak seal shall be easily accessible from the outside.
 - d. The seal system shall not rely upon the pumped media for lubrication.
 2. Seal Lubricant:

- a. Seal lubricant shall be:
 - 1) Food grade or ANSI/NSF H1 certified for use in potable water systems.
3. Shaft seal – pump side:
 - a. The lower, primary seal unit, located between the pump and the lubricant chamber shall contain one stationary and one positively driven rotating, industrial duty, corrosion resistant, seal rings.
 - b. The lower seal shall be independent of the impeller hub.
4. Shaft seal – motor side:
 - a. The upper, secondary seal unit, located between the lubricant chamber and the motor housing, chamber shall contain one stationary and one positively driven rotating, industrial duty, corrosion resistant, seal rings.
5. Configuration:
 - a. Each seal interface shall be held in contact by its own spring system.
 - b. The seals shall require neither maintenance nor adjustment and shall be capable of operating in either clockwise or counter-clockwise direction of rotation without damage or loss of seal.
 - c. No external source of seal cooling or lubrication water shall be required.
6. The following seal types shall not be considered acceptable nor considered to be equal to the dual independent seal specified:
 - a. Shaft seals without positively driven rotating members, or conventional double mechanical seals containing either a common single or double spring acting between the upper and lower seal faces.
 - b. No system requiring a pressure differential to offset pressure and to effect sealing shall be used.

B. Shaft Seal Schedule

Shaft Seal Schedule – 43 25 13 - 04

	POHWTF Drain Pumps No. 1-2
Shaft Sealing Arrangement	Dual Mechanical Seal
Seal Flush Source / API Flush Plan	None

	POHWTF Drain Pumps No. 1-2
Lower Seal Unit – Seal Face Material	Tungsten carbide and/or silicon carbide
Upper Seal Unit - Seal Face Material	Carbon, tungsten carbide, and/or silicon carbide
Metallic Components	18-8 SS, 316 SST, or 400 Series SST
Flexible Components	EPDM or BUNA N

- C. Pressure Gauges: Provide pressure gauges as indicated on the drawings and as specified under Section 43 20 00 – Pumps General.
- D. Gauge taps shall be provided on the discharge piping of the vertical submersible pumps in a location as directed by the Engineer. Gauge taps shall be threaded corporation stops, conforming to the requirements of Section 40 05 00 – Basic Mechanical Requirements. Gauges shall be as specified in Section 40 73 13 – Pressure and Differential Pressure Gauges.
- E. All anchor bolts, lifting bolts, eye lugs, etc. necessary for complete installation and maintenance of the pump shall be furnished by Supplier and constructed of Type 316 stainless steel and shall be adequately designed for its intended use.

2.10 ELECTRICAL AND CONTROL REQUIREMENTS

- A. Comply with Specification Section 43 20 00 – Pumps General.
- B. Electrical and Instrumentation Requirements and Pump and Motor Monitoring and Protection Instrumentation:

Schedule – 43 25 13 - 05

	POHWTF Drain Pumps No. 1-2
Motors	
Type	Close Coupled
Rating	460V, 3 ph, 60 Hz
Horsepower	5.0
Maximum Speed, rpm (Nominal)	1,800
Enclosure	Submersible

	POHWTF Drain Pumps No. 1-2
Insulation	Class F
Inverter Duty	No
Service Factor	1.15
Bearing Thermal Protection	None
Motor Speed Control	Constant
Maximum Sound at 3 feet, dBA	80
Motor Winding Temperature Protection	Temperature Switches
Motor Differential Current Transformers / Six-Lead External Wye Connection	No
Motor Bearing RTDs	No
Motor Bearing Vibration	No
Pump Instrumentation	
Pump Bearing RTDs	No
Pump Bearing Vibration	No
Moisture Sensor / Leak Detection	Yes
Packaged Control Panel	Yes
Packaged Control Panel Starter Size, minimum	NEMA 1
Starter Type	FVNR
Cooling Jacket	No
Rated Starts Per Hour, Minimum	10

1. Leak Detection Sensor: Where a leak detection sensor is required, the pump manufacturer shall provide a leak detection relay compatible with the sensor.
2. Seal leakage and overtemperature relay manufacturer:
 - a. Mini-CAS by Flygt
 - b. PumpSafe by KSB
 - c. CA462 by Sulzer/ABS

- d. Macromatic
- e. Primex

C. Submersible Motors:

1. All electrical appurtenances shall be rated for installation in classified areas as indicated in the Sump Pump Schedule.
2. Motors shall conform to all applicable parts of Section 26 05 60 – Low Voltage Electric Motors. The pump motor shall be designed for operation with the voltage, frequency and phase electrical characteristics scheduled herein. See schedule for motor horsepower. Motors shall be mounted on each pump and shall conform to the latest applicable NEMA, IEEE, and ANSI standards for submersible service. The motors shall be rated for continuous duty with a minimum service factor as required by schedules herein.
 - a. Type: Squirrel-cage induction, housed in a watertight chamber.
 - b. The stator winding and stator leads shall be moisture resistant.
 - c. Motor Insulation: Motor insulation shall be as scheduled herein.
 - d. The use of bolts, pins, or other fastening devices requiring penetration of the stator housing shall not be allowed.
 - e. Starts Per Hour: The motor shall be guaranteed for continuous unsubmerged duty, capable of sustaining a minimum scheduled starts per hour without overheating.
 - f. Motor Bearings: The motor shall be provided with pre-lubricated radial and thrust bearings which are designed to carry the entire load which may be imposed upon it under all operating conditions.
 - g. All motors shall be housed in enclosures specifically designed for submersible pump application.
3. Cable Entry Water Seal:
 - a. The cable entry water seal design shall insure a watertight and submersible seal without specific torque requirements.
 - b. The cable entry shall be comprised of a single cylindrical elastomer grommet, flanked by stainless steel washers all having a close tolerance fit against the cable outside diameter and the entry inside diameter and compressed by the entry body containing a strain relief function, separate

from the function of sealing the cable. The assembly shall bear against a shoulder in the pump top. The cable entry junction chamber and motor shall be separated by a stator lead sealing gland or terminal board, which shall isolate gaining access through the pump top. The junction chamber containing the terminal board shall be sealed from the motor by an elastomer compression seal O-ring. Connection between the cable conductors and stator leads shall be made with threaded compressed type binding post permanently affixed to the terminal board and thus perfectly leak proof. Each pump shall be equipped with separate terminal board that totally isolates the incoming power supply from the pump motor.

- c. An acceptable alternate cable entry seal shall include cable leads shall enter at the top of the motor and shall allow the cable-to-motor connection to be accomplished in the field without soldering. All power and control lead wires shall be double sealed as they enter the motor in such a manner that cable-wicking will not occur. This sealing system shall consist of a rubber grommet followed by epoxy that is high in adhesive qualities and has a low coefficient of expansion. Each conductor shall have a small section of insulation removed to establish a window area of bare wire and each wire shall be untwisted and surrounded by epoxy potting material. A cable strain relief mechanism shall be an integral part of the sealing system. The cable sealing system shall be capable of withstanding an external pressure test of 1,200 psi as well as a cable assembly pull test as required by Underwriters Laboratories. Power and control leads shall be terminated on a sealed terminal board. The terminal board and its bronze lugs shall be O-ring sealed.

D. Pump Cords:

- 1. Cord Length:
 - a. Power and control cables between the pumps and the control panel shall be provided by the pump manufacturer who shall be responsible for reviewing the drawings as necessary to determine the required cable length.
 - b. All pumps for the same application shall be provided with the same length of cable.
 - c. No splices shall be allowed unless specifically called for in the electrical drawings.
- 2. Pump Cord Materials: PVC or oil resistant chloroprene rubber jacketed type SPC cable suitable for submersible pump applications.
- 3. Sizing:

- a. In Accordance with NEC and ICEA standards.
 - b. Cords shall meet with MSHA approval.
4. Stainless steel strain relief connectors shall be furnished for all cables.

E. Level Elements:

1. Four (4) Float switches shall be provided with the pump controls.
2. Float switches shall comply with requirements specified under Division 40 – Control and Information Systems and Division 26 – Electrical.
3. Float switches shall be set and shall operate according to the sump pump schematic and installation details shown on the Drawings and as specified herein with the following initial settings:

Level Setpoint	Water Elevation*
All Pumps Off	78.00
Lead Pump On	83.00
Lag Pump On	87.00
High-High Water Alarm	89.00 (alarm re-transmitted to OWS)

*Water elevations given are initial settings and shall be coordinated with the requirements of the equipment supplied and the depth of the wet well.

2.11 VENDOR CONTROL PANEL

- A. Panel Materials of Construction: Motor starters and controls shall be provided as required in the materials of construction scheduled herein.
- B. Panel NEMA Rating:
 1. NEMA rating of panel and appurtenances shall be as indicated in the Schedule.
 2. The control panels shall be assembled using NEMA rated components. Components designed and built to International Electrotechnical Commission (IEC) standards are not recognized. Equipment designed, manufactured and labeled in compliance with IEC standards is not acceptable.
- C. The control panel shall include, but not be limited to, the following:
 1. Disconnect: A single fused or circuit breaker type lockable disconnect switch operable from outside the control panel.
 2. Starter:

- a. A motor circuit protector and magnetic starter of the scheduled type shall be provided for each pump.
 - b. Starter Size: The motor starter of the minimum NEMA sizing scheduled herein shall be provided for each pump.
 - c. Starter Type: The type of starter provided shall be as scheduled herein this specification section and/or shown on the Drawings.
 - d. Starter Location: Motor starters and controls for each pump installation shall be provided in a control panel.
3. Control Power: Control power shall be 120 VAC from an integral, fused control power transformer.
4. Panel Face Mounted Control Features:
- a. HAND-OFF-AUTO (H-O-A) selector switch (each pump)
 - b. Pump START pushbutton (each pump)
 - c. Pump STOP pushbutton (each pump)
 - d. Reset pushbutton (each pump)
 - e. Dry contacts for RUN indication (each pump)
 - f. Dry contacts for FAIL indication (each pump)
 - g. Dry contacts for AUTO indication (each pump)
 - h. Dry contact for "ALL PUMPS OFF" level from float switch
 - i. Dry contact for "LEAD ON" level from float switch
 - j. Dry contact for "LAG ON" level from float switch
 - k. Dry contact for "HIGH-HIGH" (LSHH) level from float switch
 - l. Alarm horn and strobe light (high level audible and visual alarm)
 - m. Alarm silence pushbutton
 - n. Alarm/indicating lights:
 - 1) "Power On"

- 2) "Pump Running" (each pump)
 - 3) "Seal Failure (Moisture Intrusion)" (each pump)
 - 4) "Motor Winding High Temperature" (each pump)
- o. The panel shall also include an Elapsed Time Meter.
 - p. Seal failure and motor over temperature alarms shall seal-in and stop the associated pump.
 - q. Functional Description Summary:
 - 1) When the H-O-A selector switch is in the HAND position, the pumps shall operate according to the START and STOP pushbuttons. When the H-O-A selector switch is in the OFF position, the pumps shall not operate. When the H-O-A selector switch is in the AUTO position, the pumps shall be controlled by the level switches as specified herein.
 - 2) The sequencing order of the pumps (lead/lag) shall be automatically alternated to equalize runtimes.
 - 3) Pumps shall cease operation in either the HAND or AUTO position on any of the following operating conditions as a minimum: (1) motor high temperature alarm; (2) motor moisture detection alarm.
 - a) Motor monitoring relay alarms shall be relayed to SCADA via common FAIL alarm.
 - 4) The ALL PUMPS OFF level switch shall shut both pumps off.
 - 5) If a HIGH-HIGH level is reached in the pump station wet well, an alarm shall be activated at the Vendor Control Panel. The ALARM horn shall be sounded, and the ALARM light actuated. The ALARM horn shall sound until the ALARM horn silence pushbutton is actuated. The ALARM light shall remain illuminated unless all FAIL conditions are cleared.
 - a) The HIGH-HIGH Level alarm signal shall be re-transmitted to the Plant PLC.
 - 6) Comply with Specification Section 40 61 96 – Process Control Descriptions.

2.12 SPARE PARTS

- A. Spare parts shall be provided in accordance with Section 46 00 00 – Equipment General Provisions and shall include the following for each series of pumps.

Spare Parts Schedule – 42 25 13 - 06

	Quantity
Component	POHWTF Drain Pumps No. 1-2
Set of lower and upper wearing rings	1
Set of motor and pump bearings	1
Complete mechanical shaft seal assembly (upper and lower)	1
Sets of gaskets and O ring seals	2

2.13 EQUIPMENT IDENTIFICATION

- A. Comply with Section 43 20 00 – Pumps General.

PART 3 – EXECUTION

3.01 SHOP TESTING

- A. Factory testing shall be in accordance with Section 43 20 00 – Pumps General, and shall include:

Shop Testing Schedule – 43 25 13 - 07

	POHWTF Drain Pumps No. 1-2
Hydraulic Performance Testing	Yes
Witnessed Performance Testing	No
Certified Performance Curves	Yes
Vibration Testing	No
Mechanical Test	No

	POHWTF Drain Pumps No. 1-2
String Test	No
NPSH Test	No
Hydrostatic Test	Yes
Casing Hardness Test	No

1. Impeller, motor rating and electrical connections shall be checked.
2. Shop testing shall be in accordance with current applicable Hydraulic Institute Standards.

3.02 SHIPMENT, DELIVERY, HANDLING AND STORAGE

- A. Shipment, delivery and handling of equipment and materials shall be in accordance with Section 01 65 00 – Product Delivery Requirements.
- B. Storage of equipment shall be in accordance with Section 01 66 00 – Product Storage and Protection Requirements.

3.03 MANUFACTURER’S FIELD SERVICES

- A. The services of a qualified manufacturer's technical representative shall be provided in accordance with Section 43 20 00 – Pumps General. For each series of pumps, field services shall include the following site visits:

Site Visits Schedule 43 25 13 - 08

Service	Number of Trips	Number of Days/Trip
Installation and Testing	1	1
Startup and Training	1	1

3.04 INSTALLATION

- A. Install pump in strict accordance with manufacturer’s recommendations and Section 43 20 00 – Pumps General.

3.05 ALIGNMENT (NOT USED)

3.06 FIELD TESTING

- A. Field testing shall be in accordance with Section 43 20 00 – Pumps General, and shall include:

Field Testing Schedule 43 25 13 - 09

	POHWTF Drain Pumps No. 1-2
Field Performance Testing	Yes
Vibration Testing	No
Natural Frequency “Bump” (Impact) Test	No

3.07 FAILURE OF EQUIPMENT TO PERFORM

- A. Comply with Section 46 00 00 – Equipment General Provisions.

3.08 PAINTING

- A. Comply with Section 46 00 00 – Equipment General Provisions.
- B. Comply with Section 09 90 00 – Painting.

END OF SECTION

SECTION 43 31 13.13
GAC ADSORPTION SYSTEM MEDIA

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. This specification covers Granular Activated Carbon (GAC) for use as an adsorption media of per- and polyfluorinated contaminants in drinking water applications.
- B. The Supplier shall provide all labor, material, and equipment required to furnish, install, and place into satisfactory operation the GAC media in gravity contactors as shown on the Drawings and as specified herein.
- C. **The GAC media for this project shall be pre-selected with a bid allowance included in the Contract Documents. The basis of award shall be the best value to the Owner over the duration of the media supply contract, which shall extend for a duration of 36 months from the initial media installation.**
- D. **Unit bid prices provided by the Supplier shall be inclusive of all materials and services (storage, handling, delivery, installation, removal, and reactivation as applicable), including the required analytical costs associated with sample analyses defined herein.**
- E. The pre-selected GAC media Supplier shall be responsible for the following:
 - 1. Deliver virgin GAC media to the newly constructed GAC Facilities and install it within each contactor.
 - 2. Remove spent media and transport it for custom reactivation or ultimate disposal.
 - 3. For resupply, furnish virgin (BASE BID) or custom reactivated GAC media (ALTERNATE BID) and install the media as specified herein.
- F. **The Contractor will be responsible for operation of the newly constructed GAC Facilities during installation of the virgin media and prior to system commissioning. The Owner will be responsible for operation of the GAC Facilities during subsequent media changeout activities.**
- G. The GAC contactors are dimensioned with the resulting volume of GAC media as specified herein. The listed depth of media represents the final condition after installation, backwashing, and any scraping to remove fines. Excess media shall be installed to allow for scraping and for voidage changes.

- H. Any material used in the treatment of Public Water Supplies shall meet and demonstrate conformance to all requirements for potable water usage as established by the North Carolina Department of Environmental Quality. All such products must conform to the requirements of the Safe Drinking Water Act and American National Standards Institute/National Sanitation Foundation (ANSI/NSF) Standard 61.

1.02 REFERENCES

- A. ANSI – American National Standards Institute
- B. NIOSH – National Institute for Occupational Safety and Health
- C. AWWA – American Water Works Association Standards
 - 1. B100 – Granular Filter Material
 - 2. B604 – Granular Activated Carbon
 - 3. B605 - Reactivation of Granular Activated Carbon
- D. NSF – Standard 61 – Requirements for GAC Media
- E. ASTM – American Society for Testing and Materials
 - 1. D2854 – Standard Test Method for Apparent Density of Activated Carbon
 - 2. D2862 – Standard Test Method for Particle Size Distribution of Granular Activated Carbon
 - 3. D2867 – Standard Test Methods for Moisture in Activated Carbon
 - 4. D4607 – Standard Test Method for Determination of Iodine Number of Activated Carbon
 - 5. D6781 – Standard Guide for Carbon Reactivation
- F. ISO - International Organization for Standardization
 - 1. ISO 9277 - Determination of the specific surface area of solids by gas adsorption — BET method
- G. All media shall be installed in accordance with the Supplier's instructions and recommendations.

1.03 SUBMITTALS

- A. The following items shall be submitted with the Supplier's proposal:

1. Supplier's name, carbon manufacturing location and address, capacity of the manufacturing facility, source of coal, agglomeration/thermal process, and product name and numbers shall be submitted.
2. Supplier's standard product data, including Material Safety Data Sheet (MSDS).
3. Media specifications, including gradation analysis, source of materials, details on the reagglomeration/thermal process, and installation instructions.
4. Data on clean bed, forward-flow headloss and expansion during backwash as a function of flow rate and at three different temperatures (e.g., 5°C, 15°C, and 25°C).
 - a. Media expansion data shall be expressed as a percentage of bed depth versus backwash flow rate (gpm per square foot of contactor surface area).
5. Documentation of ANSI/NSF 61 certification for the furnished media from an ANSI-approved certifying organization.
6. Notarized affidavit of compliance for the media stating GAC furnished complies with this Section as well as the applicable provisions of the latest revision of AWWA Standard B604 or B605, as applicable.
7. Valid ISO 9001:2015 certification for the plant of manufacture of the GAC media.
8. Certification that the Supplier will be onsite within 30 calendar days of order placement by the Owner, for removal of spent GAC media and subsequent and immediate delivery of GAC media inclusive of installation services as specified herein.
9. Municipal references
 - a. BASE BID: The Supplier of the virgin GAC media specified herein shall demonstrate a history of supplying ANSI/NSF 61 certified virgin GAC media for installation at municipal drinking water systems in North America. The Supplier shall provide a minimum of three (3) references from municipal drinking water systems for installations of similar size and use.
 - b. ALTERNATE BID: The Supplier of the custom reactivated GAC media shall demonstrate a minimum of five (5) years of reactivation experience and five (5) years of supplying GAC to municipal drinking water systems in North America. The material submitted under this bid item will be an ANSI/NSF 61 certified potable custom reactivated GAC.

10. Information on the US BLS Producer Price Index/Indices and proposed methodology that will be used to support future price adjustments. Price adjustments are subject to the following stipulations:
 - a. Price adjustments will occur no more frequently than annually. Annual increases are limited to a maximum of 10% and annual decreases are limited to a maximum of 3%. No amounts in excess of these limits (either increases or decreases) shall be carried over to subsequent years. Regardless of any annual fee adjustment calculation, unit prices will at no time be reduced below the initial bid prices as defined herein.

B. The following items shall be submitted during the shop drawing submittal review phase of the GAC Facilities construction project:

1. Complete description of sufficient detail to permit an item-by-item comparison with this Section.
2. Bill of material, including volumes.
3. Documentation regarding delivery trailer unloading procedures, information on trailer materials used that come into contact with the GAC media, confirmation that these materials are U.S. Food and Drug Administration approved, and confirmation that the trailers are dedicated to the transport of potable grade GAC filter media.
4. GAC media testing results as specified herein.

PART 2 – PRODUCTS

2.01 ACCEPTABLE SUPPLIERS

A. GAC media provided shall be one of the following:

1. Filtrasorb 400 as furnished by Calgon;
2. GAC 400 as furnished by Norit; or
3. CarbPure GAC 1240 as furnished by Arq.

No other media products shall be acceptable.

B. The material covered by this Specification is intended to be a standard product of proven reliability and manufactured by reputable Suppliers having experience in the production of such products. The materials furnished shall be designed, manufactured, and installed in accordance with the best practices and methods and shall operate satisfactorily when

installed as specified herein, shown on the Drawings, and per the Supplier's recommendations.

- C. The Owner reserves the right to sample and test the installed media in order to ensure quality and longevity. At the Owner's discretion and expense but within six (6) months of placing the GAC contactors into service and backwashing at regular intervals in accordance with the Supplier's recommendations, additional samples of the installed and backwashed media may be collected in accordance with AWWA B604 and analyzed by an independent laboratory as described elsewhere herein and within AWWA B100, B604, and B605, as applicable. Any media that is not in compliance with the requirements of this Specification Section for Effective Size ($\pm 5\%$) and Uniformity Coefficient ($\pm 5\%$) shall be removed and replaced by the Supplier at no additional cost to the Owner.
- D. All GAC supplied under this contract shall be manufactured by the same company. GAC from multiple Suppliers will not be acceptable. GAC media under this Section shall be the product of a firm regularly engaged in supplying this type of material.

2.02 GAC MEDIA

- A. The GAC media shall be placed inside the gravity contactors in a uniform manner as specified herein and as shown on the Drawings.
- B. Facility Information

	P.O. Hoffer WTF	Glenville Lake WTF
Number of gravity contactors	12	10
Number of cells per contactor	1	2
Cell interior dimensions	30'-0" length 17'-9" width	18'-0" length 11'-3" width
Media depth	10'-6"	11'-0"
Volume of media per contactor	5,591 cf	4,455 cf
Total volume of GAC media	67,095 cf	44,550 cf

- C. GAC Product Specifications

	Virgin Media (INITIAL INSTALLATION AND RESUPPLY BASE BID)	Custom Reactivated Media (RESUPPLY ALTERNATE BID)
Iodine Number	1000 mg/g (min.)	800 mg/g (min.)
Typical Apparent Density	0.48 - 0.55 g/cc	≥95% of virgin value in accordance with AWWA B604/B605
Typical Backwashed and Drained	0.425 g/cc (min.)	≥95% of virgin value in accordance with AWWA B604/B605
Cumulative DFT Pore Volume up to 500Å ^a	Report in units of cc/g	Report in units of cc/g
Moisture (% by wt.)	2% (max.)	8% (max.)
Effective Size	0.55 – 0.75 mm	0.55 – 0.75 mm
Uniformity Coefficient	<1.9	<2.1
Abrasion No. (ROTAP)	75 (min.)	75 (min.)
BET Surface Area via ISO 9277 ^a	Report in units of m ² /g	Report in units of m ² /g
Water-Extractable Ash Content	4% (max.)	4% (max.)
Ash Content	12% (max.)	N/A
Mesh Size	US Sieve Series 12 x 40	US Sieve Series 12 x 40
Screen Size - US Sieve (% by wt.)		
On 12 mesh	5% (max.)	5% (max.)
Through 40 mesh	4% (max.)	4% (max.)

^aAnalysis may be completed by a third party (Micromeritics or approved equal), or completed internally with a submitted Certificate of Analysis.

D. GAC Product Qualifications

1. The GAC to be initially installed within the newly constructed contactors shall be virgin media conforming to the latest version of AWWA B604 and the requirements specified herein.
2. The GAC to be installed during subsequent media changeout operations following exhaustion of the initially installed media shall be:
 - a. Virgin media conforming to the latest version of AWWA B604 and the requirements specified herein (BASE BID), OR
 - b. Custom reactivated media conforming to the latest version of AWWA B605 and the requirements specified herein (ALTERNATE BID).

- 1) The custom reactivated GAC media shall include virgin makeup media as required to account for media loss during the reactivation process. The custom reactivated media inclusive of any virgin makeup media shall be billed at the unit price noted in the Bid Form.
3. The GAC shall be manufactured in the United States of America from North American based raw materials.
4. GAC shall be a re-agglomerated bituminous coal-based product with petroleum or coal-based pitch binders sized to a granular form prior to baking and activation. Lignite based GAC, peat, wood, coconut, recycled, used GAC media or broken pellets will not be accepted. Direct activated GAC will not be accepted.
5. GAC shall be thermally activated by steam under rigidly controlled conditions.
6. The GAC must possess superior hardness and abrasion characteristics to withstand repeated backwashes, transfers and handling without significant change in physical size or loss of GAC volume.
7. The GAC shall be capable of removing color, tastes, odors, disinfection by-products, disinfection by-product precursors and other organic contamination from water previously pretreated by conventional water treatment processes.
8. The GAC shall contain no soluble inorganic or organic substances in quantities capable of producing deleterious or injurious effects upon the health of those consuming the water or that would otherwise render the water treated by the GAC unfit for public use following backwashing and rinsing. The GAC shall not impart to the water any contaminant that exceeds the maximum limits as defined by the Safe Drinking Water Act Public Law 93-523 or any of its amendments, or NSF 61 standards.

E. GAC Media Testing

1. Sampling associated with the initial installation of media in advance of the startup of the GAC Facilities shall be performed by the Supplier. Sampling associated with subsequent replacement of spent media shall also be performed by the Supplier. Sampling shall be in accordance with the latest revision of AWWA B604 (for virgin media) or B605 (for custom reactivated media).
2. Analyses shall be performed in accordance with AWWA B100, B604, and B605 as applicable to confirm gradation, effective size, uniformity coefficient, iodine number, ash content, abrasion number, and apparent density. No plus tolerance shall be allowed on uniformity coefficient.
3. Sample test reports shall include raw data, graphical gradation results, computation of the effective size, uniformity coefficient, and other parameters

specified within the table herein, and shall be sent directly from the certified independent laboratory.

4. All test results and notices shall be provided to the Contractor, Engineer, and Owner during the initial placement and to the Owner during subsequent spent media replacement efforts. It is understood that the Supplier will be privy to all test results and notices provided by third-party testing laboratories.
 5. Analytical costs shall be borne by the Supplier during the initial installation and also during subsequent replacement efforts of spent media.
 6. Initial testing and reporting of results by an ISO 17025 certified independent testing laboratory shall be submitted for approval prior to shipment. Test results shall include a statement certifying that the material for shipment is from the same lot as the sample submitted.
 7. Each production lot shall be sampled during manufacture by an automatic sampling device or procedure in order to take a representative sample over the preparation of the production lot. The gross sample shall be mixed thoroughly and divided to provide three 1-pound samples. Each sample shall be labeled at a minimum with the production lot number, date, time, and product description, and the label shall be signed by the sampler.
 8. One sample shall be sent to the lab for initial testing. All samples shall be sealed in air-tight, moisture-proof glass containers and delivered as described above.
 9. If the GAC does not meet the requirements of this specification or of AWWA B604/B605, a notice of nonconformance will be provided within five days after receipt of results from the independent laboratory. The results of the test shall prevail unless the Contractor (initial placement) or Supplier (subsequent spent media replacement efforts) requests a re-test to the Owner within five (5) working days of the notice. Upon receipt of the request for a retest, the Contractor or Supplier as applicable shall submit one of the duplicate sealed samples taken for analysis. Within twelve (12) days after receipt of the duplicate sealed sample by the third-party laboratory, the Owner shall receive notification if retesting reveals that the material complies with specifications. If the retest indicates compliance of the media with the specifications and AWWA B604/B605, then the other sealed sample shall be forwarded, unopened, to a different, neutral third-party laboratory agreed upon by both applicable parties for analysis. The results of the neutral laboratory analysis shall be accepted as final.
- F. If the material does not meet the requirements specified, the media shall be removed from the site when so ordered by the Owner at no additional cost. At the Owner's option, the media may be accepted subject to an agreed price adjustment.

PART 3 – EXECUTION

3.01 GENERAL

- A. Site Verification of Conditions: The Contractor shall verify that GAC contactors and appurtenances such as piping, valves, pumps, and controls are in proper operating condition to receive GAC media.
- B. By initiating installation, the Supplier accepts that the contactors and appurtenant systems are acceptable for installation.

3.02 STORAGE, HANDLING, AND DELIVERY

- A. The delivery, storage, and handling of the contactor media shall be in accordance with the Supplier's instructions. Media shall be transported, delivered, stored, and placed in a careful manner to prevent contamination or physical damage to the GAC media particles. Storage and handling of all GAC media shall be in accordance with the latest revision of AWWA B604/B605. In the event any such material, equipment, and supplies are lost, stolen, damaged, or destroyed prior to final inspection and acceptance, the same shall be replaced without additional cost to the Owner.
- B. Delivery
 - 1. Media shipment shall be made via bulk trailer or super sacks. All shipping and delivery charges shall be included. All deliveries shall be accompanied by a legible bill of lading or other evidence suitable to the Owner, indicating the gross, tare and net weight of shipment, the name of carrier, and other pertinent information. This evidence shall be presented to the Owner before or at the time of delivery.
 - 2. Bulk Shipment: Shipment shall be delivered in totally enclosed dry bulk material trailers. Trailers shall be equipped with hatches to permit inspection.
 - 3. Prior to shipment, inspect the facilities for unloading to make certain that these facilities will accommodate the type of truck intended to be used.
 - 4. At the site, utility water will be added to the bulk contents of the trailers prior to pneumatically pressurizing the tanks for transfer of the GAC. The Supplier shall provide all equipment, connections, hoses, piping and adapters necessary to utilize existing plant utility water supply. The GAC is to be transferred in slurry form from the trailer to the GAC contactors. Supplemental water may be added to the trailer discharge manifold to make the slurry more flowable and less subject to attrition.
 - 5. If required, the Supplier shall furnish compressed air, slurry system and other accessories as required for transfer of the GAC media to the contactors.

6. GAC media shall be delivered in the Suppliers' bulk trailers or super sacks used solely for transport of GAC for potable use. Trailer hatches shall bear dated seals affixed by Supplier upon loading of media into trailers, and seals shall be intact and undisturbed upon arrival at the project site. Weight tickets for all GAC media supplied shall be provided to the Owner for the actual GAC media delivered. A continuous chain of custody shall be maintained between the Supplier and the Owner during GAC media production, storage, loading, shipment, and installation of into GAC contactor(s).

C. Handling

1. It shall be the Supplier's responsibility to clean up, to the Owner's satisfaction, any GAC or slurry spills at the site and to repair any damage resulting from the GAC delivery or unloading operations.
2. The GAC media shall be handled at all times in a safe manner and as recommended by the Supplier and AWWA standards. **Media may not be placed dry. GAC depletes oxygen from air and can be hazardous in a confined area with insufficient ventilation.** Worker's safety shall be prioritized following all pertinent local, state, and federal guidelines.
3. Any media that becomes contaminated or dirty (i.e., contains more than 0.5% of foreign material by weight) either before or after it has been placed in the GAC contactors shall be removed and replaced with clean media at no cost to the Owner.

3.03 INSTALLATION

A. Method of Installation

1. The Owner shall provide a utility water source for GAC transfer and flushing/rinsing. The Supplier shall provide all necessary hoses, sight glasses, piping, eductors, and appurtenances for installing GAC media into contactors. Multiple 2-inch quick connect fittings are provided at each facility for the convenience of the Supplier. Hoses shall be carefully positioned to reduce headloss and to provide a smooth hydraulic flow path for GAC transport to the GAC contactor(s).
2. GAC media shall be transferred into the GAC contactor(s) as water slurry to minimize abrasion and dust as specified in AWWA B604/B605. If required, compressed air may be used for additional motive force. The Supplier shall furnish the compressed air system.
3. The Supplier shall be responsible for cleanup of all GAC media and slurry spills that may occur during the GAC transfer operation.

B. Placing GAC Media

1. Preparation

- a. Each GAC contactor shall be kept clean throughout installation operations. All equipment used in placing GAC media shall be cleaned and disinfected in accordance with AWWA C653. All workers shall use boots and gloves which have been disinfected in accordance with AWWA C653.
- b. GAC media shall be installed in GAC contactors by the Supplier after removal of spent media and adequate cleaning of the contactors with utility water.

2. Placement

- a. Installation of GAC media shall be performed in three layers or "lifts", each consisting of approximately one third of the total media depth specified herein. An adequate allowance of excess media for scraping shall be provided.
- b. The contactor box shall be partially filled with water prior to adding the first lift of GAC media.
- c. After placement, each lift shall be wetted for a minimum period as directed by the media Supplier.
- d. Following the wetting period (for each lift), the bed shall be backwashed with water to remove carbon fines and level the media. The initial backwash sequence shall be conducted as follows or as otherwise directed by the Supplier:
 - 1) Backwash rate of 5 gpm/sf for a duration of 5 minutes
 - 2) Backwash rate of 10 gpm/sf for a duration of 5 minutes
 - 3) Backwash rate of 15 gpm/sf for a duration of 30 minutes
 - 4) Backwash rate of 10 gpm/sf for a duration of 5 minutes
 - 5) Backwash rate of 5 gpm/sf for a duration of 5 minutes
- e. The media depth shall be measured after the addition of each lift of GAC media until the specified media depth is provided. Care should be taken to avoid overfilling or underfilling the contactors with GAC media.

- f. Following the backwash of the third and final lift, a minimum of ½ inch of surface fines shall be removed by scraping to prevent undue headloss development as described in AWWA B604. The final depth of media shall be no less than the value specified herein. Following scraping, the installed bed shall be wetted overnight prior to rinsing.
 - g. **The water level in the GAC contactors shall be maintained above the GAC media level at all times, including when the contactors are removed from service during installation and start-up functions, in order to prevent oxygen adsorption. When exposed to air, wet GAC media will rapidly adsorb oxygen and create an oxygen deficient environment. GAC media shall be covered with water and workers shall follow safety precautions before entering enclosed spaces containing wet activated carbon.**
3. Cleaning and Disposal
- a. The Owner shall supply all utility water for testing.
 - b. The Supplier shall remove and dispose of all excess material and debris. This includes but is not limited to the disposal of all super sacks and pallets if used in the delivery of the GAC media. Chlorinated water shall be disposed of in accordance with the latest version of AWWA C653.

C. GAC Media Rinsing

- 1. The Contractor shall forward-flush the GAC media once initial placement is complete to rinse out any contaminants and to stabilize pH. The pH of the individual GAC contactor effluent shall be pH 10 or less prior to placing into service. Flushing water shall be disposed using the dedicated piping for each contactor.
- 2. Following initial flushing, a sample of the effluent water shall be tested by an independent third-party laboratory to confirm that all regulated constituents are within the limits established by the National Primary and Secondary Drinking Water Regulations. The cost of the laboratory testing shall be borne by the Supplier.
- 3. If the limit for any regulated constituent is exceeded, the forward-flush procedure shall be continued and water quality testing shall be repeated until all regulated constituents are within the limits established by the US EPA National Primary and Secondary Drinking Water Regulations. Additional analytical testing shall be conducted at the expense of the Supplier.

4. Supplier shall document and communicate to the Owner the water quality of the contactor effluent. A report from a certified drinking water lab shall be submitted to the Owner and shall include the following information:
 - a. Proof of inorganic contaminants regulated by the National Primary and Secondary Drinking Water Regulations being below their respective maximum contaminant level (MCL) designated by the USEPA.

3.04 REMOVAL OF SPENT MEDIA

- A. The Owner will request removal of spent GAC on an as-needed basis throughout the duration of the media supply contract. Owner personnel will be responsible for shutting down the pertinent contactor and lockout/tagout of the contactor valves prior to media removal.
- B. The Supplier shall furnish all labor, materials, equipment, and supervision for the removal and transport of the spent GAC media to the ultimate disposal location or reactivation facility for custom reactivation.
- C. The Supplier shall provide proof of transfer of these materials by means of manifests, load tickets, and bills of lading.

3.05 REACTIVATION

- A. Only reactivation facilities and equipment used to handle spent and reactivated GAC media, classified as potable and/or food grade, shall be used. Transportation containers, including storage vessels on vehicles, transfer hose and other equipment in contact with the media, shall be suitably protected from environmental contamination and suitably cleaned, by evidence of wash-out tickets that are presented to the Owner or certifying agency on demand.
- B. Samples from each spent and custom reactivated batch of GAC media shall be retained at the GAC reactivation facility for a period of at least two (2) years and be made available upon request. Samples shall be collected in accordance with AWWA B604/B605 and the requirements specified herein.
- C. Spent GAC media that is not able to meet the requirements specified herein for custom reactivated media shall be disposed of by the Supplier. The full chain of custody shall be provided to Owner as proof of disposal for record-keeping for the entire quantity of GAC media removed from the site.

END OF SECTION

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SECTION 46 00 00
EQUIPMENT GENERAL PROVISIONS

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. The Contractor shall furnish, install, test, and place in acceptable operation all mechanical equipment and all accessories as specified, as shown on the Drawings, and as required for a complete and operable system.
- B. The mechanical equipment shall be provided complete with all accessories, special tools, spare parts, mountings, shims, sheaves, couplings, and other appurtenances as specified, and as may be required for a complete and operating installation.
- C. The Contractor shall provide the Owner complete and operational equipment/systems. To this end, it is the responsibility of the Contractor to coordinate all interfaces related mechanical, structural, electrical, instrumentation, and control work and to provide necessary ancillary items such as controls, wiring, etc., to make each piece of equipment operational as shown and specified.
- D. The complete installation shall be free from excessive vibration, cavitation, noise, and oil or water leaks.
- E. The requirements of this section shall apply to equipment furnished under Divisions 40, 41, 43, and 46.
- F. Comply with reference specifications, codes and standards as specifically modified, complimented, and supplemented herein.
- G. All wetted components of equipment used in potable water treatment, inclusive of chemical storage and feed systems, shall be NSF/ANSI 61 certified.

1.02 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

- A. All equipment, materials, and installations shall conform to the requirements of the most recent editions with latest revisions, supplements, and amendments of the specifications, codes, and standards listed in Section 01 42 00 – References along with those identified herein this and other individual specification sections.
- B. American Institute for Steel Construction (AISC)
- C. American National Standards Institute/American Bearing Manufacturers Association (ANSI/ABMA):

1. ANSI/ABMA 9 – Load Ratings and Fatigue Life for Ball Bearings
 2. ANSI/ABMA 11 – Load Ratings and Fatigue Life for Ball Bearings
- D. Acoustical Society of America (ASA) / American National Standard Institute (ANSI) S2.75, Shaft Alignment Methodology:
1. Part 1: General Principles, Methods, Practices, and Tolerances
 2. Part 2: Vocabulary
 3. Part 3: Alignment of Vertically Oriented Rotating Machinery
 4. Guidelines and recommendations included in ASA/ANSI S2.75 shall establish and be interpreted as the minimum requirements for acceptance for leveling, grouting and alignment related work.
- E. American National Standards Institute / American Society of Mechanical Engineers (ANSI/ASME) Standard B29.1, Heavy Duty Offset Sidebar Transmission Roller Chains and Sprocket Teeth.
- F. American Welding Society (AWS):
1. D1.1 "Structural Welding Code - Steel"
 2. D1.2 "Structural Welding Code - Aluminum" of the American Welding Society
- G. Electrical Apparatus Service Association, Inc. (EASA) Mechanical Reference Handbook (latest revision).
- H. Standard, ISO 1940 – Mechanical Vibration – Balance quality requirements for rotors balance quality grade for rotors in a constant rigid state.
- I. In the event of conflict between individual specifications and reference specifications, codes and standards, the more restrictive criteria shall govern.

1.03 ACTION/INFORMATIONAL SUBMITTALS

- A. Product Data:
1. Comply with Section 01 33 00 – Submittals Procedures
 2. Fabrication information
- B. Provide submittals identified in individual equipment specification sections in addition to the submittals identified herein.

C. Shop Drawings shall include the following information in addition to the requirements of Section 01 33 00 – Submittal Procedures and shall include the following additional information:

1. Equipment name, identification number and specification number.
2. Performance characteristics and descriptive data, including but not limited to capacity, power, speed, torque, and efficiency.
3. Detailed equipment dimensional drawings and setting plans including but not limited to:
 - a. General cutaway sections
 - b. Materials of construction
 - c. Dimension of shaft projections
 - d. Shaft and keyway dimensions
 - e. Shaft diameter
 - f. Shaft connection details
 - g. Dimension between bearings
 - h. General dimensions of equipment
 - i. Anchor bolt locations
 - j. Forces
 - k. Assembly views
 - l. Weights: Provide weight of entire equipment assembly, including motor and base weight of individual major subassemblies. Indicate the weight of each component, and total static and dynamic loads imparted by the equipment to the supporting structure.
 - m. Rotating assembly technical information and illustration.
 - n. Drawings shall identify each component by tag number to which the catalog data and detail sheets pertain.
 - o. Drawings showing the location and type of all equipment, system components, supports, hangers, foundations and the required clearances to operate and maintain equipment, valves and system components in a code

compliant, safe and ergonomic manner. Drawings shall show clearances reserved for walking access around all sides, for opening access doors fully, for visual inspection for condition monitoring, and for the performance of maintenance tasks including but not limited to changing filters, replacing belts, maintaining lubrication levels, predictive maintenance and performing diagnostic functions.

4. Drive and motor data as required by Division 26 – Electrical. Complete motor data shall include but not be limited to size, make, type and characteristics along with wiring diagrams. Where equipment and motor speeds are to be regulated by variable speed drives, the CONTRACTOR shall coordinate, furnish and exchange all necessary requirements with the respective equipment manufacturers to ensure compatibility and shall submit equipment, shafting, coupling, motor and variable speed drive shop drawings.
5. Bearings:
 - a. Information on bearings including but not limited to: type, size, materials of construction.
 - b. Bearing life calculations including but not limited to: basic dynamic load rating, static load rating, rating life, ABMA L10 reliability (expressed in hours of bearing life) and bearing system life.
6. Gear box design and performance criteria and AGMA service factor, including but not limited to the following:
 - a. Thermal horsepower rating
 - b. Bearing type
 - c. Actual gear ratio
 - d. Forced lubrication system: Provide description of equipment, system and instrumentation including but not limited to flow meter, pressure switches, etc.
 - e. Gear tooth finish quality
7. Piping schematics.
8. Equipment protective device details and connection diagrams.
9. Panel layout drawings, schematic wiring diagrams, and component product data sheets for control panels.

10. A list of spare parts and special tools to be provided.
11. Information on equipment appurtenances including couplings, shaft guards, v-belt drive systems, etc.
12. Any additional information required to demonstrate conformance with the equipment specifications.
13. Results of critical speed analyses, structural, lateral, and torsional dynamic analyses as required herein and in the individual specification sections.
14. Warranty documentation including statement of duration of warranty period and contact phone numbers and addresses for warranty issues.
15. Shipment, delivery, handling, and storage instructions.
16. Installation instructions
17. Manufacturers literature and brochures
18. Materials of construction and associated specifications (such as AISI, ASTM, SAE, etc.), including grade and type.
19. Anchor design in accordance with Section 05 05 23 – Metal Fastening.
20. Intermediate shafting design, including but not limited to general arrangement drawings, engineering data, materials of construction, recommended angular offsets (for cardan universal jointed shafts), and shaft critical speed analyses (including 1st, 2nd and 3rd critical speed analysis).
21. Coatings: Coating system data and description of coating system, surface preparation and shop painting, including certification that the shop paint is compatible with the finish paint.
22. Pre-commissioning lubrication oil flushing plan developed by a machinery lubrication specialist, specifically for each piece of lubricated equipment. Plan shall identify, describe procedure and demonstrate data-based approach to demonstrating achievement of lubricant cleanliness via flushing. Level of lubricant cleanliness shall be as required by equipment manufacturer's written recommendations.
23. Equipment installation lists.
24. Equipment specific requirements for levelness, plumbness, flatness, coplanarity and coplanar surface deviation.

1.04 CLOSEOUT SUBMITTALS

- A. Submit warranty documentation in compliance with:
 - 1. Section 01 33 00 – Submittal Procedures
 - 2. Section 01 61 00 – Product Requirements and Options
- B. Operation and Maintenance (O&M) manuals shall be submitted in accordance with Section 01 33 00 – Submittal Procedures and Section 01 78 23 Operation and Maintenance Data.

1.05 MAINTENANCE MATERIALS SUBMITTALS

- A. Operation and Maintenance (O&M) manuals shall be submitted in accordance with:
 - 1. Section 01 33 00 – Submittal Procedures
 - 2. Section 01 78 23 – Operation and Maintenance Data
- B. Comply with Section 01 78 43 – Spare Parts and Extra Materials:
 - 1. For spare parts, extra stock materials, and tools, submit quantity of items specified in associated Specification Section.
 - 2. Submit complete list of spare parts, extra stock materials, maintenance supplies and special tools required for maintenance for one year with unit prices and source of supply. Indicate number/quantity specified and furnished, manufacturer, part number, description,
- C. Comply with Section 01 79 00 – Instructions of Owner's Personnel.
- D. Lubrication Information:
 - 1. Comply with Specification Section 01 78 23 – Operation and Maintenance Data.
 - 2. Complete lubrication instructions and lubricant schedule, including manufacturer's recommended lubricant. All lubricants shall be food grade, NSF H1 approved. Schedule shall include frequency of lubricant application, type of lubricant, and instructions regarding lubricant application

1.06 QUALITY ASSURANCE SUBMITTALS

- A. Factory testing plan.
- B. Factory Test Results shall be submitted and approved prior to shipment of equipment.

- C. Field testing plan.
- D. Comply with Section 01 75 00 – Check Out and Start Up Procedures.
- E. Alignment Report:
 - 1. Alignment reports shall contain numerical values to express offset and angular alignment and all other parameters documented in ANSI/ASA S2.75.
 - 2. Alignment reports shall be submitted immediately after each of the following activities have been completed:
 - a. Preliminary Alignment
 - b. Final Alignment (at both ambient and operating temperatures)
 - c. Re-check of alignment
- F. Preliminary field test data
- G. System field quality control testing
- H. Final field test data
- I. Certified test reports

1.07 GENERAL INFORMATION AND DESCRIPTION

- A. All parts of the equipment furnished shall be designed and constructed for the maximum stresses occurring during fabrication, transportation, installation, testing, and all conditions of operation. All materials shall be new and shall conform to all applicable Sections of these Specifications.
- B. All parts of duplicate equipment shall be interchangeable without modification. Manufacturer's design shall accommodate all the requirements of these Specifications.
- C. Equipment and appurtenances shall be designed in conformity with specifications, codes and reference standards.
- D. All bearings and moving parts shall be protected by bushings or other Engineer approved means against wear, and provision shall be made for accessible lubrication by extending lubrication lines and fittings to approximately 30 inches above finished floor elevation.
- E. Details shall be designed for appearance as well as utility. Protruding members, joints, corners, gear covers, etc., shall be finished in appearance. All exposed welds on

machinery shall be ground smooth and the corners of structural shapes shall be rounded or chamfered.

- F. Machinery parts shall conform within allowable tolerances to the dimensions shown on the working drawings.
- G. All machinery and equipment shall be safeguarded in accordance with the specifications, codes, and reference standards.
- H. All rotating shafts, couplings, or other moving pieces of equipment shall be provided with protective guards of sheet metal or wire mesh, neatly and rigidly supported. Guards shall be removable as required to provide access for repairs.
- I. All equipment greater than 100 pounds shall have lifting lugs, eyebolts, etc., for ease of lifting, without damage or undue stress exerted on its components.
- J. All manufactured items provided under this Section shall be of current manufacture and shall be the products of manufacturers specializing in the manufacture of such products.
- K. Code Compliance, safety and ergonomics for operating and maintenance personnel accessing equipment shall be considered during shop drawing development, fabrication, and installation. Items to considering include but are not limited to clearances reserved for walking access around all sides, for opening access doors fully, for visual inspection for condition monitoring, and for the performance of maintenance tasks including but not limited to changing filters, replacing belts, maintaining lubrication levels, predictive maintenance and performing diagnostic functions.

1.08 EQUIPMENT WARRANTIES

- A. Warranty requirements shall be as specified in Section 01 61 00 – Product Requirements and Options and Section 01 75 00 – Checkout and Startup Procedures. Warranty requirements are supplementary to the individual equipment specifications.

1.09 DEFINITIONS

- A. Comply with specification Section 01 42 00 – References.
- B. Refer to the specified reference specifications, codes and standards for definitions applicable to this specification. Additional definitions are included hereafter.
- C. Chockplate: A solid steel (or alloy steel) plate with a machined top surface that is grouted to a concrete foundation to support and maintain alignment of a machinery structural steel base plate.
- D. Equipment Train: Two or more rotating equipment machinery elements consisting of at least one driver and one driven element joined together by a coupling.

- E. Mounting plate: A device used to attach equipment to concrete foundations; includes base plates, soleplates, and chockplates. A mounting plate is a base-support mechanism for the attached machinery and all individual pieces of machinery are expected to be removable from the mounting plate as a single assembly.
- F. Operating Temperature (Thermal) Alignment: A procedure to determine the actual change in relative shaft positions within a machinery train from the ambient (not running) condition and the normal operating temperature (running) condition by taking measurements from start-up to normal operating temperature while the machine(s) is (are) operating, or after the shafts have been stopped but the machines are still near operating temperature.
- G. Preliminary alignment: The aligning of two adjacent machinery shafts to ensure that final alignment can be achieved without being bolt bound. This is accomplished before grouting (for horizontal machines) and the measurement of piping strain on the machinery.
- H. Soleplate: A solid steel (or alloy steel) plate with a machined top surface that is grouted to a concrete foundation to support and maintain alignment of machinery.

PART 2 – PRODUCTS

2.01 GENERAL

- A. All like components within a piece of equipment shall be provided by the same manufacturer.
- B. Base plates:
 - 1. Top surface of mounting plates shall be machined in locations where equipment supports/feet will contact the plate.
 - 2. Equipment contact points shall be flat and parallel within ASA/ANSI 2.75 tolerances or 0.002-inches per foot, whichever is more stringent, and within related tolerances.
 - 3. There shall be no paint where equipment supports or feet contact mounting plate.
 - 4. Mounting plate shall be sufficiently rigid to avoid bending or flexing when equipment is installed.

2.02 ANCHORS AND SUPPORTS

- A. Comply with the following Specification Sections:
 - 1. Specification Section 05 05 23 – Metal Fastening.

2. Comply with individual equipment specifications.
- B. The Contractor shall furnish, install, and protect all necessary guides, bearing plates, anchor and attachment bolts, and all other appurtenances required for the installation of the devices included in the equipment specified. Working Drawings for installation shall be furnished by the equipment manufacturer, and templates shall be used by the Contractor when required in the detailed equipment Specifications.
- C. Anchor bolts and fasteners:
1. Anchor bolts shall be designed and provided by the Contractor in accordance with Section 05 05 23 – Metal Fastening, and with the individual equipment Specifications.
 2. All anchor bolts shall have at least the minimum diameter as required by Specification Section 05 05 23 – Metal Fastening.
 3. All anchor bolts, guard bolts, washers, clips, clamps, fasteners, and leveling plate pads, nuts, shims, and jack bolts of any type shall be constructed of 316 stainless steel, unless otherwise specified the individual equipment Specifications.
 4. Undercutting of anchors or fasteners shall not be permitted.
- D. Pipe sleeves as a means for adjusting anchor bolts shall be provided where indicated in the contract documents or required by the equipment manufacturer.
- E. The Contractor shall provide all concrete pads or pedestals required for equipment furnished. All concrete equipment pads shall be a minimum of 4" high, unless otherwise shown on the Drawings, and shall be doweled.

2.03 DEFAULT MATERIALS

- A. Equipment shall be constructed out of the materials specified in respective individual pumping specification sections. Material not specifically called for shall be high-grade, standard commercial quality, free from all defects and imperfection that might affect the serviceability of the product for the purpose for which it is intended.

2.04 STRUCTURAL STEEL

- A. Structural steel used for fabricating equipment shall conform to the requirements of Section 05 12 00 – Structural Steel.
- B. All materials shall conform to applicable provisions of the AISC Specifications for the design and fabrication of structural steel, and to pertinent ASTM Standard Specifications.

2.05 DISSIMILAR METALS

- A. All dissimilar metals shall be isolated in accordance with Section 05 10 00 – Metal Materials and to the satisfaction of the Engineer.

2.06 GALVANIZING

- A. Where required by the equipment specifications, galvanizing shall be performed in accordance with Section 05 05 13 – Galvanizing.

2.07 STANDARDIZATION OF GREASE FITTINGS

- A. The grease fittings on all mechanical equipment shall be such that they can be serviced with a single type of grease gun. Fittings shall be “Zerk” type.

2.08 ELECTRICAL REQUIREMENTS

- A. All electrical equipment and appurtenances, including but not limited to motors, panels, conduit, and wiring, etc., specified in the equipment specifications shall comply with the applicable requirements of the Division 26 specifications and the latest National Electric Code. Motor starters and controls shall be furnished and installed under Division 26 and Division 40 unless otherwise specified in the individual equipment specifications.
- B. In the individual equipment specifications, specified motor horsepower is intended to be the minimum size motor to be provided. If a larger motor is required to meet the specified operating conditions and performance requirements, the Contractor shall furnish the larger sized motor and shall upgrade the electrical service (conduit, wires, starters, etc.) at no additional cost to the Owner.
- C. Where variable frequency drives (VFDs) are specified, the Contractor shall be responsible for coordinating between equipment supplier and VFD supplier to ensure a complete and operational system. VFDs shall be furnished under Division 26 unless otherwise specified in the equipment specification. Wherever variable speed drives (VSDs) are specified the same requirements as for VFDs shall apply.
- D. Motor starters and controls shall be furnished and installed under Division 26 and Division 40 unless otherwise specified in the individual equipment specifications.

2.09 ACCESSORIES, SPARE PARTS, AND SPECIAL TOOLS

- A. Accessories, spare parts, and special tools shall be provided in accordance with Section 01 78 43 – Spare Parts and Extra Materials.

2.10 EQUIPMENT IDENTIFICATION

- A. All mechanical equipment shall be provided with a substantial stainless-steel nameplate, mechanically fastened with stainless steel hardware in a conspicuous place, and clearly inscribed with:
 - 1. The manufacturer's name
 - 2. Year of manufacture
 - 3. Serial number
 - 4. Principal rating data such as (for example):
 - a. Capacity
 - b. Pressure
 - c. Horsepower
 - d. Speed
- B. Each piece of mechanical equipment shall also be identified as to name and number by a suitable laminated plastic or stainless-steel nameplate mechanically fastened with stainless steel hardware; for example, "Raw Water Pump #1 (RWP-1)". Coordinate name and number with same on remotely located controls, control panel, and other related equipment.
- C. Nameplates shall not be painted over.

PART 3 – EXECUTION

3.01 SHOP TESTING

- A. All equipment shall be tested in the shop of the manufacturer in a manner which shall conclusively prove that its characteristics comply fully with the requirements of the Contract Documents and that it will operate in the manner specified or implied.
- B. No equipment shall be shipped to the project site until the Engineer has been furnished a certified copy of test results and has notified the Contractor, in writing, that the results of such tests are acceptable.
- C. A certified copy of the manufacturer's actual test data and interpreted results thereof shall be forwarded to the Engineer for review.

- D. If required by the individual equipment Specifications, arrangements shall be made for the Owner/Engineer to witness performance tests in the manufacturer's shop. The Engineer shall be notified ten working days before shop testing commences. Expenses are to be paid by the Contractor.
- E. Shop testing of electric motors shall conform to:
 - 1. Section 26 05 00 – Basic Electrical Requirements
 - 2. Section 26 05 60 – Low-Voltage Electric Motors

3.02 SHIPMENT, DELIVERY, HANDLING AND STORAGE

- A. Shipment, delivery, and handling of equipment and materials shall be in accordance with Section 01 65 00 – Product Delivery Requirements.
- B. Storage of equipment and materials shall be in accordance with Section 01 66 00 – Product Storage and Protection Requirements.
- C. Shipping plans shall include consideration for protecting bearings and/or other rotating equipment from chatter damage.
- D. Any equipment shipped to site that needs further attention shall have a WARNING tag affixed to it with indication of the action that should be taken in preparation for startup. Examples are: Final Lubrication, Mechanical Seal not in final position, etc.

3.03 MANUFACTURER'S FIELD SERVICES

- A. Manufacturer's field services shall be in accordance with Section 01 75 00 – Checkout and Startup Procedures.
- B. The Contractor shall arrange for a qualified factory trained Technical Representative from each manufacturer or supplier of equipment who is regularly involved in the inspection, installation, start-up, troubleshooting, testing, maintenance, and operation of the specified equipment. Qualification of the Technical Representative shall be appropriate to the type of equipment furnished and subject to the approval of the Engineer and the Owner. Where equipment furnished has significant process complexity, furnish the services of engineering personnel knowledgeable in the process involved and the function of the equipment. When necessary, the Contractor shall schedule multiple Technical Representatives to be present at the same time for the purpose of coordinating the operation of multiple pieces of related equipment.
- C. Services of the Technical Representative will require a minimum of two (2) site visits, one for installation and testing and one for startup and training, and will be for the minimum number of days recommended by the manufacturer and approved by the Engineer but will not be less than the number of days specified in individual equipment

sections. Additional site visits may be required as described below and in the equipment specifications.

- D. For each site visit, the Technical Representative shall submit jointly to the Owner, the Engineer, and the Contractor a complete signed report of the results of their inspection, operation, adjustments, and testing. The report shall include detailed descriptions of the points inspected, tests and adjustments made, and quantitative results obtained if such are specified.
- E. The manufacturer's Technical Representative shall provide the following services.
 - 1. Installation: The Technical Representative shall inspect the installed equipment to verify that installation is in accordance with the manufacturer's requirements. Where required by individual equipment specifications, the Technical Representative shall also supervise the installation of the equipment.
 - 2. Testing: After installation of the equipment has been completed and the equipment is presumably ready for operation, but before it is operated by others, the Technical Representative shall inspect, operate, test, and adjust the equipment as required to prove that the equipment is in proper condition for satisfactory operation under the conditions specified. Unless otherwise noted in the signed site visit report, the report shall constitute a certification that the equipment conforms to the requirements of the Contract and is ready for startup and that nothing in the installation will render the manufacturer's warranty null and void. The report shall include date of final acceptance field test, as well as a listing of all persons present during tests.
 - 3. Startup: The Technical Representative shall start up the equipment for actual service with the help of the Contractor. If equipment or installation problems are experienced, the Contractor and the representative shall provide the necessary services until the equipment is operating satisfactorily and performing according to the specifications at no additional cost to the Owner. Unless otherwise noted in the signed site visit report, the report shall constitute a certification that the equipment conforms to the requirements of the Contract and is ready for permanent operation and that nothing in the installation will render the manufacturer's warranty null and void.
 - 4. Training: Training shall be provided in accordance with Section 01 79 00 – Instruction of Owner Personnel.
 - 5. Services after Startup: Where required by the individual equipment specifications, the Technical Representative shall return to the project site thirty (30) days after the startup date to review the equipment performance, correct any equipment problems, and conduct operation and maintenance classes as required by the Owner. This follow-up trip is required in addition to the specified services of

Technical Representative prior to and during equipment startup. At this time, if there are no equipment problems, each manufacturer shall certify to the Owner in writing that their equipment is fully operational and capable of meeting operating requirements. If the equipment is operating incorrectly, the Technical Representative will make no certification to the Owner until the problems are corrected and the equipment demonstrates a successful thirty (30) days operating period.

- F. The Contract amount shall include the cost of furnishing the Technical Representative for the minimum number of days specified, and any additional time required to achieve successful installation and operation. The times specified for services by the Technical Representative in the equipment Specifications are exclusive of travel time to and from the facility and shall not be construed as to relieve the manufacturer of any additional visits to provide sufficient service to place the equipment in satisfactory operation.
- G. The Contractor shall notify the Engineer at least 14 days in advance of each equipment test or Owner training session.
- H. The Technical Representative shall sign in and out at the office of the Engineer's Resident Project Representative on each day the Technical Representative is at the project.

3.04 INSTALLATION

- A. The Contractor shall obtain written installation manuals from the equipment manufacturer prior to installation. Equipment shall be installed strictly in accordance with recommendations of the manufacturer. A copy of all installation instructions shall be furnished to the Engineer's field representative one week prior to installation.
- B. The Owner's field representative (e.g., the Engineer or similar) shall witness all activities involved with equipment installation.
- C. The Contractor shall have on hand personnel, construction equipment, and machinery of capacity to facilitate the work and to handle all emergencies encountered in work of this character. To minimize field erection problems, mechanical units shall be factory assembled insofar as practical.
- D. Equipment shall be erected in a neat and workmanlike manner on the foundations at the locations and elevations shown on the Drawings.
- E. All equipment sections and loose items shall be match-marked prior to shipping.
- F. The Contractor shall furnish oil and grease for initial operation and testing. The manufacturer and grades of oil and grease shall be in accordance with the recommendations of the equipment manufacturer.

G. Leveling and Grouting:

1. Set equipment to dimensions shown on drawings. Dimensions shall be accurate to $\pm 1/16$ inch except as otherwise specified, required or indicated on the drawings.
2. Base plate Surface Preparation – Prior to setting equipment and grouting, inspect and clean equipment mounting base plates, pads, feet, and frames to remove all grease, rust, paint, and dirt.
3. Wedges (i.e., tapered shims) shall not be used for leveling, aligning, or supporting equipment.
4. General Equipment Leveling:
 - a. Non-rotating Equipment: Set level to $\pm 1/16$ inch per 10-foot length (0.005 inch per foot) unless manufacturer's requirements are more stringent.
 - b. Rotating Equipment: Install, set to the most stringent of the following requirements for levelness, plumbness, flatness, coplanarity and coplanar surface deviation:
 - 1) ASA-ANSI S2.75, Shaft Alignment Methodology. Comply with tolerance ranges scheduled at the end of this specification section.
 - 2) Individual equipment specifications
 - 3) Manufacturer's pre-printed written requirements.
 - 4) When the equipment manufacturer's pre-printed tolerances are more stringent than those stated in ASA/ANSI 2.75 or more stringent than the individual pump specification, the cost of field machining sole plates or precision grouting sole plates shall be covered by the Contractor.
 - c. Shims or leveling nuts shall be used unless equipment is furnished with leveling feet. Set shims flush with equipment base plate edges. When grouting is required, equipment shall be shimmed to allow a minimum of one-inch grout thickness. Grout shall cover shims at least 3 inches. Final level check shall be held for inspection and approval by Engineer before proceeding.
 - d. Equipment shall be leveled by first using sitting nuts on the anchor bolts, and then filling the space between the equipment base and concrete pedestal with epoxy base plate grout, unless alternate methods are recommended by the manufacturer and are acceptable to the Engineer (e.g., such as shim leveling pumps, or chemical grout).

5. Grouting

- a. Comply with Section 03 60 00 – Grout.
- b. Grout Materials:
 - 1) Rotating Equipment: Grout for rotating equipment shall be epoxy base plate grout. Cementitious grouts shall not be accepted for rotating equipment.
 - 2) Non-rotating Equipment: Grout shall be as per the non-rotating equipment manufacturer's pre-printed written installation instructions and shall be subject to the Engineer's approval.
- c. Fill pipe sleeves with grout, after bolt alignment is proven, and prior to placing grout under equipment bases.
- d. Concrete Surface Preparation: Roughen concrete equipment pad surface by chipping, removing laitance, and unsound concrete. Clean area of all foreign material such as oil, grease, and scale.
 - 1) When grouting with cementitious grouts is approved, the contact area of the concrete equipment pad shall be saturated with water at least 4 hours prior to grouting, removing excess water ponds.
- e. Application:
 - 1) Place grout after the equipment base has been set and its initial alignment and level have been approved.
 - 2) Form around the base, mix grout, and place in accordance with the grout manufacturers published instructions.
 - 3) Grout mixture shall be flowable. Dry packing of grout shall not be permitted.
 - 4) Eliminate all air or water pockets beneath the base using a drag chain or rope.
 - 5) Grout voids detectable by tapping the top of the base plate with a hammer shall be grounds for removal and reinstallation of the work.
- f. Finishing: Point the edges of the grout to form a smooth 45-degree slope.
- g. After cementitious grout has cured (not before 3 days after placement) paint exposed surfaces of grout with shellac.

- h. Level Verification. After grout has cured, and immediately prior to final drive alignment, recheck equipment for level and plumb. Re-level and square as necessary. Hold final checks for inspection and approval by Engineer.
- 6. Inspect for and remove all machining burrs or thread pulls in female holes on mating surfaces of mounting frame and machine feet.

3.05 ALIGNMENT

- A. For equipment that requires field alignment and connections, the Contractor shall provide the services of the manufacturer's qualified mechanic, millwright, or machinist, to align the equipment and motor prior to making piping connections or anchoring the equipment base. Alignment shall be as specified herein.
- B. Rotating Equipment Shaft Alignment: Assembled equipment shafts shall be set to comply with the most stringent of the following tolerance requirements for shaft runout and shaft-to-shaft alignment tolerances expressed in angle at flex plane, in offset and angularity and/or in offset per tolerance plane separation:
 - 1. ASA-ANSI S2.75, Shaft Alignment Methodology. Comply with tolerance ranges scheduled at the end of this specification section.
 - 2. Individual equipment specifications
 - 3. Manufacturer's pre-printed written requirements.
- C. Use the machined surfaces on which the equipment sets for the base/mounting frame leveling plane. Use the machined shaft surface for equipment leveling plane.
- D. Sprocket and Sheave Alignment:
 - 1. Check shaft mounted components for face runout and eccentricity (outside diameter) runout by magnetically mounting a dial indicator on a stationary base and indicating over 360 degrees on a continuous machined surface at the outside diameter of the component. Maximum allowable total indicated face runout and eccentricity for sprockets and sheaves will be per ANSI Standard B29.1-1975.
 - 2. Drive and driven sheaves shall lie in the same plane. The sum of parallel and angular sheave misalignment measured across the span length of the belt and angular misalignment perpendicular to the belt span length shall each not exceed ½ degree or the belt manufacturer's recommendation whichever is more stringent.
- E. Belt tensioning: Set drive belt tension to manufacturer's specification for the belt type. Recheck alignment after drive tensioning.

F. Thermal/Mechanical Growth: Thermal/mechanical growth corrections for driver and driven machines will be used in vertical and horizontal alignment where applicable. The equipment manufacturer will determine thermal/mechanical growth applicability for any machine and provide the correction offsets to be used.

G. Rotating Shaft Alignment

1. Measurement devices/fixtures will be set up on the driver and driven machine, or machine shaft surfaces. Machined coupling hubs may be used only if there is no clearance to mount fixtures directly on the shafts.
2. Account for possible coupling flex by always rotating coupled machines in the same direction during alignment.
3. Final alignments shall be performed utilizing laser alignment tools unless otherwise approved by the Engineer.
4. Cardan Universal Jointed Intermediate Shafting:
 - a. Align cardan universal joints in accordance with manufacturer's written offset recommendations.
 - b. Offsets shall be field verified.
 - c. Contractor shall have unit responsibility for all components of extended shaft driven equipment, including but not limited to the coordination of shaft design with equipment, variable frequency drive and control strategies.
5. Alignment Steps: Each of the following alignment steps are required in all instances, including but not limited to, all vertically and horizontally mounted drivers:
 - a. Preliminary alignment is when uncoupled. Preliminary Alignment (at ambient temperature):
 - 1) Perform prior to grouting and piping connections.
 - 2) Check shaft straightness (runout).
 - 3) Correct for soft foot.
 - b. Final alignment method is when coupled. Final Alignment (at ambient temperature):
 - 1) Perform after grouting and piping connections have been completed.
 - 2) Check for pipe strain.

- 3) Alignment shall be within tolerances.
 - c. Final alignment method is when coupled. Final Alignment (at operating temperature after 1-hour of continuous operation):
 - 1) Check for pipe strain.
 - 2) Alignment shall be within tolerances (coupled).
 - d. Re-check alignment (at operating temperature):
 - 1) After a minimum of 24-hours of run time
 - 2) Alignment shall be within tolerances (coupled)
- 6. Additional Alignment Steps for Vertical Mixers:
 - a. Level gearbox.
 - b. Verify vertical plumbness of shaft (while shaft is not turning).
 - c. Grout.
 - d. Check shaft runout.
 - e. Install impeller blades.

3.06 FIELD TESTING

- A. Field testing shall be in accordance with Section 01 75 00 – Checkout and Startup Procedures.
- B. All equipment shall be set, aligned, and assembled in conformance with the manufacturer's drawings and instructions. Provide all necessary calibrated instruments to execute performance tests. Submit report certified by the pump manufacturer's representative.
- C. Preliminary Field Tests, Yellow Tag.
 - 1. As soon as conditions permit, after the equipment has been secured in its permanent position, the Contractor shall:
 - a. Verify that the equipment is free from defects.
 - b. Check for alignment as specified herein.

- c. Check for direction of rotation.
 - d. Check motor for no load current draw.
- 2. Contractor shall flush all bearings, gear housings, etc., in accordance with the pre-commissioning lubrication oil flushing plan and manufacturer's pre-printed written recommendations, to remove any foreign matter accumulated during shipment, storage or erection. Lubricants shall be added as required by the manufacturer's instructions.
- 3. When the Contractor has demonstrated to the Engineer that the equipment is ready for operation, a yellow tag will be issued. The tag will be signed by the Engineer, or the Engineer's assigned representative and attached to the equipment. The tag shall not be removed.
- 4. Preliminary field tests, yellow tag, must be completed before equipment is subjected to final field tests, blue tag.

D. Final Field Tests, Blue Tag

- 1. Upon completion of the above, and at a time approved by the Engineer, the equipment will be tested by operating it as a unit with all related piping, ducting, electrical and controls, and other ancillary facilities.
- 2. The equipment will be placed in continuous operation as prescribed or required and witnessed by the Engineer or the Engineer's assigned representative and the Owner or the Owner's assigned representative.
- 3. The tests shall prove that the equipment and appurtenances are properly installed, meet their operating cycles and are free from defects such as overheating, overloading, and undue vibration and noise. Operating field tests shall consist of the following:
 - a. Check equipment for excessive vibration and noise.
 - b. Check motor current draw under load conditions. The rated motor nameplate current shall not be exceeded. The rated motor nameplate horsepower shall not be exceeded when a torque transducer is provided.
 - c. Recheck alignment where applicable, after unit has run under load for a minimum of 24 hours.

E. Additional field testing recommended by the manufacturer shall be performed at no cost to Owner.

- F. Until final field tests are acceptable to the Engineer, the Contractor shall make all necessary changes, readjustments, and replacements at no additional cost to the Owner.
- G. Upon acceptance of the field tests, a blue tag will be issued. The tag will be signed by the Engineer and attached to the unit. The tag shall not be removed, and no further construction work will be performed on the unit, except as required during start-up operations and directed by the Engineer.
- H. Defects which cannot be corrected by installation adjustments will be sufficient grounds for rejection of any equipment.
- I. All costs in connection with field testing of equipment such as lubricants, temporary instruments, labor, equipment, etc., shall be borne by the Contractor. Power, fuel, chemicals, water, etc. normally consumed by specific equipment shall be supplied by the Owner unless otherwise specified in the individual equipment specifications.
- J. The Contractor shall be fully responsible for the proper operation of equipment during tests and instruction periods and shall neither have nor make any claim for damage which may occur to equipment prior to the time when the Owner formally takes over the operation thereof.
- K. Field testing of electric motors shall be in accordance with Section 26 05 60 – Low-Voltage Electric Motors and Section 26 05 00 – Basic Electrical Requirements.

3.07 VIBRATION TESTING

- A. Vibration testing shall be in accordance with Section 01 75 00 – Checkout and Startup Procedures.

3.08 FAILURE OF EQUIPMENT TO PERFORM

- A. Any defects in the equipment, or failure to meet the guarantees or performance requirements of the Specifications shall be promptly corrected by the Contractor by replacements or otherwise.
- B. If the Contractor fails to make these corrections, or if the improved equipment shall fail again to meet the guarantees or specified requirements, the Owner, notwithstanding their having made partial payment for work and materials which have entered into the manufacture of said equipment, may reject said equipment and order the Contractor to remove it from the premises at the Contractor's expense.
- C. The Contractor shall then obtain specified equipment to meet the contract requirements or upon mutual agreement with the Owner, adjust the contract price to reflect not supplying the specific equipment item.

- D. In case the Owner rejects said equipment, then the Contractor hereby agrees to repay to the Owner all sums of money paid to him for said rejected equipment on progress certificates or otherwise on account of the lump sum prices herein specified.
- E. Upon receipt of said sums of money, the Owner will execute and deliver to the Contractor a bill of sale of all rights, title, and interest in and to said rejected equipment; provided, however, that said equipment shall not be removed from the premises until the Owner obtains from other sources other equipment to take the place of that rejected.
- F. Said bill of sale shall not abrogate Owner's right to recover damages for delays, losses, or other conditions arising out of the basic contract.

3.09 PAINTING

- A. The equipment and motor shall be painted. All surface preparation, shop painting, field repairs, finish painting, and other pertinent detailed painting specifications shall conform to applicable paragraphs of Section 09 90 00 – Painting.
- B. All shop coatings shall be compatible with proposed field coatings.
- C. All inaccessible surfaces of the equipment, which normally require painting, shall be finished painted by the manufacturer.
- D. Gears, bearing surfaces, and other unpainted surfaces shall be protected prior to shipment by a heavy covering of rust-preventive compound sprayed or hand applied which shall be maintained until the equipment is placed in operation. This coating shall be easily removable by a solvent.

3.10 WELDING

- A. The Equipment Manufacturer's shop welding procedures, welders, and welding operators shall be qualified and certified in accordance with the requirement of AWS D1.1 "Structural Welding Code - Steel" or AWS D1.2 "Structural Welding Code - Aluminum" of the American Welding Society, as applicable.
- B. The Contractor's welding procedures, welders, and welding operators shall be qualified and certified in accordance with the requirements of AWS D1.1 "Structural Welding Code - Steel" or AWS D1.2 "Structural Welding Code - Aluminum" of the American Welding Society, as applicable.
- C. The Contractor shall perform all field welding in conformance with the information shown on the Equipment Manufacturer's drawings regarding location, type, size, and length of all welds in accordance with "Standard Welding Symbols" AWS A2.0 of the American Welding Society, and special conditions, as shown by notes and details.

END OF SECTION

Schedule 46 00 00 – 01 – Applicable Tolerance Range

Equipment Horsepower	ANSI/ASA S2.75 Quality Grade Tolerance Range
<= 25 HP	Minimal
> 25 HP < 100 HP	Standard
>= 100 HP	Precision

Scheduled ANSI/ASA S2.75 Quality grade tolerance range categories relate to ANSI/ASA S2.75 quantified tolerances for: levelness, plumbness, flatness, coplanarity, coplanar surface deviation, shaft runout, shaft-to-shaft alignment, flex plane offset, angularity, and offset per tolerance plane separation.

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SECTION 46 41 17
IN-LINE STATIC MIXING EQUIPMENT

PART 1 -- GENERAL

1.01 THE REQUIREMENT

- A. The Contractor shall furnish, install, test, adjust, and place in satisfactory operation in-line static mixing complete with mixing elements, housing pipe with flanges and injection ports compatible with all chemical injection assemblies as indicated on the Drawings and in Section 46 41 42 – Chemical Injection Assemblies.
- B. Equipment shall be provided in accordance with the requirements of Section 46 00 00 - Equipment General Provisions and Division 40 – Process Interconnections.

1.02 OPERATING CONDITIONS AND PERFORMANCE REQUIREMENTS

- A. In-Line Static Mixing Equipment

Service	Pre-Clearwell Chemical Injection
Max Lay Length	48 inches
Pipe Diameter	30"
Process Flow Rate	6.0 – 24.0 MGD
Process Line Pressure	10 psi
Max Pressure Drop	1.15 psi
Number of Chemical Injector Ports	See Section 46 41 42 – Chemical Injection Assemblies
Location	Post-GAC Chemical Vault, Glenville Lake

1.03 SUBMITTALS

- A. Shop Drawings shall be submitted with the Shop Drawings in accordance with, or in addition to, the submittal requirements specified in Section 01 33 00 – Submittal Procedures and Section 46 00 00 – Equipment General Provisions:
 - 1. Shop drawings with dimensions for general review.
 - 2. Product Data sheets for make and model being supplied
 - 3. Complete catalog information, descriptive literature, specifications and identification of materials of construction.

4. CFD Calculations are to be shown for flow characteristics, flow velocity and pressure drop.
5. Material of construction with ASTM reference and grade. Submit Manufacturer's compliance with referenced standards.
6. Chemical resistance data for wetted parts.
7. Operations and Maintenance Manual.
8. Submit Performance Affidavit in accordance with Section 46 00 00 – Equipment General Provisions.

PART 2 -- PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. The in-line static mixing equipment shall be as manufactured by Komax Systems, Inc., Koflo Corporation, Statiflo Corporation, or equal.

2.02 CONSTRUCTION AND MATERIALS

- A. The mixer shall be the static in-line type with no moving parts. Mixer shall provide uniform mixing of aqueous chemicals as specified herein.
- B. Mixing shall be by stationary, rigid elements arranged to split and recombine streams to provide a homogeneous stream at the mixer outlet. Mixing elements shall be constructed of grade 316L stainless steel.
- C. The mixer shall be fabricated in one piece and have flat faced flanges for insertion into the pipeline. Flanges shall be AWWA C207, minimum Class B rating. Refer to Section 40 06 20 – Process Pipe, Valve, and Gate Schedule for pressure rating requirements piping.
- D. Mixer housing shall be constructed of carbon steel and shall conform to AWWA C200. Steel pipe housing shall be new and shall meet or exceed the manufacturer and material requirements of ASTM A53, Grade B or ASTM A139, Grade B. Steel pipe shall be in accordance with AWWA M11 Design Guide
 1. Steel pipe shall be fabricated by either the spiral weld or single longitudinal seam method with a minimum yield strength of 35,000 psi. Design stress in the pipe wall at the design pressure shall not exceed 50 percent of the minimum yield strength of the steel.
 2. Steel pipe shall have a 0.25 in. minimum wall thicknesses.

3. The interior of the carbon steel housing and mixing elements shall be coated with an NSF-61 approved epoxy coating in accordance with Section 09 90 00 – Painting.

E. The mixer shall achieve a Coefficient of Variation (CoV) value of 0.05 or less for all injected chemical solutions across all flow conditions at a location 6 pipe diameters downstream of the mixer based on the following chemical dosing conditions.

	Solution Concentration Range	Chemical Flowrate Range
Sodium Hypochlorite	4%	5 – 60 gph
Orthophosphate	< 28% (as phosphate)	1.0 - 1.075 gpm (includes 1 gpm of carrier water)
Hydrofluosilicic Acid	< 23%	1.0 - 1.3 gpm (includes 1 gpm of carrier water)

- H. In the event the carrier water system fails, the injection lances and any other equipment in contact with the bulk chemicals must be materially compatible with the maximum bulk chemical concentrations as described in the table above.
- I. Injection ports shall be arranged in one row of three injection openings per row unless otherwise approved. Injection ports within shall be spaced 6 inches on center along the longitudinal axis of the mixer. All chemical injection assemblies on the project shall be of the same make; contractor shall coordinate to ensure compatibility between the injection assemblies specified in Section 46 41 42 – Chemical Injection Assemblies and the static mixer injection ports.
- J. The contractor shall provide a double flange isolating gasket kit for dielectric separation of the steel flanges on the static mixer from the ductile iron pipe on the upstream and downstream ends of the static mixer. Gasket shall be Type E, full faced isolating gasket. Flange isolating kit shall be made by Advanced Products and Systems Inc., Pipe Seal and Insulator, Inc. or equal.

PART 3 -- EXECUTION

3.01 MANUFACTURER'S FIELD SERVICES

- A. The services of a qualified manufacturer's technical representative shall be provided in accordance with Section 46 00 00 – Equipment General Provisions.

Service	Number of Trips	Number of Days/Trip
Installation, Testing, and Training	1	1

3.02 INSTALLATION

- A. The mixer shall be installed as indicated on the Drawings and as recommended by the manufacturer.
- B. Field tests shall be made in accordance with Section 46 00 00 – Equipment General Provisions, Section 43 20 00 – Pumps - General, and Division 1. Preliminary field tests shall be made as soon as possible after installation. Final acceptance tests shall demonstrate the following:
 - 1. That the pressure drop across the static mixer does not exceed the maximum pressure drop listed herein. Contractor shall coordinate with Engineer on where to locate temporary pressure gauges for measurement.

3.03 FIELD PAINTING

- A. The exterior of static mixer housing shall be field painted as specified in Section 09 90 00 - Painting.

- END OF SECTION -

SECTION 46 41 42
CHEMICAL INJECTION ASSEMBLIES

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. The Contractor shall furnish, install, test, adjust, and place in satisfactory operation chemical injection assemblies as shown on the Drawings and as specified herein.
- B. Equipment shall be provided in accordance with the requirements of Section 46 00 00 - Equipment General Provisions, and Division 40 – Process Interconnections.

1.02 OPERATING CONDITIONS AND PERFORMANCE REQUIREMENTS

- A. Chemical Injection Assemblies

Service	Sodium Hypochlorite	Hydrofluosilicic Acid	Zinc Orthophosphate
No. of Assemblies	1	1	1
Type of Feed Device	Injector	Injector	Injector
Maximum Concentration	4%	23%	28%
Chemical Pipe Diameter	1.5"	1"	1"
Chemical Pipe Material	PVC	PVC	PVC
Maximum Chemical Feed Rate	50 gph	3.1 gph	25 gph
Max Chemical Discharge Pressure	145 psi	100 psi	145 psi
Receiving Pipe Diameter	30"	30"	30"
Receiving Pipe Material	316 SS	316 SS	316 SS
Maximum Receiving Pipe Pressure	10 psi	10 psi	10 psi
Maximum Receiving Pipe Velocity	7.57 fps	7.57 fps	7.57 fps
Application Point	Post-GAC Chemical Vault, Glenville Lake	Post-GAC Chemical Vault, Glenville Lake	Post-GAC Chemical Vault, Glenville Lake

1.03 SUBMITTALS

- A. The following items shall be submitted with the Shop Drawings in accordance with, or in addition to, the submittal requirements specified in Section 01 33 00 – Submittal Procedures, and Section 46 00 00 – Equipment General Provisions:
 - 1. Equipment specifications and data sheets, with identification of all materials of construction.

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2. Complete assembly, layout, installation and shop drawings, with clearly marked dimensions, tolerances, jointing and anchoring details.
3. Weights of equipment component parts.
4. Chemical resistance data for wetted parts.

PART 2 – PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. The chemical injection assemblies shall be as manufactured by SAF-T-FLO Water Services, Inc., or approved equal.

2.02 CONSTRUCTION AND MATERIALS

- A. Each injection assembly shall be specifically designed for the particular chemical service for which it is being supplied. The materials of construction for the assemblies shall be compatible with the chemicals being fed and shall be suitable for the pressure in the chemical solution line and receiving pipe, the maximum velocity in the receiving pipe, and the insertion length.
- B. Chemical injection assembly components that come into contact with the chemical shall be constructed of materials that meet NSF-61 certification standards.
- C. Acceptable injection assembly construction shall be as follows:

Flanged Quill	Sodium Hypochlorite and Hydrofluorosilicic Acid	Zinc Orthophosphate
Injection Quill:		
Valve Class	150	150
Isolation Valve	Flanged [316 SS]	Flanged [316 SS]
Tube	Hastelloy C	316 SS
Tip Configuration	Standard	Standard
Check Valve Material	Hastelloy C	316 SS
Check Valve Seal	FKM	FKM
Flexible Tubing Assembly:		
Valve	PVC	PVC
Seal	FKM	FKM
Tubing	Reinforced PVC	Reinforced PVC

End Connection

FNPT Outlet

FNPT Outlet

- D. The injection assemblies shall be retractable and furnished with an isolation assembly, solution tube assembly including check valve, locking device, and safety chains. The locking device shall connect the solution tube to the corporation stop on the receiving pipe to prevent accidental withdrawal of the solution tube. A stainless steel safety chain shall prevent the solution tube from being withdrawn past the compression ring in the gland. Safety chain length shall be determined by the manufacturer based on solution tube length.
- E. The assemblies shall be sized to match the pump discharge line or injection flow rate and shall be of the same diameter as the chemical piping. The injection assembly solution tubes shall penetrate into the pipe a distance equivalent to a minimum of 1/3 of the pipe diameter into which the chemicals are being injected.
- F. Each injector shall be furnished with a flexible hose assembly consisting of flexible hose/tubing, connection fittings, seals and ball valve, specifically designed for the particular chemical service for which it is being supplied. Flexible hose assembly shall also be capable of withstanding maximum pump discharge line pressure.

PART 3 – EXECUTION

3.01 MANUFACTURER'S FIELD SERVICES

- A. The services of a qualified manufacturer's technical representative shall be provided in accordance with Section 46 00 00 – Equipment General Provisions.

Service	Number of Trips	Number of Days/Trip
Installation, Testing, and Training	1	1

3.02 INSTALLATION

- A. The Contractor shall furnish the chemical injectors and all associated equipment and accessories as required and specified herein in accordance with the manufacturer's instructions and in accordance with Section 46 00 00 – Equipment General Provisions.

END OF SECTION

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SECTION 46 61 00
CONTACTOR UNDERDRAINS

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. The Contractor shall furnish, install, and place into satisfactory operation the contactor underdrain system, and appurtenances for ten (10) granular activated carbon (GAC) contactors at Glenville Lake WTF and twelve (12) granular activated carbon (GAC) contactors at P.O. Hoffer WTF, complete with all necessary supports and appurtenances required to provide a complete installation as shown on the Contract Drawings and/or as specified herein. A single manufacturer shall take responsibility for all equipment furnished under this section.
- B. Equipment shall comply with the requirements of Section 46 00 00, Equipment General Provisions.
- C. Refer to Section 43 31 13.13, GAC Media.

1.02 OPERATING CONDITIONS AND PERFORMANCE REQUIREMENTS

- A. Underdrains

Design Parameter	P.O. Hoffer WTF GAC Contactors	Glenville Lake WTF GAC Contactors
Number	12	10
Configuration	Single Cell	Dual Cell
Nominal Cell Dimensions	30'-0" x 17'9"	18' 0" x 11' 3"
Loading Conditions		
Water temperature range, °C	4 - 32	4 - 32
Maximum Downflow Loading Rate, gpm/ft ²	5.0	5.0
Maximum Upflow Backwash Rate, gpm/ft ²	15.0	15.0
Maximum Headloss in Clean Contactor Underdrain During Normal Operation (downflow), inches	8	4
Maximum Headloss During Water Backwash (upflow), inches	45	45
Maximum Maldistribution of Backwash Water Flow	3%	3%

- B. The ability to efficiently repair the underdrain system if that becomes necessary is a key aspect of this project. Anchorage must be designed so that all elements of the underdrain system can be removed for repairs and/or cleaning and reinstalled without damaging any stainless steel contactor underdrain system components, concrete, or grout.

1.03 SUBMITTALS

- A. The following items shall be submitted with the Shop Drawings in accordance with the submittal requirements specified in Section 01 33 00, Submittal Procedures and Section 46 00 00, Equipment General Provisions:
1. Manufacturer's certification that media proposed (GAC) are compatible for use with the underdrain.
 2. Overall plans and sections, materials of construction, installation instructions and recommendations and leveling requirements for the underdrain.
 3. Complete headloss data for water flows through the underdrain header over all performance cases for this installation.
 4. Welder Certifications for underdrain system installation.

5. Verification of compliance with NSF/ANSI 61.
 6. Anchorage design details and calculations (sealed by a licensed professional engineer)
- B. The Contractor shall submit operation and maintenance manuals in accordance with Section 01 33 00, Submittal Procedures and Section 46 00 00, Equipment General Provisions.

1.04 MATERIAL WARRANTY

- A. Warranty and Guarantee shall be as specified in Section 46 00 00 – Equipment General Provisions and clarified herein.
- B. All materials furnished shall be guaranteed to be free from defects in design and/or materials for a period of five (5) years. The period of such warranties shall start on the date the particular materials are placed in use by the Owner with corresponding start-up certification provided as specified herein, provided that the materials demonstrate satisfactory performance during the thirty-day operational period after startup. If the materials do not perform satisfactorily during the thirty-day operational period, the start of the warranty period will be delayed until proper operation is demonstrated. Any material (or part thereof) which is defective or showing undue wear within the guarantee period, shall be either repaired or replaced with new material if the mechanical performance is unsatisfactory; furnishing all materials, labor, removal, and replacement of GAC media as required, etc., necessary to return to the specified performance level without charge to the Owner.

PART 2 – PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Two types of underdrains are approved for the contactor underdrain equipment.
1. Phoenix Underdrain System, AWI, Sandy, UT
 2. Triton Underdrain System, Johnson Screens, New Brighton, MN
- B. Identifying a manufacturer by name in these specifications indicates that the manufacturer is regularly engaged in the manufacture of contactor underdrain systems. The appearance of a manufacturer's name in these specifications in no way relieves the manufacturer from the obligation to provide a product that meets the detailed requirements of these specifications.
- C. The manufacturer must have regularly been involved in providing contactor underdrain systems for a period of five (5) years with valid reference projects installed in at least ten

(10) separate sites, and a total installation base in excess of 100,000 square feet of underdrain area. Valid references for fulfilling this requirement must use a stainless steel product identical to the product being offered for this project and projects must be of a size and scope of work that allows performance to be reasonably compared to this project.

- D. The materials furnished shall be designed, constructed, and installed in accordance with the best practices and methods and shall operate satisfactorily when installed as specified and per the manufacturer's recommendations. Installation of contactor underdrains and related improvements shall be performed by WGK Construction, Kemp, Inc., All-Service Contracting Corp., or approved equal. If the Contractor elects to self-perform this work, references shall be submitted with the Shop Drawings demonstrating that the Contractor has successfully installed the proposed equipment in the same application (municipal drinking water treatment) within the last 10 years. References shall include project location, owner contact information, number of installed underdrain systems, and total installed capacity (MGD).

2.02 GENERAL REQUIREMENTS

- A. The underdrain system shall be designed in accordance with the dimensions and layout shown in the Contract Drawings and shall cover the entire contactor floor area. It shall be suitable for water backwash, and shall be designed to ensure long term stability in its operating characteristics. The underdrain system shall be designed to resist plugging and all other effects which would in time cause loss of hydraulic efficiency (maldistribution) or effectiveness of its operation.
- B. Materials used in the underdrain system shall conform to the requirements specified herein.
- C. All equipment furnished shall be amply designed and constructed for the maximum stresses occurring during fabrication, erection, and continuous operation. All materials shall be new and both workmanship and materials shall be of the very best quality, entirely suitable for the service to which it is to be subjected and shall conform to all applicable sections of these specifications. All parts of duplicate equipment shall be interchangeable without modification. Manufacturer's design shall accommodate all the requirements of these specifications.
- D. All grout used in installing the laterals shall be cement grout meeting the requirements of Section 03 60 00. Grout shall be installed as required to provide a clean and level surface for the underdrains per the underdrain manufacturers recommendation.
- E. All exposed metals, anchor bolts, handrail bolts, washers, clips, clamps, fasteners of any type, etc. shall be constructed of 316 stainless steel. All anchor bolts shall be a minimum of ½-inch in diameter.

- F. The underdrain system shall be designed to withstand a differential pressure of 10 psi across a completely plugged underdrain lateral delivering the specified underdrain performance without failing structurally or leaking the specified GAC media at any fabricated joint. No credit shall be taken for the weight of the GAC media.
- G. Underdrains shall be anchored with anchor bolts along the entire length of the lateral and sufficient anchorage shall be provided to resist buoyant and dynamic forces during operation. Anchor bolts shall conform to the requirements specified herein and Section 05 05 23, Metal Fastening. Systems that use any anchoring system that cannot be tested in the field at the pull strength specified herein will not be permitted. All anchor bolts shall be a minimum of ½-inch in diameter. All adhesive anchors shall be epoxy type chemical bond anchor bolts and must be set according to instructions provided by the manufacturer and must be installed into the parent contactor box concrete. Anchors that only extend into the leveling grout will not be permitted. Anchorage system shall be capable of exceeding the structural requirements of supporting a vertical downward load of 1,600 pounds per square foot and a vertical upward load of 2,000 pounds per square foot.

2.03 CONTACTOR UNDERDRAIN EQUIPMENT

A. General Requirements

- 1. The contactor underdrains shall be furnished as a complete and integrated system by one manufacturer, and system shall include the underdrain laterals, header assembly, water seal plates, and angle hold-downs and installation hardware.
- 2. All welding performed during fabrication and installation of the underdrain system shall be performed by welders certified to the following American Welding Society standards:
 - a. AWS D1.3 - Structural Welding Code - Sheet Steel
 - b. AWS D1.6 - Structural Welding Code - Stainless Steel
 - c. AWS D17.2 - Specification for Resistance Welding - Spot Welding by Machine
 - d. AWS G2.1 - Guide for the Joining of Wrought Nickel-Based Alloys
- 3. The underdrain must be designed to accommodate water flow during a water backwash. The water conduit must make provisions to vent any air which might be trapped in the backwash piping to escape during backwashing operations.

B. Performance

1. The underdrain system shall provide uniform water backwash over the entire surface of the contactor. Maldistribution of backwash water flow shall not exceed the tolerances specified herein. There shall be no localized areas with flow rates which would cause mounding, lateral displacement, or other disturbances in the contactor media.

C. Laterals

1. Johnson Screens

- a. The contactor underdrain system shall consist of 316L stainless steel scallop laterals as shown on the plans. The laterals shall be unitized assemblies of Vee-Wire screen and perforated integral channel rod and shall be fitted for bottom center connections.
- b. The underdrains shall accommodate water backwash through the lateral and be specifically designed to provide uniform water during backwashing through integral channel rod orifices.
- c. The underdrain shall accommodate direct retention of media with no gravel layers. Design shall support 0.21 mm media materials without loss into the lateral.
- d. The media retention surface shall cover a minimum of 107% of the floor surface of the contactor and shall have a minimum open area of 10% of the floor surface area.
- e. Laterals shall have a maximum height of 5 inches and be supplied fully assembled to full length.
- f. Hold-down angles shall be provided in each contactor basin to secure the underdrain laterals in place. The hold downs shall be constructed from 316 stainless steel angle with stainless anchoring hardware. Number, size, and configuration of hold-down angles shall be as determined by the underdrain manufacturer.

2. AWI

- a. Laterals shall be one-piece construction designed to distribute water during contactor backwashing.
- b. The underdrains shall accommodate water backwash through a lateral and be specifically designed to provide uniform distribution of water during backwashing.

- c. Variably sized orifices shall be provided to control the distribution of backwash water.
- d. Media retaining slots having a maximum width of 0.25 millimeters shall be integrally fabricated with the laterals to support GAC media without the need for gravel while allowing passage of water for filtered water collection and backwashing.
- e. Laterals shall be fabricated from 316L stainless steel material.
- f. Anchorage shall be accomplished through the use of hold down clamps bolted to the concrete floor. Anchor bolts shall be of the epoxy bond type not less than ½-inch in diameter.
- g. Chemical bond anchor bolts shall be set according to instructions provided by the manufacturer.

D. Water Distribution Flume Configuration

1. Filtered water is collected and backwash water is distributed via a front flume as depicted in the Drawings. The contactor underdrain system shall include contactor underdrain laterals designed to span the flume with conduits for distribution of backwash water. The manufacturer shall conduct hydrostatic testing of the underdrain and testing of the entire system for water distribution.
2. Each lateral will have an integral seal plate where the lateral spans the flume. The seal plate will seal to the floor on either side of the flume. Each lateral seal plate will bolt and seal to the adjacent lateral.
3. Flume seal plates will include an orifice for each lateral to control the flow of backwash water to the lateral. Orifices will be designed to ensure that the water is metered in proportion to the area of the contactor that the lateral services.
4. Underdrain laterals will be sealed using a natural sponge rubber NSF 61 compliant gasket installed with an appropriate sealant.
5. The contactor underdrain anchorage system shall be capable of handling the structural loads specified herein, applied at the contactor flume.

PART 3 – EXECUTION

3.01 UNDERDRAIN SYSTEM INSTALLATION

- A. The equipment shall be installed and field tested by the Contractor in accordance with the instructions and drawings of the manufacturer and Section 46 00 00, Equipment General Provisions.
- B. The Contractor shall ensure that the underdrain deck is completely clean and free from debris and foreign materials before installing the new underdrain system specified herein.
- C. The Contractor shall arrange for the equipment manufacturer to furnish the services of a qualified service person with at least three (3) years of experience who is regularly involved in the inspection, installation, start up, troubleshooting, testing, maintenance, and operation of contactor underdrain systems. The service person shall:
 - 1. Witness and check installation of the system.
 - 2. Assist the Contractor in conducting field tests and preparing a written report as specified below.
 - 3. Witness and check startup of the system.
 - 4. Assist the Contractor in making adjustments and modifications as necessary to optimize operation of system components.
 - 5. Troubleshoot and correct any problems with the underdrain system which are noted during tests and startup.
 - 6. Submit written certification that the system has been properly installed, tested, and adjusted including date of final acceptance test, as well as a listing of all persons present during the tests.
 - 7. Investigate and supervise correction of any operating problems which may arise up to the end of the guarantee period of the equipment. Such services shall be furnished at no additional cost to the Owner.
- D. The underdrain shall be securely anchored against all testing and operating conditions. Anchors shall be furnished by the underdrain system manufacturer.
- E. The Contractor shall obtain from the underdrain manufacturer such written installation details and recommendations as are necessary to interface the contactor underdrain system with all surrounding structures, including requirements for grouting keys and pockets, dowels, support ledges, anchorage, etc. The Contractor is cautioned that such installation details are not shown on the Contract Drawings.

- F. Contactor underdrains shall not be installed until each contactor box has been inspected for watertightness and all leaks have been repaired.
- G. A backwash circuit flush shall be performed on each contactor prior to underdrain installation, to remove foreign debris from the contactor flume and to allow for measuring the baseline backwash piping system backpressure. The circuit flush shall have a duration of five (5) minutes at the typical seasonal contactor backwash flow rate.
- H. The Contractor shall take precautions as required to prevent breakage or warpage of any stored or installed underdrain component. Underdrain components shall be handled carefully to prevent damage and shall be stored on platforms supported clear of the ground. Only sound, undamaged units shall be installed. Units damaged before final completion of the work shall be removed and replaced with undamaged units by the Contractor without additional expense to the Owner.
- I. After the adhesive manufacturer's recommended cure time has elapsed, pull tests shall be performed on 25% of the anchor bolts in one contactor box prior to installing underdrains in the next contactor box. The Engineer shall select the exact bolts for testing and shall witness the test. For testing, anchor bolts shall be proof tested to 1.33 times the allowable load as specified herein. No visible signs of movement of the anchor bolts/dowels is permitted under this load. Upon receiving satisfactory results from these tests, installation may commence on the next contactor box underdrain and anchors. If satisfactory results are not obtained, Contractor shall make whatever provisions necessary to reinstall the failed anchors and achieve the specified pull strength. Testing may continue in the next contactor on 25% of the anchor bolts. After satisfactory results are obtained on 25% of the anchor bolts in one contactor, test a minimum of 10% of the anchors, as selected by the Engineer, in the remaining contactor boxes as previously described.
- J. Contractor shall take all necessary precautions recommended by the underdrain manufacturer in writing and as specified herein to ensure that the underdrain system and piping connected thereto is completely clean and free of any debris, dirt, or other foreign materials which could clog the underdrain system or interfere with flow. Backwash water piping shall be thoroughly flushed clean. All loose debris and dirt within the contactor shall be removed by brooming down, vacuuming, and water flushing. Care shall be taken as necessary to prevent grout from extruding into any flow passages or ports, and any such grout shall be removed. As installation progresses, underdrain sections partially completed shall be protected with heavy building paper, masking tape, or other means to maintain cleanliness. Cleanliness shall be maintained until final placement of contactor media.
- K. The final underdrain assembly shall be level to within $\pm \frac{1}{4}$ -inch.

3.02 FIELD TESTING OF UNDERDRAIN SYSTEM

- A. The Contractor shall conduct all testing specified herein and recommended by the manufacturer, and shall furnish all material, instrumentation, temporary pumps, personnel, etc. for conducting tests as specified herein. Finished water shall be used for all field tests in this section. The costs of all work and materials to correct deficiencies revealed during testing and the cost of retesting shall be borne by the Contractor.
- B. The Contractor shall submit a test plan for Engineer review and approval prior to field testing.
- C. The underdrain system in each contactor shall be flooded with water to the top of the underdrain system in order to ascertain that the level tolerance is as specified herein. Measurements of level tolerance shall be collected at representative locations within the contactor and reported to the Engineer.
- D. After start-up and prior to final acceptance, the Contractor shall conduct an Engineer witnessed performance demonstration test on the contactor underdrains in one of the contactors selected by the Engineer. Uniformity of backwash water distribution shall be confirmed to be within the allowed variance of $\pm 3\%$ by isolating and sealing four (4) separate minimum two thirds of a square foot segments of the contactor and directly measuring the rate of flow in each segment. Measurement in each segment will be accomplished by timing the rate of liquid level rise within the segment. Pressure measured inside a contactor underdrain is not proportionate to the key backwash flow parameter. As a result, measurement of pressure in an attempt to infer backwash rate of flow is not acceptable.
- E. The contactor underdrain system in each contactor shall be given a visual water flow distribution test to verify that orifices are not clogged with debris and flow distribution is uniform. This test shall be performed before contactor media is placed. The contactor underdrain system shall be partially filled with clean water to approximately half the height of the underdrain system at the beginning of the test. The test flow rate shall very slowly and gradually approach the normal design backwash rate as specified herein, and the flow rate shall be sustained for approximately 2 minutes while visual observations are made. The test shall be repeated three (3) times. During each test, flow from each orifice as well as any sign of dead spots or boils shall be visually observed and corrected as required.
- F. The Contractor shall take all necessary measures to correct any deficiencies revealed by these tests and shall repeat the specified tests until such deficiencies are corrected.

3.03 MANUFACTURER'S FIELD SERVICES

- A. The services of a qualified manufacturer's technical representative shall be provided in accordance with Section 46 00 00, Equipment General Provisions, and shall include the following for each plant:

1. Field Testing of the Underdrain System
 2. Installation Supervision and Checking
 3. Final Checking and Certification
 4. Backwash Testing
- B. The minimum number of days required to complete these services are 16 days for P.O. Hoffer WTF and 30 days for Glenville Lake WTF.
- C. Qualified field service representatives must be a direct employee of the underdrain system manufacturer and have a minimum of three (3) years of experience installing the specific contactor underdrain product provided for this project.
- D. Any additional time required to achieve successful installation and operation shall be at the expense of the Contractor.

END OF SECTION

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SECTION 46 61 19
CONTACTOR WASHWATER TROUGHS

PART 1 – GENERAL

1.01 THE REQUIREMENT

- A. The Contractor shall provide all labor, materials, equipment and incidentals as shown, specified and required to furnish and install fiberglass-reinforced plastic (FRP) troughs complete and operational as shown and specified.
- B. The Manufacturer shall provide all materials, and necessary services, for the installation of FRP wash troughs including all structural components for support and anchoring and field services for inspecting and performance testing.
- C. The Contractor shall coordinate with the Manufacturer regarding details of Manufacturer's scope, schedule, and terms and conditions.
- D. Troughs shall be furnished in accordance with the requirements of NSF and AWWA.
 - 1. NSF/ANSI 61 – Drinking Water System Components - Health Effects. The manufacturer shall have a current NSF-61 certification.
 - 2. ANSI/AWWA F101 – Contact Molded, Fiberglass-Reinforced Wash-Water Troughs and Launderers
- E. The wash trough system shall be designed to withstand, with a prudent safety factor, either intermittent operation or continuous 24-hour per day operation.

1.02 RELATED SPECIFICATIONS

- A. Division 5 – Metals.
- B. Section 06 51 00 – Glass Fiber and Resin Fabrications
- C. Section 33 01 10.13 – Disinfection of Water Treatment Facilities
- D. Section 43 31 13.13 – GAC Adsorption System Media
- E. Section 46 61 00 – Filter Underdrain System
- F. Other Divisions or Sections, not referenced above, shall also apply to the extent required for proper performance of the Work.

1.03 QUALITY ASSURANCE

- A. Manufacturer's Qualifications: Manufacturer shall have experience in manufacturing FRP troughs of the same or larger size to the items specified. For a manufacturer to be determined acceptable for providing FRP troughs on this project, it must show evidence of five (5) separate, substantially similar installations, which have been in satisfactory operation for a minimum of five (5) years.
- B. All items specified herein shall be obtained from a single supplier or manufacturer who, with the Contractor, shall assume full responsibility for the completeness of the system.
- C. Source Quality Control
 - 1. Shop Tests: As a minimum, supply certified test reports for each fiberglass-reinforced plastic fabrication in accordance with the following:
 - a. ASTM D 256, Impact, Notched Izod.
 - b. ASTM D 570, Water Absorption.
 - c. ASTM D 638, Tensile Strength.
 - d. ASTM D 696, Coefficient of Linear Thermal Expansion.
 - e. ASTM D 790, Flexural Strength.
 - f. ASTM D 790, Flexural Modulus
 - g. ASTM D 2583, Barcol Hardness.
 - 2. Obtain test specimens and conduct test program as specified in AWWA F101.
 - 3. Each test shall be witnessed by a professional engineer who may or may not be an employee of the manufacturer. Licensed professional engineer shall sign and seal all test reports. The state of the Engineer's registration, Engineer's number, and name on the seal shall be clearly legible.
 - 4. Fabrications shall not be shipped until the Engineer has approved the test reports.
- D. Reference Standards: Comply with applicable provisions and recommendations of the following, except as otherwise shown or specified:
 - 1. American Society of Testing and Materials, ASTM.
 - 2. American National Standards Institute, ANSI.
 - 3. National Sanitation Foundation, NSF.

4. American Water Works Association, AWWA.
5. Standards of the Reinforced Plastics/Composites Institute.
6. National Bureau of Standards, PS 15-69.

1.04 SUBMITTALS

- A. Shop Drawings: The Contractor shall submit for approval the following:
 1. Manufacturer's literature, illustrations, specifications and engineering data including materials of construction, dimensions, weight and performance data.
 2. Drawings showing the general arrangement of the equipment and methods of installation with detailed mounting 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.
 3. Affidavit of Compliance in accordance with Section 1.5 of AWWA F101.
 4. Site storage requirements.
 5. Installation requirements.
 6. Leveling approaches.
- B. Calculations: The Contractor shall submit, for record purposes only, design calculations for the following:
 1. Maximum vertical deflection of troughs under full buoyant or gravity load.
 2. Maximum sidewall deflection of troughs.
 3. Maximum bottom deflection of troughs.
 4. Maximum stress developed in trough walls.
 5. Contraction and expansion of troughs.
 6. Design of supports and wall connections.
- C. Test Results: The Contractor shall submit results of tests specified herein.
- D. Operation and Maintenance Data: The Contractor shall submit Operations and Maintenance Manuals in accordance with Section 01 33 00, Submittals and 01 78 23, Equipment Operation and Maintenance Data.

1.05 PRODUCT DELIVERY, STORAGE AND HANDLING

- A. Deliver materials to the site to ensure uninterrupted progress of the Work. Deliver anchorage devices which are to be embedded in or attached to cast-in-place concrete in ample time not to delay the Work.
- B. Handle all FRP materials and appurtenances very carefully. Any material which is damaged will not be acceptable.
- C. Store materials to permit easy access for inspection and identification. Protect equipment including packaged materials from weather, corrosion, and deterioration.

1.06 WARRANTY

- A. Warranty shall be provided in accordance with the requirements of Sections 01 61 00 - Product Requirements and Options, 01 75 00 - Checkout and Startup Procedures and 46 00 00 - Equipment General Provisions.
- B. Warranty shall be for a period of three (3) years.

PART 2 – PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Provide fiberglass-reinforced plastic troughs as manufactured by one of the following:
 - 1. Warminster Fiberglass
 - 2. Leopold
 - 3. Midwestern Fabricators
 - 4. Enduro Composites
 - 5. Protectolite
 - 6. NEFCO

2.02 GENERAL REQUIREMENTS

- A. Description: Construct troughs of fiberglass-reinforced polyester resin laminates embedded with 316 stainless steel reinforcing and to the dimensions and shapes shown. Troughs shall be specifically designed, constructed and installed in the Contactors as indicated on the Drawings and comply with the characteristics specified herein.
- B. Characteristics of the Troughs and water entering the Contactors shall be as follows.
Note: All dimensions shall be field verified prior to Fabrication.

	P.O. Hoffer WTF	Glenville Lake WTF
Number of cells per contactor	1	2
Number of troughs per cell	4	3
Total number of troughs	48	60
Contactor cell interior dimensions	30'-0" length 17'-9" width	18'-0" length 11'-3" width
Trough length	17'-9" + gullet wall thickness	11'-3" + gullet wall thickness
Trough interior width	18"	15"
Trough depth	20" + weir plate	16" + weir plate
Trough bottom configuration	Round	Round
Trough spacing	7'-6" on center 3'-9" from outer walls to centerlines of outboard troughs	4'-9" on center 2'-4" from outer walls to centerlines of outboard troughs
Maximum flow per trough	2,000 gpm	1,100 gpm
Water temperature range	4°C to 32°C	4°C to 32°C
pH range	6.0 - 8.0	6.0 - 8.0
Free chlorine residual	< 2 ppm	< 2 ppm

C. Trough Loadings

1. Troughs shall be capable of supporting, within stress and deflection limitations, the following loads:
 - a. Gravity Loads: All downward vertical loads including the weight of the trough and appurtenant attachments together with the weight of water at the maximum water surface elevation within the trough.
 - b. Buoyant Load: The load which acts vertically upward and which is equal in magnitude to the weight of the water displaced by the trough. Consider the line of action of this force to pass through the centroid of the submerged cross-sectional area.
 - c. Lateral Load: Loads acting against the trough side walls, specifically those induced by differential water levels on either side of the trough walls.
 - d. When calculating deflection, fiber stress and other critical properties, use the maximum possible differential existing when the trough is empty and the tank full, or when the trough is full and the tank is empty.

D. Trough Deflections and Expansion/Contraction

1. Design troughs to meet the limits specified below:
 - a. Vertical Deflection: Maximum vertical deflection under full buoyant or gravity load measured at the mid-point between supports shall not exceed 3/16-inch or $L/1000$, whichever is less, where L is the unsupported length in inches.
 - b. Side Wall Deflection: Maximum trough side wall horizontal deflection under full lateral load shall not exceed 3/16-inch or $D/100$, whichever is less, where D is the trough depth, in inches.
 - c. Maximum bottom deflection under full buoyant or gravity load shall not exceed 3/16-inch or $W/100$, whichever is less, where W is the trough width in inches.
 - d. Glass Fiber Stress: In addition to the deflection criteria specified above, design troughs such that the maximum wall stress under the most severe loading condition does not exceed 1,500 psi.
 - e. Thermal Expansion/Contraction: Design troughs to accommodate a thermally induced expansion or contraction in length over a temperature range of -10 to 100°F. Troughs shall be capable of withstanding ambient temperature variations of up to 80°F that could occur within a 24-hour period without exceeding specified deflection or stress limitations.

- E. Torsional Stability: Design trough systems to resist torsional oscillations induced by the flow of water over the trough edges. Maximum allowable torsional oscillation sideways or torsionally during normal operating conditions shall be 3/8-inch. Provide torsional stabilization by methods described in Section 4.3.2.3 of AWWA F101 when torsional oscillation exceeds the maximum allowable limit. Provide wall-to-wall lateral stabilizers for backwash troughs installed in air-scour backwash systems as specified in Section 4.3.2.3 of AWWA F101. Design of stabilizers and appurtenant mounting hardware shall be the responsibility of the trough manufacturer.

2.03 DETAILS OF CONSTRUCTION

- A. Classification: Troughs shall be Type I fabrications as defined in Section 4 of AWWA F101.
- B. Materials of Construction
 1. Troughs
 - a. Reinforcing Materials

- 1) Glass Fiber: Materials used shall be Type E (electrical borosilicate), or equivalent, glass with a chrome or silane finish, and a binder compatible with the resin. Surfacing veil, if used, shall be 0.010-inch Type C (chemical) or equivalent, veil with a binder containing silane and compatible with the lay-up resin.
- 2) Synthetic Fibers: Use synthetic surfacing mat for chemical environment when Type C veil is not compatible with the intended chemical environment.
- 3) Metallic: Metal reinforcements shall be 316 stainless steel, free of rust, oil and foreign matter. Completely encapsulate reinforcement with 1/8-inch laminate to ensure against pinhole bleeding and subsequent rust streaking. Galvanizing or rust inhibitive priming does not preclude requirement for encapsulation.
- 4) Composites: Use liquid-resistant materials such as end-grain balsa wood or closed-cell polyurethane foam for core materials. Standard wood products are not acceptable.

b. Plastic Resin

- 1) Resin shall be a commercial-grade polyester thermosetting resin which has either been evaluated in a laminate or which has been determined to be acceptable for the service conditions intended.
- 2) Resin shall contain no fillers or additives except as follows:
 - a) A thixotropic agent, which does not interfere with laminate quality or with the required chemical resistance of the laminate, may be added for viscosity control.
 - b) Pigments, dyes or colorants used shall be suitable for contact with potable water. Pigments shall be light stable, not soluble in water and compatible with the resin. Color shall be translucent blue-green.
 - c) Ultraviolet Stabilization: Provide ultraviolet stabilizers in all laminates. The laminate shall exhibit not greater than 2 percent deterioration of flexural and tensile properties after 1,000 hours of exposure in a Type F, single open-flame, sunshine carbon-arc lamp apparatus as detailed in ASTM G 23.
 - d) Additives: Add catalysts, accelerators and/or promoters to provide a complete cure of the laminate and to meet the physical properties specified herein.

C. Laminate Construction

1. General: Laminate comprising the fabrications shall consist of a molded or inner surface, a structural layer, and an exterior or outer surface with integral metallic structural elements as required.
 - a. Inner Surface: The molded or inner surface shall be one of the following systems:
 - 1) A resin-rich layer, 0.010 to 0.020-inch thick, reinforced with a C veil surfacing mat or an organic fiber surface material as specified herein. This resin-rich layer shall contain less than 20 percent by weight of the reinforcement material.
 - 2) A gelcoat consisting of a resin-rich layer 0.015 to 0.020-inch thick may be used in place of that specified above. Acceptable commercial gelcoat resins shall have been tested and proven in fabrications manufactured for use in potable water service.
 - a) Gelcoat used for surfacing shall be a commercially manufactured gelcoat, shall be crack and craze resistant, and shall exhibit the following properties:

Property	Test Method	Value of Property
Minimum Tensile Strength	ASTM D 638	6 x 10 ³ psi
Minimum Modulus of Elasticity	ASTM D 638	4.5 x 10 ³ psi
Minimum Barcol Hardness	ASTM D 2583	35
Maximum Water Absorption	ASTM D 570	0.2%
Porosity, Blisters, Wrinkles	None	N/A

- b) The gelcoat shall be compatible with the resins and shall not show delamination from the substrate when subjected to the tests described in Section 5 of AWWA F101.
 - b. Structural Layer
 - 1) Reinforcement placed after that which is installed in the inner surface shall consist of plies of chopped strand mat or spray-up passes to provide a laminate structure in accordance with the requirements specified herein.
 - 2) In all structural designs, each successive ply or pass of reinforcement shall be thoroughly wetted with resin and shall be well rolled to exclude

all air pockets and bubbles prior to the application of additional reinforcement.

- c. Exterior Surface: Exterior or outer surface shall consist of a resin-rich layer not less than 0.020-inch thick of resin paraffinated to prevent air inhibition. Apply exterior surface after gelation or cure of the structural layer suitably embeds all reinforcing fibers.
2. Integral Metallic Elements: Encapsulate integral metallic structural elements, where required, as specified herein. Extend overlay laminate or encapsulate, where feasible, a minimum of 2-inches beyond the metal members.
3. Composite Structural Elements: Encapsulate core elements of composite structural fabrications with a minimum of 1/8-inch structural laminate layer. Extend overlay, where feasible, not less than 2-inches beyond the core member.
4. Reinforce troughs with integrally shaped longitudinal stiffener sections. Additional horizontal stiffness and rigidity may be provided through the use of spreaders placed at appropriate points and fastened to the troughs with stainless steel hardware.
5. Laminate Cuts, Slots and Holes: Sand smooth and seal with resin solution all cut edges, drilled holes, machined slots and similar work and laminate structures. Paraffinate resin solution to prevent air inhibition and to ensure complete sealing of edges to prevent water from penetrating or wicking into the laminate.
6. Tolerances
 - a. Top edges of troughs shall be level and parallel with a tolerance of 1/8- inch, measured when the fabrications are empty.
 - b. Length of troughs shall have a tolerance of 1/8-inch per 10 feet.
 - c. Thickness of fabrications shall be in accordance with requirements specified herein, but not less than 3/16-inch. Thickness tolerance shall be 1/16-inch, but in no event shall thickness be less than 3/16-inch.
 - d. At locations of supports such as saddles, thickness shall be at least 1.5 times the nominal thickness of the fabrication and shall be in accordance with the fiber stress limitations specified herein.
 - e. End flanges and blind ends shall be not less than 1.5 times the nominal thickness of the fabrication and shall be in accordance with the fiber stress limitations specified herein.
7. Finish and Appearance

- a. Check finished laminate visually. Defects in excess of limitations stipulated in Table 5 of AWWA F101 may be cause for rejection. Defects in excess of those listed in Table 5 of AWWA F101 may be repaired except where such repairs may affect the serviceability of the fabrication.
 - b. Repair defects by sanding or grinding to remove defective areas. Follow by coating with an overlay of paraffinated resin, used for manufacture and reinforcement consisting of a minimum of one layer of 1.5 oz/sf chopped strand glass, plus either a surfacing mat 0.015-inch of gel-coat. Buildup all repaired areas until the surface is flush and the original thickness is restored. Fill pits or other small deep defects with resin putty. All such remedial work shall be subject to the approval of Engineer.
 - c. There shall be no areas of the laminate that are excessively resin rich or poorly wetted out. The laminate shall be dense without dry spots or cracked or crazed surfaces. Minimum ratio of resin to glass shall be 70 to 30.
8. Minimum Physical Requirements: All laminates shall meet the minimum physical properties listed below:

Property	Test Method	Value of Property
Tensile Strength	ASTM D 638	12.0 x 10 ³ psi
Flexural Strength	ASTM D 790	19.0 x 10 ³ psi
Flexural Modulus	ASTM D 790	900 x 10 ³ psi
Barcol Hardness	ASTM D 2583	35 (min.)
Izod Notched Impact	ASTM D 256	13 ft-lb/in.
Water Absorption (24 hr)	ASTM D 570	0.2% max.

D. Trough Details

1. Provide an integrally-molded water stop on the discharge end of each trough for installation in oversized wall openings.
2. The back end of each trough shall be integrally formed with the bottoms and walls of the fabrications. Provide slotted holes in the back end of each trough to permit a minimum vertical leveling adjustment of 1-1/2 inches. Provide space between mounting walls and troughs for thermal expansion.
3. Provide adjustable FRP weir plates conforming to Section 06 51 00 – Glass Fiber and Resin Fabrications. Weir plates shall be installed at elevation shown in drawings and have vertical adjustment of 2 inches.

4. Each trough shall be provided in one continuous piece with no flanged connections.
5. Lateral support shall be provided between troughs with 316 stainless steel structural elements. Holes in the trough necessary for support shall be sealed completely to provide a watertight trough.

2.04 IDENTIFICATION

- A. Provide each FRP trough furnished under this Specification with product identification as described in Section 6.1.1 of AWWA F101.

2.05 ACCESSORIES

- A. Provide all mounting brackets, anchor bolts, supports, stabilizing bars, angles or rods, fasteners and similar accessories required for installation of the equipment furnished. All accessories shall be Type 316 stainless steel.
- B. The trough manufacturer shall design and furnish Type 316 SST supports for the closed end of each trough as shown on the Drawings.
- C. The trough manufacturer shall design and furnish wall-to-wall lateral stabilizers for backwash troughs as specified herein.
- D. The trough manufacturer shall design and furnish and Type 316 SST intermediate hanger supports and support beams as shown on the Drawings.
 1. Intermediate hanger supports shall be designed to withstand the gravity and buoyant loads defined herein while limiting trough deflection in accordance with the requirements of this Section and AWWA F101.
 - a. Support beams shall be sufficiently designed such that beam deflection under all cases shall be limited to 3/16-inch.
 - b. Support beams shall be sufficiently designed to independently support troughs at intermediate support points without adjacent troughs providing support.
 2. If the troughs are capable of withstanding the loads and meeting the deflection requirements defined herein and in AWWA F101 without intermediate hanger supports, the trough manufacturer may submit design calculations demonstrating that intermediate hanger supports and support beams are not required. Calculations shall be submitted in accordance with the requirements of Part 1 of this Section.

PART 3 – EXECUTION

3.01 INSPECTION

- A. Contractor shall inspect and verify that structures or surfaces on which the equipment will be installed have no defects which would adversely affect the installation.
- B. Contractor shall promptly report, in writing, defects which may affect the Work to the Engineer.

3.02 INSTALLATION

- A. Install in a manner and to the tolerances recommended by the equipment manufacturer. Do not install damaged items. Install troughs, weirs, and trough supports such that the installed troughs are watertight when full.
- B. Set anchor bolts in accordance with approved manufacturers drawings.
- C. Install troughs at the locations and to the elevations shown. Maximum variation of the weir edges from level, throughout the entire length of the trough, shall not exceed 1/8 inch.
- D. After the troughs have been leveled and aligned to the required accuracy, the troughs, stabilizer assemblies, and support assemblies shall be field drilled and bolted.
- E. Seal all edges cut in the field with resin.

3.03 MANUFACTURERS FIELD SERVICES

- A. Manufacturer's field services shall be provided in accordance with Section 01 75 00 – Checkout and Startup Procedures.
- B. A manufacturer's factory-trained representative shall check and approve all installations before operation. The representative shall operate and test system in the presence of Engineer and verify that the equipment conforms to requirements, and instruct plant personnel on care and maintenance. The representative shall revisit the job site as often as necessary until all deficiencies are corrected.
- C. The services of the manufacturer's representative shall be provided as follows:
 - 1. One (1) trip of two (2) days to supervise and check installation of the wash troughs for P.O. Hoffer.
 - 2. One (1) trip of two (2) days to supervise and check installation of the wash troughs for Glenville Lake.

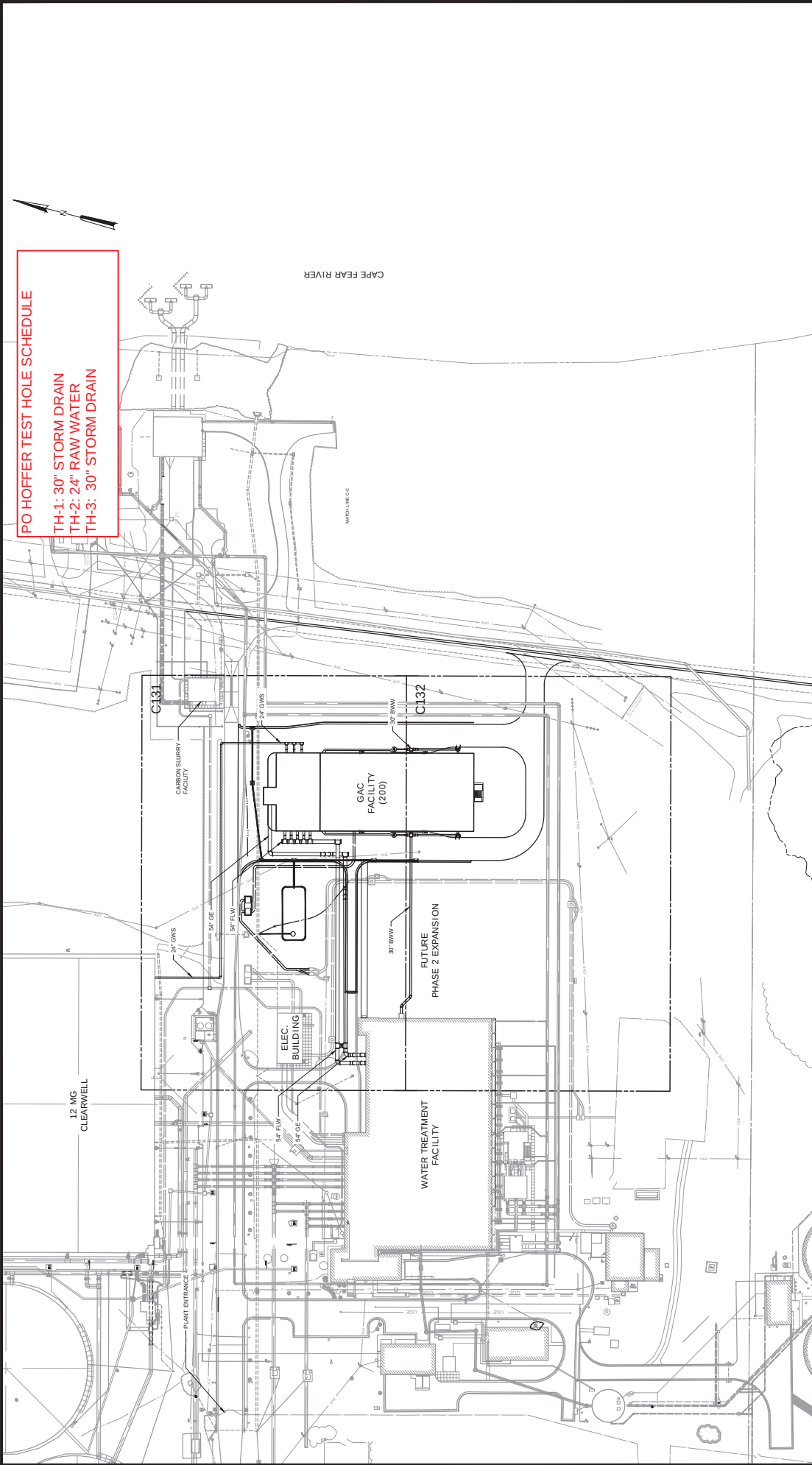
3. One (1) trip of one (1) day to perform final checking and certification of the installation and to instruct the Owner's personnel in proper operation and maintenance of the equipment for P.O. Hoffer.
 4. One (1) trip of one (1) day to perform final checking and certification of the installation and to instruct the Owner's personnel in proper operation and maintenance of the equipment for Glenville Lake.
- D. Testing of the equipment shall be performed under the technical direction of the manufacturer's factory-trained representative.
1. The troughs shall be filled with water and visually inspected for leakage. Any leaks shall be repaired.
 2. A backwash shall be conducted in each contactor cell and the troughs shall be visually inspected for leakage, deflection, and oscillation. Non-functioning components (including support systems) shall be repaired.

END OF SECTION

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APPENDIX A

SUE TEST RESULTS

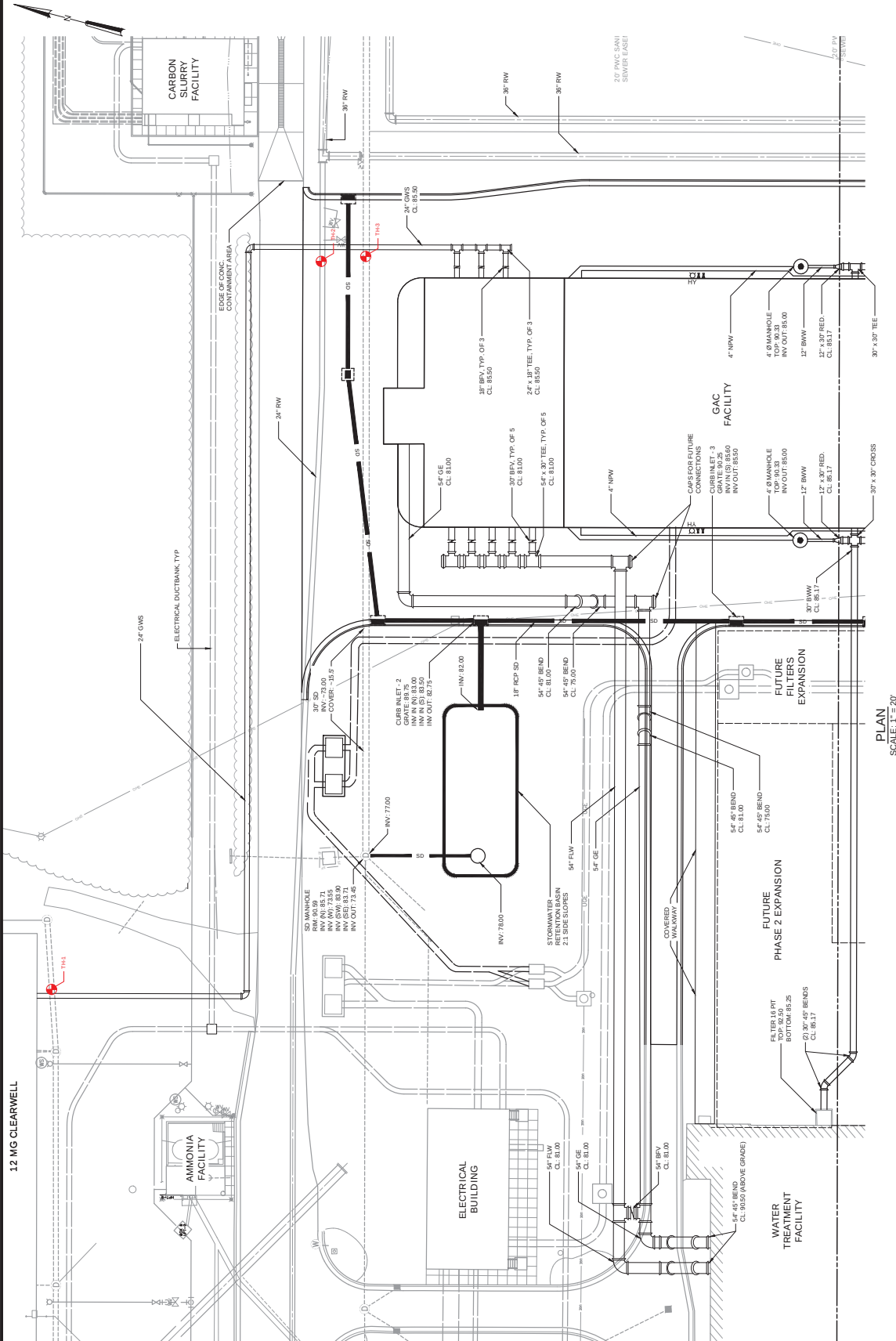


PLAN
SCALE: 1" = 60'



PROJECT ENGINEER C. HOPKINS		PRELIMINARY DRAWING DO NOT USE FOR CONSTRUCTION		PUBLIC WORKS COMMISSION CITY OF FAYETTEVILLE, NORTH CAROLINA		P. O. HOFFER - CIVIL YARD PIPING PLAN OVERALL SITE PLAN		DATE 2024
DESIGNED BY: K. THOMPSON		DRAWN BY: A. MARCH		GLENVILLE LAKE AND P.O. HOFFER WATER TREATMENT FACILITY POST FILTER GAC ADSORPTION FACILITIES		HAZEN NO.: 30402-067		HAZEN NO.: 30402-067
CHECKED BY: K. THOMPSON		IF THIS BAR DOES NOT MEASURE 1" THIS DRAWING IS NOT TO FULL SCALE		GLENVILLE LAKE AND P.O. HOFFER WATER TREATMENT FACILITY POST FILTER GAC ADSORPTION FACILITIES		CONTRACT NO.: 1		CONTRACT NO.: 1
ISSUED FOR		BY		C130		DRAWING NUMBER		DRAWING NUMBER

Hazen
HAZEN AND SAWYER
4011 WESTCHASE BOULEVARD, SUITE 500
RALEIGH, NORTH CAROLINA 27607
LICENSE NO.: C-5581



PROJECT ENGINEER

DESIGNED BY

DRAWN BY

CHECKED BY

ISSUED FOR

REV

C. HOPKINS

K. THOMPSON

A. MARCH

K. THOMPSON

DATE

BY

PRELIMINARY DRAWING

DO NOT USE FOR CONSTRUCTION

HAZEN

HAZEN AND SAWYER

4011 WESTCHASE BOULEVARD, SUITE 500

RALEIGH, NORTH CAROLINA 27607

LICENSE NO.: C-03581

PUBLIC WORKS COMMISSION

CITY OF FAYETTEVILLE, NORTH CAROLINA

GLENVILLE LAKE AND P.O. HOFFER WATER TREATMENT FACILITY POST FILTER GAC ADSORPTION FACILITIES

P. O. HOFFER - CIVIL

YARD PIPING PLAN

AREA 1

DATE

HAZEN NO.

CONTRACT NO.

DRAWING NUMBER

C131

20'

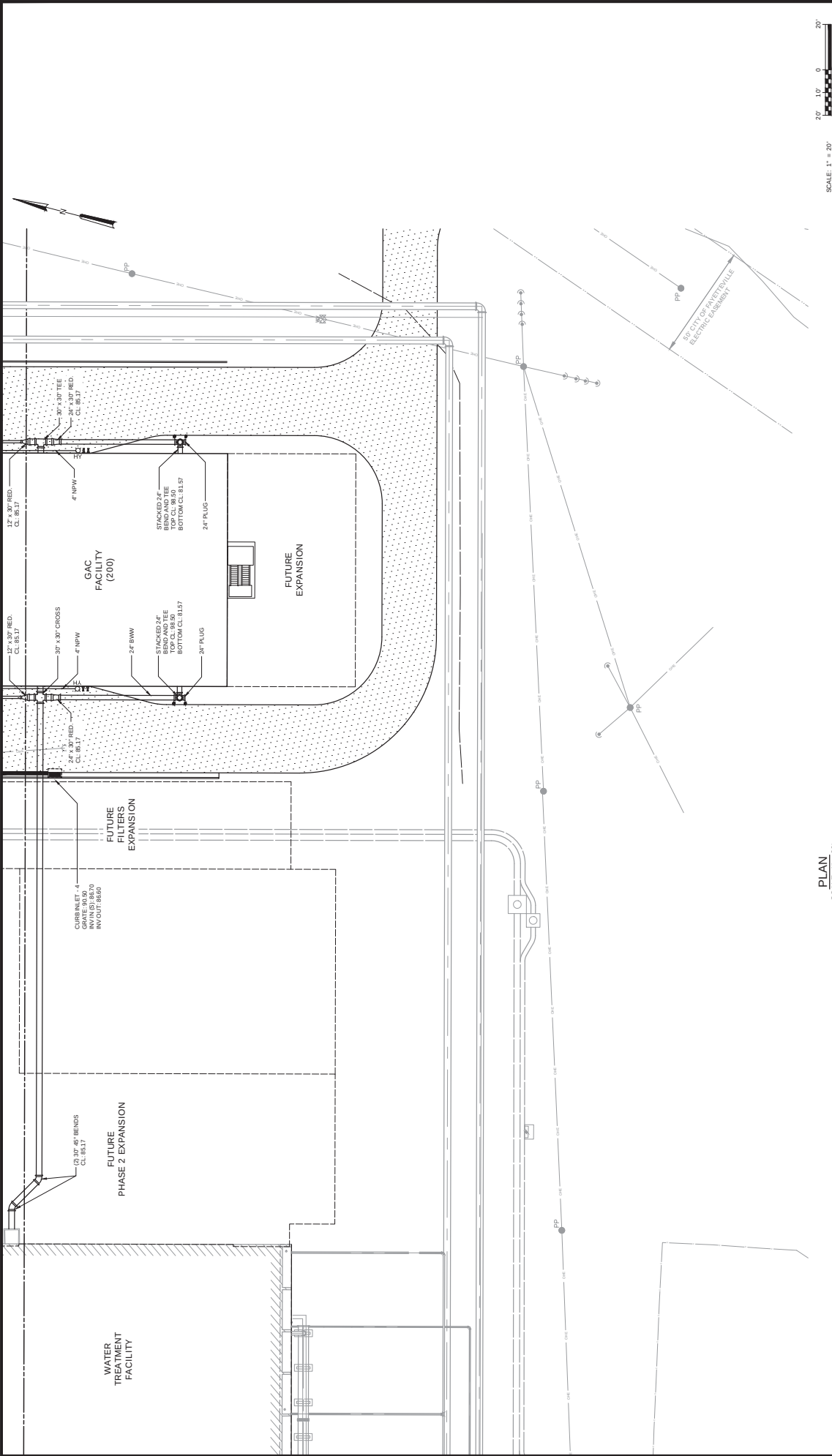
10'

0

20'

SCALE: 1" = 20'

FILE: C:\USERS\AMARCH\PROJECTS\HAZEN AND SAWYER\202402-067 POST-FILTER GAC ADSORPTION FACILITIES\PROJECT FILES\DESIGN\CD\CL31.dwg
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PLOT DATE: 11/03/2024 11:49 PM BY: AMARCH
PLOT BY: AMARCH



SCALE: 1" = 20'



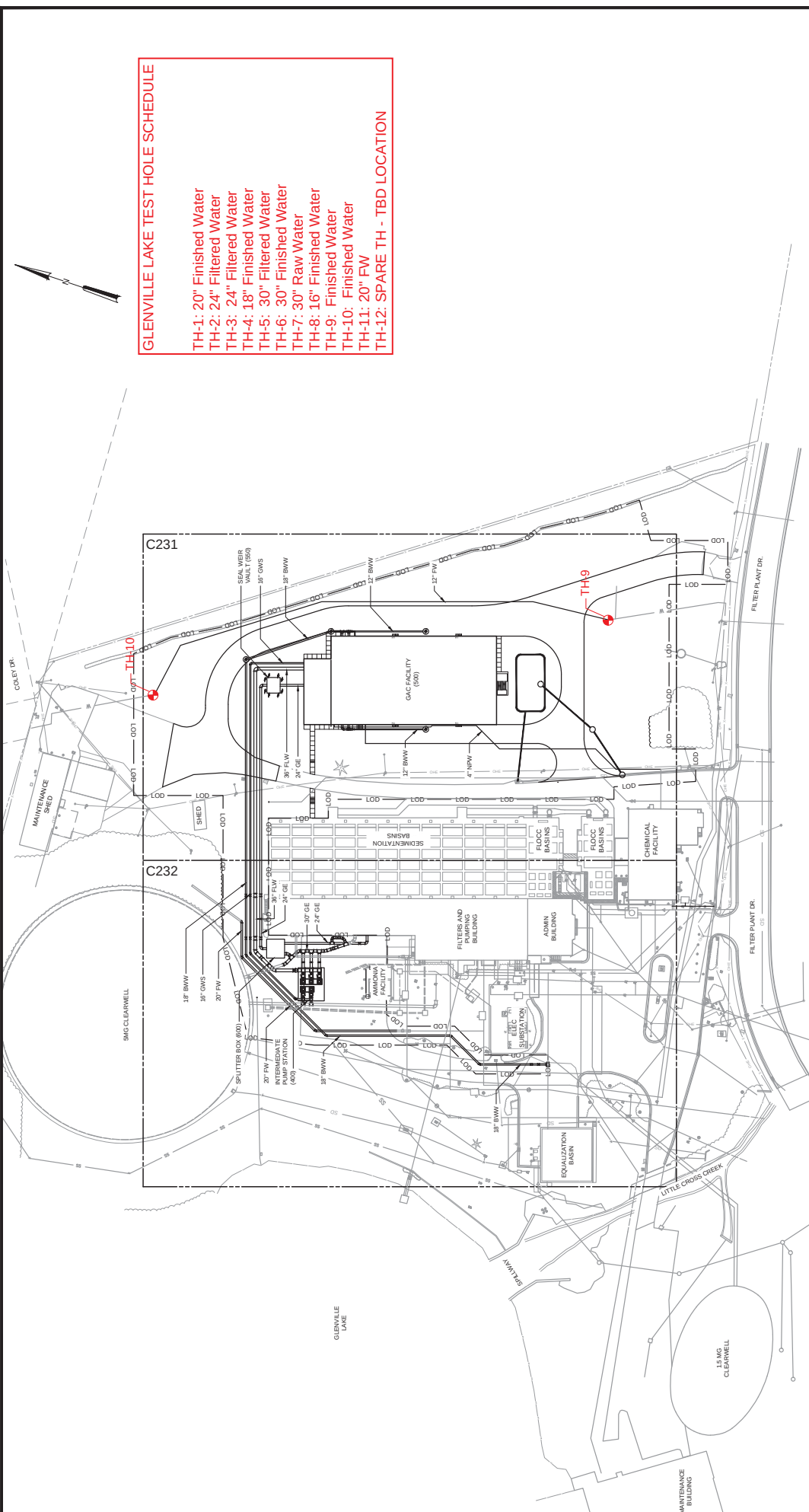
PLAN
SCALE: 1" = 20'

PROJECT INFORMATION		PROJECT NAME		PROJECT NO.	
PROJECT ENGINEER	C. HOPKINS	PUBLIC WORKS COMMISSION		2024	
DESIGNED BY:	K. THOMPSON	CITY OF FAYETTEVILLE, NORTH CAROLINA		HAZEN NO.: 30402-067	
DRAWN BY:	A. MARCH	GLENVILLE LAKE AND P.O. HOFFER WATER TREATMENT FACILITY POST FILTER GAC ADSORPTION FACILITIES		CONTRACT NO.: 1	
CHECKED BY:	K. THOMPSON	HAZEN AND SAWYER		DRAWING NUMBER	
IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO FULL SCALE		HAZEN AND SAWYER		C132	
DATE	BY	ISSUED FOR		C132	

Hazen

HAZEN AND SAWYER
4011 WESTCHASE BOULEVARD, SUITE 500
RALEIGH, NORTH CAROLINA 27607
LICENSE NO.: C-03861

PRELIMINARY DRAWING
DO NOT USE FOR
CONSTRUCTION



GLENVILLE LAKE TEST HOLE SCHEDULE	
TH-1:	20" Finished Water
TH-2:	24" Filtered Water
TH-3:	24" Filtered Water
TH-4:	18" Filtered Water
TH-5:	30" Filtered Water
TH-6:	30" Finished Water
TH-7:	30" Raw Water
TH-8:	16" Finished Water
TH-9:	Finished Water
TH-10:	Finished Water
TH-11:	20" FW
TH-12:	SPARE TH - TBD LOCATION

PLAN
SCALE: 1" = 50'



PROJECT ENGINEER C. HOPKINS		DATE 2024	
DESIGNED BY: K. THOMPSON		HAZEN NO.: 30402-067	
DRAWN BY: A. MARCH		CONTRACT NO.: 1	
CHECKED BY: K. THOMPSON		DRAWING NUMBER	
IF THIS BAR DOES NOT MEASURE THE DRAWING IS NOT TO FULL SCALE		C230	
ISSUED FOR		GLENVILLE LAKE - CIVIL YARD PIPING PLAN OVERALL SITE PLAN	
PUBLIC WORKS COMMISSION CITY OF FAYETTEVILLE, NORTH CAROLINA		GLENVILLE LAKE AND P.O. HOFFER WATER TREATMENT FACILITY POST FILTER GAC ADSORPTION FACILITIES	
PRELIMINARY DRAWING DO NOT USE FOR CONSTRUCTION		Hazen HAZEN AND SAWYER 4011 WESTCHASE BOULEVARD, SUITE 500 RALEIGH, NORTH CAROLINA 27607 LICENSE NO.: C-03581	



TH-1: 20" Finished Water
TH-2: 24" Filtered Water
TH-3: 24" Filtered Water
TH-4: 18" Finished Water
TH-5: 30" Filtered Water
TH-6: 30" Finished Water
TH-7: 30" Raw Water
TH-8: 16" Finished Water
TH-9: Finished Water
TH-10: Finished Water
TH-11: 20" FW
TH-12: SPARE TH - TBD

PLAN
SCALE: 1" = 20'

Hazen

HAZEN AND SAWYER
4011 WESTCHASE BOULEVARD, SUITE 500
RALEIGH, NORTH CAROLINA 27607
LICENSE NO. : C-0381

PUBLIC WORKS COMMISSION
CITY OF FAYETTEVILLE, NORTH CAROLINA

GLENVILLE LAKE AND P.O. HOFFER
WATER TREATMENT FACILITY POST
FILTER GAC ADSORPTION FACILITIES

GLENVILLE LAKE - CIVIL
YARD PIPING PLAN
AREA 1

DATE:	2024
HAZEN NO.:	30402-067
CONTRACT NO.:	1
DRAWING NUMBER:	

C231

PRELIMINARY DRAWING
DO NOT USE FOR
CONSTRUCTION

[illegible]



1"=20'-0"

[illegible]



PROJECT NAME: PWC GAC FACILITIES - P.O. HOFFER

CLIENT JOB # 30402-067

LOCATE REQUESTED BY: HAZEN & SAWYER

PROJECT LOCATION: FAYETTEVILLE, NC

REQUESTED:

30" STORM PIPE

SHEET 1 OF 1 PROPOSED: N/A

FOUND:

N/A

FORM BY: NM ASSISTED BY: NW

OF HOLES: 1

PAVING CONDITION: N/A

DATE DUG: 12/9/24

SOIL CONDITIONS: MOIST CLAY

DO RECORDS AGREE WITH UTILITY AS FOUND? N/A (SEE NOTES)

UTILITY CONDITIONS: FAIR UTILITY COLOR: N/A

SURVEY MARKER: N/A

SURVEY PIN TO BE LOCATED BY: OTHERS

INSTALLED OVER THE: N/A

GENERAL NOTES:
BOC=BACK OF CURB
EOP=EDGE OF PAVEMENT

REVIEWED BY:

Logan Derberry

RIBBON INSTALLED: N/A

COULD NOT FIND PIPE.
DOWN MEASURES
TAKEN FROM M.H.'S
PROVIDED IN BELOW
SKETCH FOR GENERAL
DEPTH REFERENCE.

I, JAMES M. PEARSALL, certify that this report was prepared under my supervision, from an actual ground survey made under my supervision; that the measurements shown hereon were obtained with a tape measure and level rod and they are reported relative to existing structures and ground surface elevation; that this spatial data is not meant to be reported relative to any coordinate system; that the north arrow shown hereon is approximate and is only shown for adequate orientation to the existing structures; that the positional accuracy is 0.20' and conforms to Class A LIS/GIS survey requirements; and that the method used to evaluate the accuracy was repeat measurements.

ELEV SURVEY MARKER

N/A

PAVING
THICKNESS

N/A

PAVING
TYPE

N/A



COVER (TOP)

N/A

TOP ELEV.

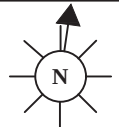
N/A

SURVEY NOTES:



DRAWING IS NOT TO SCALE.

12 MG CLEARWELL



TH 1
APPR. LOCATION



MAN HOLE
24" PIPE

11.57' DOWN MEASURE FROM
RIM TO TOP OF PIPE



MAN HOLE
6" PIPE

11.45' DOWN MEASURE FROM
RIM TO TOP OF PIPE



PROJECT NAME: PWC GAC FACILITIES - GLENVILLE LAKE

LOCATE REQUESTED BY: HAZEN & SAWYER

REQUESTED:

WATERLINE

FOUND:

24" DUCTILE IRON WATERLINE

DO RECORDS AGREE WITH UTILITY AS FOUND? YES

SURVEY MARKER: HUB & TACK

INSTALLED OVER THE: CROWN

RIBBON INSTALLED: BLUE

ELEV SURVEY MARKER

112.81'

PAVING
THICKNESS

N/A

PAVING
TYPE

N/A



N/A

N/A

COVER (TOP)

9.10'

TOP ELEV.

103.71'

WIDTH (O.D.)

26" +/-

DRAWN FACING

NW

CLIENT JOB # 30402-067

PROJECT LOCATION: FAYETTEVILLE, NC

SHEET 1 OF 1 PROPOSED: N/A

FORM BY: NM ASSISTED BY: NW

OF HOLES: 1

PAVING CONDITION: N/A

DATE DUG: 12/4/24

SOIL CONDITIONS: MOIST CLAY

UTILITY CONDITIONS: FAIR

UTILITY COLOR: BLACK

SURVEY PIN TO BE LOCATED BY: OTHERS

GENERAL NOTES:
BOC=BACK OF CURB
EOP=EDGE OF PAVEMENT

REVIEWED BY:

Logan Derberry

I, JAMES M. PEARSALL, certify that this report was prepared under my supervision, from an actual ground survey made under my supervision; that the measurements shown hereon were obtained with a tape measure and level rod and they are reported relative to existing structures and ground surface elevation; that this spatial data is not meant to be reported relative to any coordinate system; that the north arrow shown hereon is approximate and is only shown for adequate orientation to the existing structures; that the positional accuracy is 0.20' and conforms to Class A LIS/GIS survey requirements; and that the method used to evaluate the accuracy was repeat measurements.

SURVEY NOTES:

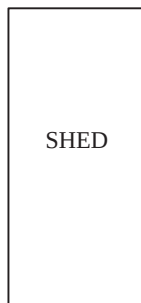
MARKER COORDINATES

N: 480422.39'

E: 2031113.77'



DRAWING IS NOT TO SCALE.



SHED



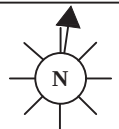
SHED

2.7'

6.1'



27.3'



BUILDING

ASPHALT



PROJECT NAME: PWC GAC FACILITIES - P.O. HOFFER

CLIENT JOB # 30402-067

LOCATE REQUESTED BY: HAZEN & SAWYER

PROJECT LOCATION: FAYETTEVILLE, NC

REQUESTED:

24" RAW WATER PIPE

SHEET 1 OF 1 PROPOSED: N/A

FOUND:

N/A

FORM BY: NM ASSISTED BY: NW

OF HOLES: 1

PAVING CONDITION: N/A

DATE DUG: 12/9/24

SOIL CONDITIONS: MOIST CLAY

DO RECORDS AGREE WITH UTILITY AS FOUND? N/A (SEE NOTES)

UTILITY CONDITIONS: FAIR UTILITY COLOR: N/A

SURVEY MARKER: HUB & TACK

SURVEY PIN TO BE LOCATED BY: OTHERS

INSTALLED OVER THE: CENTER OF SIGNAL

GENERAL NOTES:
BOC=BACK OF CURB
EOP=EDGE OF PAVEMENT

REVIEWED BY:

Logan Derberry

RIBBON INSTALLED: N/A

CREW HIT REFUSAL AT
7.5' DEEP AND PROBED
TO 9' DEEP WITHOUT
FEELING ANY
INDICATION OF PIPE.
SIGNAL WAS OBTAINED
VIA GPR.

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ELEV SURVEY MARKER

89.64'

PAVING
THICKNESS

N/A

PAVING
TYPE

N/A



N/A

N/A

COVER (TOP)

N/A

TOP ELEV.

N/A

SURVEY NOTES:

MARKER COORDINATES

N: 484603.11'

E: 2040139.86'



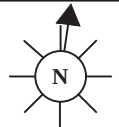
WIDTH (O.D.)

N/A

DRAWN FACING

N/A

DRAWING IS NOT TO SCALE.





PROJECT NAME: PWC GAC FACILITIES - GLENVILLE LAKE

LOCATE REQUESTED BY: HAZEN & SAWYER

REQUESTED:

24" WATERLINE

FOUND:

24" CAST IRON WATERLINE

DO RECORDS AGREE WITH UTILITY AS FOUND? YES

SURVEY MARKER: PK NAIL

INSTALLED OVER THE: CROWN

RIBBON INSTALLED: BLUE

ELEV SURVEY MARKER

111.33'

PAVING
THICKNESS

4"

PAVING
TYPE

ASPHALT



N/A

N/A

COVER (TOP)

2.99'

TOP ELEV.

108.34'

WIDTH (O.D.)

26" +/-

DRAWN FACING

NW

CLIENT JOB # 30402-067

PROJECT LOCATION: FAYETTEVILLE, NC

SHEET 1 OF 1 PROPOSED: N/A

FORM BY: NM ASSISTED BY: NW

OF HOLES: 1

PAVING CONDITION: N/A

DATE DUG: 12/4/24

SOIL CONDITIONS: MOIST CLAY

UTILITY CONDITIONS: FAIR

UTILITY COLOR: BLACK

SURVEY PIN TO BE LOCATED BY: OTHERS

GENERAL NOTES:
BOC=BACK OF CURB
EOP=EDGE OF PAVEMENT

PK NAIL SET OVER
FITTING OF PIPE.

SURVEY NOTES:

MARKER COORDINATES

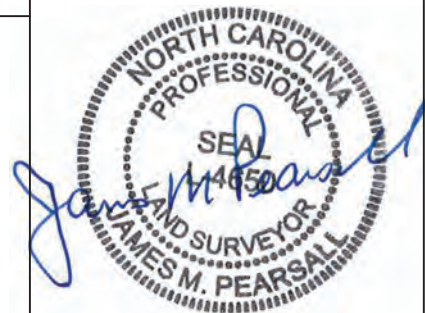
N: 480372.21'

E: 2031152.04'

REVIEWED BY:

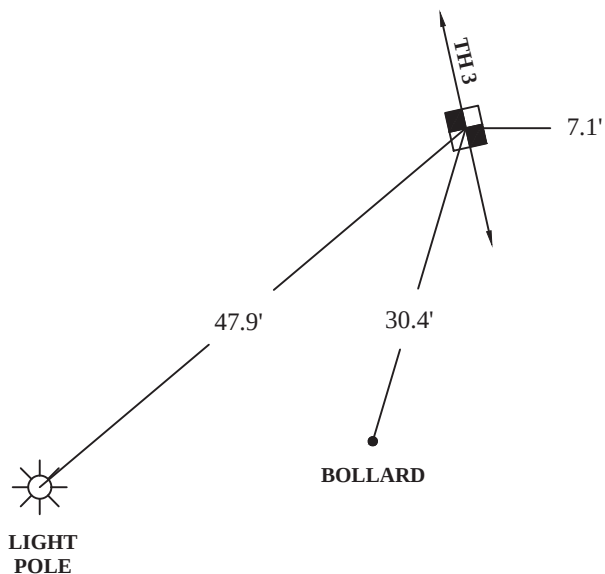
Logan Derberry

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DRAWING IS NOT TO SCALE.

ASPHALT



BUILDING



PROJECT NAME: PWC GAC FACILITIES - P.O. HOFFER

CLIENT JOB # 30402-067

LOCATE REQUESTED BY: HAZEN & SAWYER

PROJECT LOCATION: FAYETTEVILLE, NC

REQUESTED:

24" RAW WATER PIPE

SHEET 1 OF 1 PROPOSED: N/A

FOUND:

N/A

FORM BY: NM ASSISTED BY: NW

OF HOLES: 1

PAVING CONDITION: N/A

DATE DUG: 12/9/24

SOIL CONDITIONS: MOIST CLAY

DO RECORDS AGREE WITH UTILITY AS FOUND? N/A (SEE NOTES)

UTILITY CONDITIONS: FAIR UTILITY COLOR: N/A

SURVEY MARKER: HUB & TACK

SURVEY PIN TO BE LOCATED BY: OTHERS

INSTALLED OVER THE: CENTER OF SIGNAL

GENERAL NOTES:
BOC=BACK OF CURB
EOP=EDGE OF PAVEMENT

REVIEWED BY:

Logan Derberry

RIBBON INSTALLED: N/A

CREW HIT REFUSAL AT
7.5' DEEP AND PROBED
TO 9' DEEP WITHOUT
FEELING ANY
INDICATION OF PIPE.
SIGNAL WAS OBTAINED
VIA GPR.

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ELEV SURVEY MARKER

89.64'

PAVING
THICKNESS

N/A

PAVING
TYPE

N/A



N/A

N/A

COVER (TOP)

N/A

TOP ELEV.

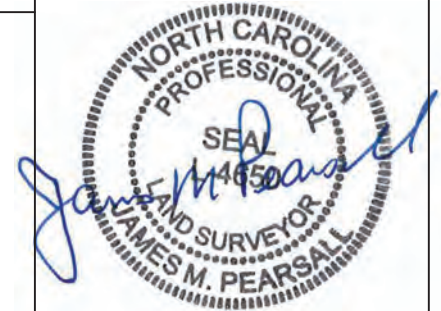
N/A

SURVEY NOTES:

MARKER COORDINATES

N: 484603.11'

E: 2040139.86'



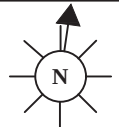
WIDTH (O.D.)

N/A

DRAWN FACING

N/A

DRAWING IS NOT TO SCALE.





PROJECT NAME: PWC GAC FACILITIES - GLENVILLE LAKE

LOCATE REQUESTED BY: HAZEN & SAWYER

REQUESTED:

WATERLINE

FOUND:

18" DUCTILE IRON WATERLINE

DO RECORDS AGREE WITH UTILITY AS FOUND? YES

SURVEY MARKER: PK NAIL

INSTALLED OVER THE: CROWN

RIBBON INSTALLED: BLUE

ELEV SURVEY MARKER

112.50'

PAVING
THICKNESS

N/A

PAVING
TYPE

N/A



N/A

N/A

COVER (TOP)

5.42'

TOP ELEV.

107.08'

WIDTH (O.D.)

20" +/-

DRAWN FACING

E

CLIENT JOB # 30402-067

PROJECT LOCATION: FAYETTEVILLE, NC

SHEET 1 OF 1 PROPOSED: N/A

FORM BY: NM ASSISTED BY: NW

OF HOLES: 1

PAVING CONDITION: N/A

DATE DUG: 12/4/24

SOIL CONDITIONS: MOIST CLAY

UTILITY CONDITIONS: FAIR

UTILITY COLOR: BLACK

SURVEY PIN TO BE LOCATED BY: OTHERS

GENERAL NOTES:
BOC=BACK OF CURB
EOP=EDGE OF PAVEMENT

REVIEWED BY:

Logan Derberry

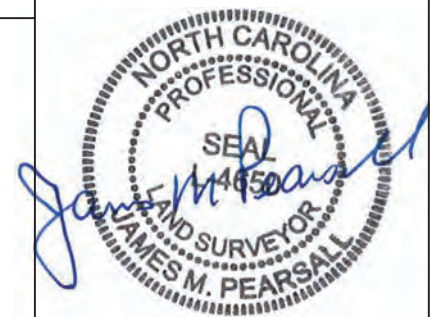
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SURVEY NOTES:

MARKER COORDINATES

N: 480415.56'

E: 2031127.85'



DRAWING IS NOT TO SCALE.

ASPHALT

CONC.
PAD

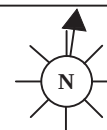
15.4'

12.4'

TH 4

16.3'

BUILDING





PROJECT NAME: PWC GAC FACILITIES - GLENVILLE LAKE

LOCATE REQUESTED BY: HAZEN & SAWYER

REQUESTED:

FW WATERLINE

FOUND:

30" FW DUCTILE IRON WATERLINE

DO RECORDS AGREE WITH UTILITY AS FOUND? YES

SURVEY MARKER: HUB & TACK

INSTALLED OVER THE: CROWN

RIBBON INSTALLED: BLUE

ELEV SURVEY MARKER

109.24'

PAVING
THICKNESS

N/A

PAVING
TYPE

N/A



COVER (TOP)

2.18'

TOP ELEV.

107.06'



WIDTH (O.D.)

32" +/-

DRAWN FACING

E

CLIENT JOB # 30402-067

PROJECT LOCATION: FAYETTEVILLE, NC

SHEET 1 OF 1 PROPOSED: N/A

FORM BY: NM ASSISTED BY: NW

OF HOLES: 1

PAVING CONDITION: N/A

DATE DUG: 12/4/24

SOIL CONDITIONS: MOIST CLAY

UTILITY CONDITIONS: FAIR

UTILITY COLOR: BLACK

SURVEY PIN TO BE LOCATED BY: OTHERS

GENERAL NOTES:
BOC=BACK OF CURB
EOP=EDGE OF PAVEMENT

REVIEWED BY:

Logan Derberry

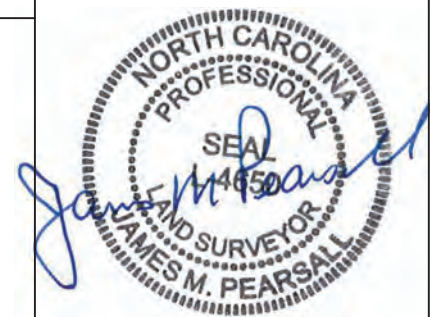
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SURVEY NOTES:

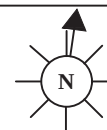
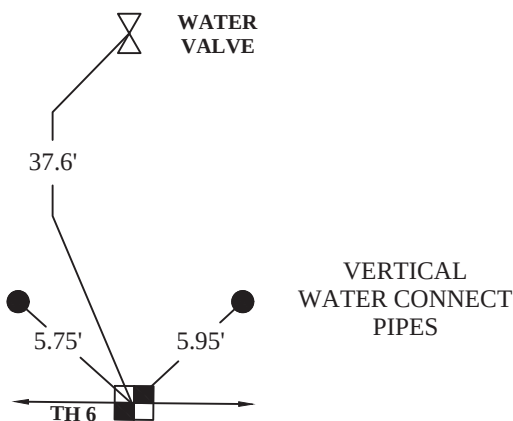
MARKER COORDINATES

N: 480286.93'

E: 2031077.03'



DRAWING IS NOT TO SCALE.



BUILDING



PROJECT NAME: PWC GAC FACILITIES - GLENVILLE LAKE

LOCATE REQUESTED BY: HAZEN & SAWYER

REQUESTED:

30" RW WATERLINE

FOUND:

30" CONCRETE RW WATERLINE

DO RECORDS AGREE WITH UTILITY AS FOUND? YES

SURVEY MARKER: HUB & TACK

INSTALLED OVER THE: CROWN

RIBBON INSTALLED: BLUE

ELEV SURVEY MARKER

108.89'

PAVING
THICKNESS

N/A

PAVING
TYPE

N/A

COVER (TOP)

3.06'

TOP ELEV.

105.83'

WIDTH (O.D.)

32" +/-

DRAWN FACING

E

CLIENT JOB # 30402-067

PROJECT LOCATION: FAYETTEVILLE, NC

SHEET 1 OF 1 PROPOSED: N/A

FORM BY: NM ASSISTED BY: NW

OF HOLES: 1

PAVING CONDITION: N/A

DATE DUG: 12/5/24

SOIL CONDITIONS: MOIST CLAY

UTILITY CONDITIONS: FAIR

UTILITY COLOR: GRAY

SURVEY PIN TO BE LOCATED BY: OTHERS

GENERAL NOTES:
BOC=BACK OF CURB
EOP=EDGE OF PAVEMENT

REVIEWED BY:

Logan Derberry

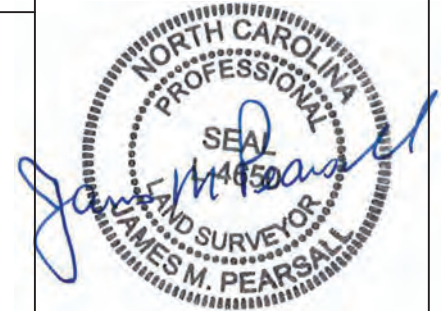
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SURVEY NOTES:

MARKER COORDINATES

N: 480247.24'

E: 2031093.06'



DRAWING IS NOT TO SCALE.

VERTICAL
WATER CONNECT
PIPES

39.1'

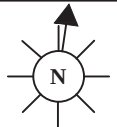
TH 8

43.1'

44.5'

WATER
VAULTS

BUILDING





PROJECT NAME: PWC GAC FACILITIES - GLENVILLE LAKE

LOCATE REQUESTED BY: HAZEN & SAWYER

REQUESTED:

WATERLINE

FOUND:

16" FW DUCTILE IRON WATERLINE

DO RECORDS AGREE WITH UTILITY AS FOUND? YES

SURVEY MARKER: HUB & TACK

INSTALLED OVER THE: CROWN

RIBBON INSTALLED: BLUE

ELEV SURVEY MARKER

106.87'

PAVING
THICKNESS

3"

PAVING
TYPE

ASPHALT



N/A

N/A

COVER (TOP)

5.44'

TOP ELEV.

101.43'

WIDTH (O.D.)

18" +/-

DRAWN FACING

E

CLIENT JOB # 30402-067

PROJECT LOCATION: FAYETTEVILLE, NC

SHEET 1 OF 1 PROPOSED: N/A

FORM BY: NM ASSISTED BY: NW # OF HOLES: 1

PAVING CONDITION: N/A DATE DUG: 12/5/24

SOIL CONDITIONS: MOIST CLAY

UTILITY CONDITIONS: FAIR UTILITY COLOR: BLACK

SURVEY PIN TO BE LOCATED BY: OTHERS

GENERAL NOTES:
BOC=BACK OF CURB
EOP=EDGE OF PAVEMENT

REVIEWED BY:

Logan Derberry

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SURVEY NOTES:

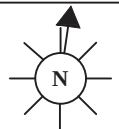
MARKER COORDINATES

N: 480199.02'

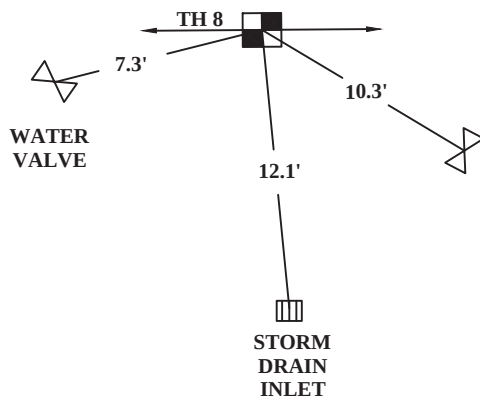
E: 2031077.71'



DRAWING IS NOT TO SCALE.



BUILDING





PROJECT NAME: PWC GAC FACILITIES - GLENVILLE LAKE

LOCATE REQUESTED BY: HAZEN & SAWYER

REQUESTED:

12" FW WATERLINE

FOUND:

20" FW DUCTILE IRON WATERLINE

DO RECORDS AGREE WITH UTILITY AS FOUND? NO (SEE NOTES)

SURVEY MARKER: HUB & TACK

INSTALLED OVER THE: CROWN

RIBBON INSTALLED: BLUE

ELEV SURVEY MARKER

122.16'

PAVING
THICKNESS

N/A

PAVING
TYPE

N/A



N/A

N/A

COVER (TOP)

4.25'

TOP ELEV.

117.91'

WIDTH (O.D.)

20" +/-

DRAWN FACING

E

CLIENT JOB # 30402-067

PROJECT LOCATION: FAYETTEVILLE, NC

SHEET 1 OF 1 PROPOSED: N/A

FORM BY: NM ASSISTED BY: NW

OF HOLES: 1

PAVING CONDITION: N/A

DATE DUG: 12/5/24

SOIL CONDITIONS: MOIST CLAY

UTILITY CONDITIONS: FAIR

UTILITY COLOR: BLACK

SURVEY PIN TO BE LOCATED BY: OTHERS

GENERAL NOTES:
BOC=BACK OF CURB
EOP=EDGE OF PAVEMENT

RECORDS CALL FOR A
12" PIPE. POTENTIAL 20"
CASING AROUND 12"
FW.

SURVEY NOTES:

MARKER COORDINATES

N: 480212.53'

E: 2031578.28'

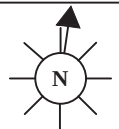
REVIEWED BY:

Logan Derberry

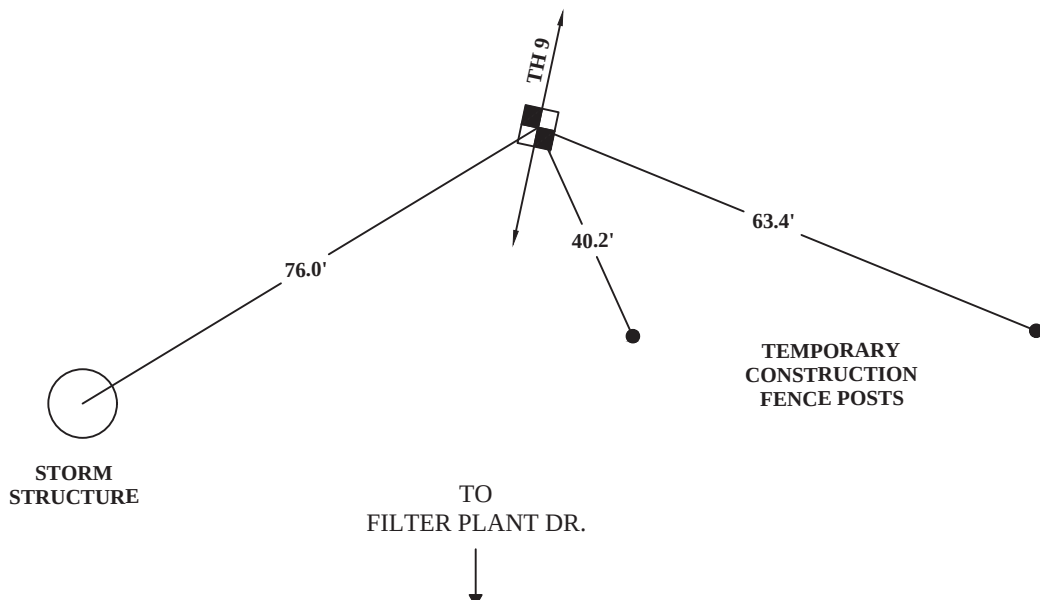
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DRAWING IS NOT TO SCALE.



STAGING
YARD





PROJECT NAME: PWC GAC FACILITIES - GLENVILLE LAKE

LOCATE REQUESTED BY: HAZEN & SAWYER

REQUESTED:

12" FW WATERLINE

FOUND:

20" STEEL WATERLINE

DO RECORDS AGREE WITH UTILITY AS FOUND? NO (SEE NOTES)

SURVEY MARKER: HUB & TACK

INSTALLED OVER THE: CROWN

RIBBON INSTALLED: BLUE

ELEV SURVEY MARKER

137.43'

PAVING
THICKNESS

N/A

PAVING
TYPE

N/A



6" PLASTIC PIPE
UNKNOWN UTILITY

COVER (TOP)

3.94'

TOP ELEV.

133.49'

WIDTH (O.D.)

20" +/-

DRAWN FACING

N

CLIENT JOB # 30402-067

PROJECT LOCATION: FAYETTEVILLE, NC

SHEET 1 OF 1 PROPOSED: N/A

FORM BY: NM ASSISTED BY: NW

OF HOLES: 1

PAVING CONDITION: N/A

DATE DUG: 12/6/24

SOIL CONDITIONS: MOIST CLAY

UTILITY CONDITIONS: FAIR

UTILITY COLOR: BLACK

SURVEY PIN TO BE LOCATED BY: OTHERS

GENERAL NOTES:
BOC=BACK OF CURB
EOP=EDGE OF PAVEMENT

RECORDS CALL FOR A
12" PIPE. POTENTIAL 20"
CASING AROUND 12"
FW.

6" PLASTIC PIPE FOUND
AT 3.1' DEEP IN SAME
HOLE.

SURVEY NOTES:

MARKER COORDINATES

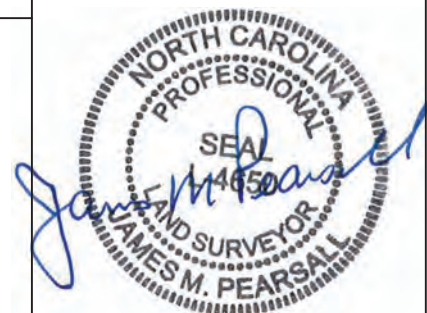
N: 480622.71'

E: 2031359.06'

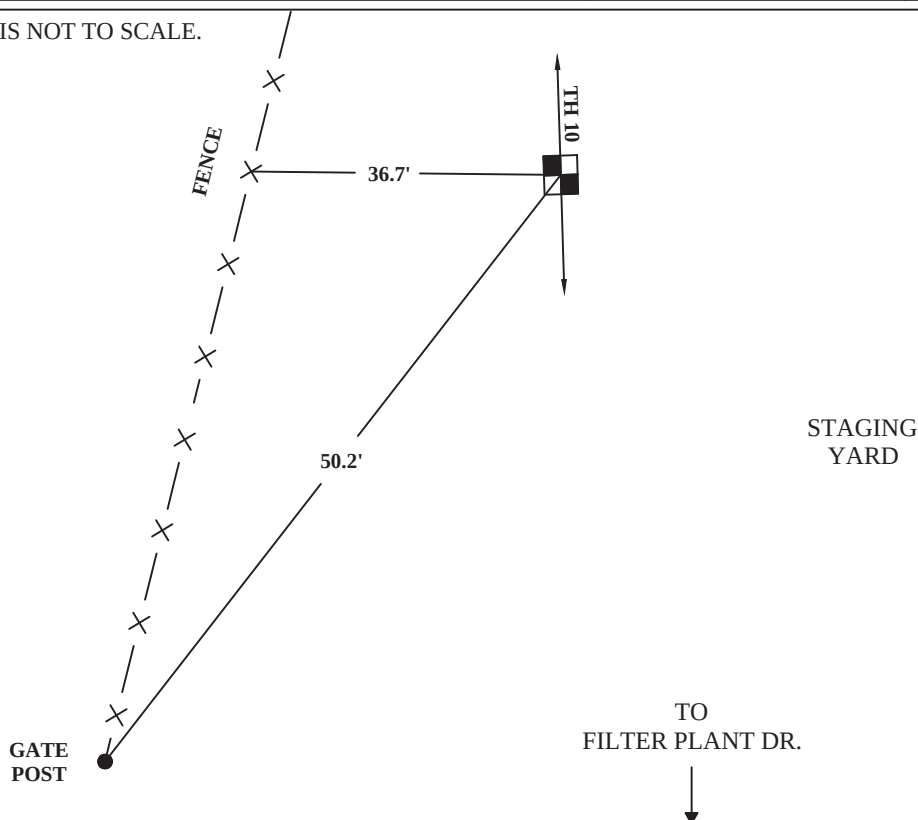
REVIEWED BY:

Logan Derberry

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DRAWING IS NOT TO SCALE.





PROJECT NAME: PWC GAC FACILITIES - GLENVILLE LAKE

LOCATE REQUESTED BY: HAZEN & SAWYER

REQUESTED:

FW WATERLINE

FOUND:

20" FW CONCRETE WATERLINE

DO RECORDS AGREE WITH UTILITY AS FOUND? YES

SURVEY MARKER: HUB & TACK

INSTALLED OVER THE: CROWN

RIBBON INSTALLED: BLUE

ELEV SURVEY MARKER

109.41'

PAVING
THICKNESS

N/A

PAVING
TYPE

N/A



N/A

N/A

COVER (TOP)

2.65'

TOP ELEV.

106.76'

WIDTH (O.D.)

22" +/-

DRAWN FACING

E

CLIENT JOB # 30402-067

PROJECT LOCATION: FAYETTEVILLE, NC

SHEET 1 OF 1 PROPOSED: N/A

FORM BY: NM ASSISTED BY: NW

OF HOLES: 1

PAVING CONDITION: N/A

DATE DUG: 12/6/24

SOIL CONDITIONS: MOIST CLAY

UTILITY CONDITIONS: FAIR

UTILITY COLOR: GRAY

SURVEY PIN TO BE LOCATED BY: OTHERS

GENERAL NOTES:
BOC=BACK OF CURB
EOP=EDGE OF PAVEMENT

REVIEWED BY:

Logan Derberry

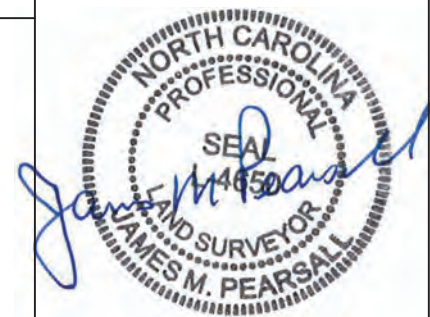
I, JAMES M. PEARSALL, certify that this report was prepared under my supervision, from an actual ground survey made under my supervision; that the measurements shown hereon were obtained with a tape measure and level rod and they are reported relative to existing structures and ground surface elevation; that this spatial data is not meant to be reported relative to any coordinate system; that the north arrow shown hereon is approximate and is only shown for adequate orientation to the existing structures; that the positional accuracy is 0.20' and conforms to Class A LIS/GIS survey requirements; and that the method used to evaluate the accuracy was repeat measurements.

SURVEY NOTES:

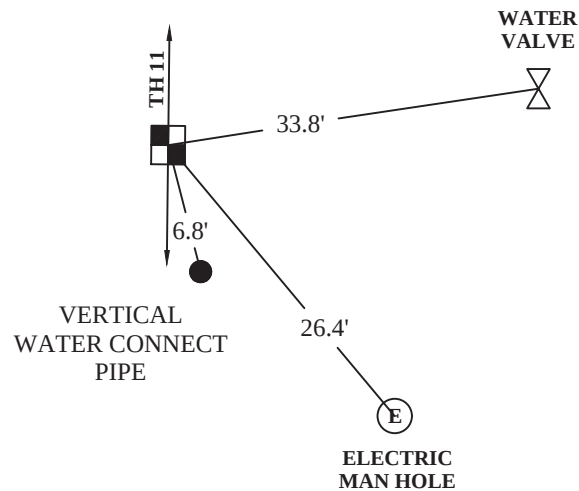
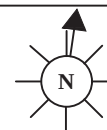
MARKER COORDINATES

N: 480297.99'

E: 2031078.44'



DRAWING IS NOT TO SCALE.



BUILDING



PROJECT NAME: PWC GAC FACILITIES - GLENVILLE LAKE

LOCATE REQUESTED BY: HAZEN & SAWYER

REQUESTED:

FW WATERLINE

FOUND:

16" FW DUCTILE IRON WATERLINE

DO RECORDS AGREE WITH UTILITY AS FOUND? YES

SURVEY MARKER: HUB & TACK

INSTALLED OVER THE: CROWN

RIBBON INSTALLED: BLUE

ELEV SURVEY MARKER

108.80'

PAVING
THICKNESS

N/A

PAVING
TYPE

N/A



COVER (TOP)

7.87'

TOP ELEV.

100.93'

WIDTH (O.D.)

18" +/-

DRAWN FACING

E

CLIENT JOB # 30402-067

PROJECT LOCATION: FAYETTEVILLE, NC

SHEET 1 OF 1 PROPOSED: N/A

FORM BY: NM ASSISTED BY: NW

OF HOLES: 1

PAVING CONDITION: N/A

DATE DUG: 12/6/24

SOIL CONDITIONS: MOIST CLAY

UTILITY CONDITIONS: FAIR

UTILITY COLOR: BLACK

SURVEY PIN TO BE LOCATED BY: OTHERS

GENERAL NOTES:
BOC=BACK OF CURB
EOP=EDGE OF PAVEMENT

REVIEWED BY:

Logan Derberry

I, JAMES M. PEARSALL, certify that this report was prepared under my supervision, from an actual ground survey made under my supervision; that the measurements shown hereon were obtained with a tape measure and level rod and they are reported relative to existing structures and ground surface elevation; that this spatial data is not meant to be reported relative to any coordinate system; that the north arrow shown hereon is approximate and is only shown for adequate orientation to the existing structures; that the positional accuracy is 0.20' and conforms to Class A LIS/GIS survey requirements; and that the method used to evaluate the accuracy was repeat measurements.

SURVEY NOTES:

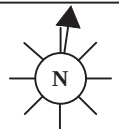
MARKER COORDINATES

N: 480242.15'

E: 2031091.80'



DRAWING IS NOT TO SCALE.



VERTICAL
WATER CONNECT
PIPES

43.7'

TH 12

44.5'

40.3'

WATER
VAULTS

BUILDING

APPENDIX B

SUBSURFACE GEOTECHNICAL INVESTIGATIONS

October 10, 2024

Laura Bobier, P.E.
HAZEN & SAWYER
4011 Westchase Boulevard, Suite 500
Raleigh, NC 27607

Re: PO Hoffer WTP GAC Facility
508 Hoffer Drive
Fayetteville, North Carolina
GeoTechnologies Project No. 1-24-0773-EA

Ms. Bobier:

GeoTechnologies has completed a subsurface investigation for the referenced project located at 508 Hoffer Drive in Fayetteville, North Carolina. Subsurface conditions were investigated by completing four soil test borings with a track mounted drill rig as shown on Figure 1. The test borings were advanced to depths of about 30 to 45 feet with automatic hammer standard penetration testing performed at selected intervals. This report presents the findings of the investigation and our recommendations based on the conditions encountered.

PROJECT AND SITE INFORMATION

Plant improvement information is summarized below:

Facility	Structure	Bearing Elevation	Existing Elevation	Maximum Bearing (psf)	Boring Numbers
Seal Weir Tankage	CIP Tank on a Mat	74	90	2,500	B1
Electrical Building	Masonry on a Mat	89.5	90	2,500	B1
IPS Building	Slab	77.33-77.83	89.5	2,500	B1
GAC Tankage	Masonry on a Mat	89	89.5	3,000	B2-B4

The area of the new construction is generally wooded. Some standing water was observed in the proximity of borings B-3 and B-4 at the time that the borings were performed which followed a period of wet weather.

SUBSURFACE CONDITIONS

A generalized subsurface profile prepared from the test boring data is attached to this report as Figure 2 to graphically illustrate subsurface conditions encountered in the borings. More detailed descriptions of the conditions encountered in the boring are then presented on the attached test boring records in Appendix A.

The subsurface profile typically included surface topsoil which was underlain by variable clays and sands which were more consistently firm at depths of about 1.5 to 5 feet. These materials exhibited penetration resistances of 3 to 10+ blows per foot (bpf). With depth, the borings encountered a mixture of sands and low to high plasticity clays with penetration resistances of 11 to 50+ bpf. The borings were terminated at the plan depths of 30 to 45 feet.

The boreholes included groundwater at 0 to 5 feet after a 24+ hour monitoring period, including in a piezometer set in boring B-4. The piezometer will be monitored over a period of about 4 months and the water level results will be updated after that period. It should be noted that groundwater and perched water levels will vary during different periods of the year and could be higher during construction.

RECOMMENDATIONS

The following recommendations are made based upon a review of the attached test boring data, our understanding of the proposed construction, and experience with similar projects and subsurface conditions. Should the project plans change significantly from those now under consideration, we would appreciate being provided with that information so that these recommendations may be confirmed, extended, or modified as necessary. Additionally, should subsurface conditions adverse to those indicated by this report be encountered during construction, those differences should be reported to us for review and comment.

Site Grading Considerations. Site grading should begin with clearing and stripping of topsoil, excavation to plan grade as necessary, and the removal of any soft soils deemed unsuitable by the geotechnical engineer. The subgrade soils should be proofrolled for stability with a partially loaded dump truck or similar piece of rubber tired equipment; however, hand auger borings should also be performed as part of the evaluation.

The required excavation for the seal weir and IPS building will remove all soft surface soil; however, some of this material will remain in-place below the at grade structures. Our borings indicate that soft soils are present from about 1.5 to 5 feet from current grade which implies that significant undercut and replacement will be necessary. Ideally, repairs will be implemented during a period of warm and dry weather typical of the months from April into early October.

Backfill Materials/Placement. The on-site soils, excluding topsoil and highly plastic soils, will be suitable for reuse as structural fill if the material can be brought to within about 2% of the optimum moisture content with drying as required. However, most of the near surface soils and the submerged soils were wet of the optimum moisture content at the time of our drilling. As such, the contractor should be prepared to dry any wet of optimum soils unless those soils will be wasted and replaced with imported select fill. Highly plastic soils should not be reused as fill within 3 feet of grade.

Off-site borrow should consist of silty and clayey sands or low plasticity silts and clays having Unified Soil Classifications of SM, SC, ML, or CL. Cleaner (SP/SW) sands should be used where undercut extends below the water table. All fill materials in structural areas should be compacted to not less than 95% of the standard Proctor maximum dry density except in the final foot below any pavements where this requirement should be increased to 98% of the standard Proctor maximum. It is recommended that quality control testing be performed to verify that the proper soil density specifications are being met and to confirm that fill placement is being performed in a controlled manner.

An exception to the above will occur in areas where the placement of new soil fill may result in higher than allowable post-construction settlement (assumed to be 1-1.5 inches total and 0.5-1.0 inches differential for the purpose of this report). In these areas, we recommend that backfill consist of either #57/67 washed stone or CABC stone. Quarry screenings, processed fill or possibly clean sands may also be considered at the discretion of the geotechnical engineer following classification submittals.

Quarry or pit materials should be compacted to the standards previously described except that #57/67 stone may be compacted in 24 inch lifts before compaction with a vibratory roller unless otherwise directed by the geotechnical engineer.

Excavation Considerations. Our borings did not encounter any difficult excavation materials for typical excavation equipment, such as a CAT 330.

Dewatering Considerations. Deeper excavations for below grade structures and undercut will encounter groundwater. Excluding some shallow clean sands, most of the soils in this profile contain enough fines to be of low permeability. As such, it may be possible to control groundwater with some type of shallow interior perimeter trench and a sump; however, selection of dewatering methods and depths should be left to the discretion of the contractor. If a sump and trench approach is not effective, a more proactive approach will need to be considered. The grain size data in Appendix B may be used by dewatering contractors.

Uplift Considerations. Excessive hydrostatic uplift can be resisted by increasing the size of the foundation to engage additional soil if desired. Alternatively, soil anchors can be used to provide additional resistance. If soil anchors are used to provide additional resistance to uplift loads, we recommend that the anchors be preliminarily designed for an ultimate grout to soil shear strength of 12 psi. We recommend load testing a few anchors to 2.5 times the design capacity for verification and modifying the design as needed.

We recommend that an exterior well be tied into washed stone below the submerged structures to monitor water pressure. If tank contents will be lowered or removed for maintenance, the water level in the well should be compared to the uplift design water level. If the water level in the well exceeds the design level, the well should be pumped down to reduce water pressures before the tank contents are lowered or emptied.

Below Grade Walls. Below grade walls may be designed using the soil parameters indicated in the table below. Material placed within 4 feet of walls should be compacted with hand held rather than with heavy mechanized equipment. Backfill should be compacted to at least 95% of the standard Proctor maximum dry density, with 98% being achieved within the upper 12 inches of grade in any pavement areas. The values assume level grade behind or in front of the wall and should be modified for sloping grades. At-rest earth pressures should be used for non-yielding walls. Appropriate safety factors should be applied to design calculations.

At-rest EFP Above Water	At-rest EFP Below Water	Active EFP Above Water	Active EFP Below Water	Passive EFP	Base Friction
55 pcf	90 pcf	40 pcf	80 pcf	300 pcf	0.35

Temporary Shoring/Slopes. Means and methods for implementing the required excavations should be left to the discretion of the contractor. There are several alternatives including use of a lagging wall, sheeting, or a soil nail wall if adequate room exists to install the nails.

If sloped excavations are used instead of shoring, the slopes should comply with OSHA guidelines. The slopes should be inspected by the competent person at the time of excavation and at least three times a day during construction to verify that surface sloughs/tension cracks are not developing. If instability is observed, personnel should leave the excavation until it is properly stabilized.

Permanent Slopes. In this geology, dry and well compacted unreinforced fill slopes built at 2.5H:1V or flatter are stable without exception provided that compaction is carried to the face of the slope. Steeper fill slopes can be used with properly designed and installed geosynthetic reinforcement. Cut slopes should also be 2.5H:1V or flatter. Any water encountered on the face of slopes should be brought to the attention of the geotechnical engineer so that necessary provisions can be made.

Vibrations. We anticipate that minimizing construction vibrations will be important for this project. A common peak particle velocity (PPV) threshold value used to minimize the risk of damage to structures is 2.0 inches per second;

however, for sensitive installations we recommend that contractors maintain vibrations at 0.50 inches per second at 10 to 100 cycles per second (Hz). This recommendation should be reviewed by facility personnel in the event that critical and/or highly sensitive structures are located in close proximity to the planned construction.

Shallow Foundations. Shallow foundations may be designed for the indicated maximum soil bearing pressures of 2,000 to 3,000 psf or a subgrade modulus of 175 pci (for a 1 foot by 1-foot area, scale for other dimensions). Higher soil bearing and/or subgrade modulus values can be considered on a case by case basis. All foundations should bear at least 12 inches below grade for frost protection and all subgrades should be evaluated by the geotechnical engineer to determine if repairs are warranted. This includes repairs associated with any highly plastic soils at or near the foundation bearing elevation.

Previous flat plate dilatometer testing (DMT) at the PO Hoffer plant by GeoTechnologies (included in Appendix C) has demonstrated that the on-site soils are highly overconsolidated and have very high modulus values. As such, even for the large GAC structure with a bearing stress of 3,000 psf, we are estimating total and differential settlements of less than 2 inches (total) and 1 inch (differential). These values are lowered to about 1.2 inches and 0.75 inches for a bearing stress of 2,000 psf and are lowered further to about 1 inch and 0.75 inches for a bearing stress of 2,000 psf and the use of select backfill for areas which are undercut. A summary of these analyses and analyses for the other components of the facility are summarized in the table below.

Where settlement estimates are provided below, they should be considered preliminary and should be updated as additional information about construction sequencing and foundation design (including the distribution of bearing stresses) details become available. A significant portion of the estimated settlement is associated with near surface conditions and therefore structural backfilling associated with undercut, temporary slopes and utility installation below structures needs to be considered in final settlement estimates.

STRUCTURE	BEARING STRESS (PSF)	NET STRESS AFTER UNLOADING (PSF)	TOTAL SETTLEMENT (IN)	DIFFERENTIAL SETTLEMENT (IN)
Seal Weir Tankage	2,500	1,250	<1.0	0.50
Electrical Building	2,500	2,500	1.0*	0.75*
IPS Building	2,500	1,500	<1.0	0.50
GAC Tankage	3,000	3,000	1.7*	1.0*
GAC Tankage	2,000	2,000	1.2*	0.75*
GAC Tankage	2,000	2,000	1.0**	0.75**

*Assumes undercut/replacement of soft soils as directed.

** Assumes undercut/replacement of soft soils as directed with backfill being select quarry or sand pit (pending approval) material.

Aggregate Piers. If finalized settlement estimates are found to be excessive, consideration will need to be given to using intermediate support. A common intermediate system is aggregate piers designed for an allowable bearing pressure of 6 to 8 ksf. These are proprietary design build systems that typically include internal design review and field quality control by the installer. As such, the role of the geotechnical engineer is limited to providing soil data which is interpreted by the specialty contractor. Unlike most conventional pile systems in the area, these foundations do not reduce settlement to some negligible value, but when properly designed are intended to limit settlement to a given criteria. If aggregate piers are used, it is the responsibility of the specialty contractor to verify that the design model selected is appropriate for the foundation configuration, planned grading, groundwater, and site geology. This includes superposition of foundation loading as necessary and accounting for any fill induced settlements.

Using aggregate piers will also help to reduce (but not eliminate) undercut associated with soft near surface soils.

Slab-on-Grades. We recommend placing at least 8 to 12 inches of #57 or #67 stone over the subgrade for slabs, especially for below-grade structures, to protect the subgrade and to provide a medium for dewatering as needed prior to concreting. A geotextile fabric separator should be used between the subgrade and stone. If the stone will be subject to traffic before concreting, consideration should be given to using CABC stone instead of, or in conjunction with the washed stone.

Seismic Design Considerations. Our investigation assigned a seismic site class of “D” based on standard penetration resistances. However, because site class assignment based on shear wave velocity data can often provide for a more favorable site classification, GeoTechnologies performed ReMi geophysical testing to evaluate shear wave velocities in the upper 100 feet of grade (near boring B-2). Based on the results of our testing, the average shear wave velocity in the upper 100 feet was found to exceed 1,200 feet per second (Figure 3). Based on this result, a site class of “C” may be used for design.

A short period spectral acceleration (S_s) of 0.155 may be used, and a 1-second period acceleration (S_1) of 0.072 may be used assuming that the 2024 North Carolina Building Code is applicable.

SUMMARY

In summary, site conditions are characterized by the presence of near surface soft soils which will need to be undercut to depths on the order of 1.5 to 5 feet. Repairs should be performed as directed by the geotechnical engineer. The contractor should be prepared to dewater below grade excavations. Dewatering and shoring/sloping methods are the responsibility of the contractor. Select backfill will likely be needed to facilitate backfilling near the water table and to help minimize settlements.

Preliminary settlement estimates for expected bearing conditions have been provided; however, these estimates will need to be updated as specific foundation details, loadings and construction sequences become available. If settlements are found to be excessive, consideration will need to be given to using aggregate piers for support.

We appreciate the opportunity to have provided you with our services during this phase of the project. Please contact us if you have questions regarding this report or if we may be of further assistance.

Sincerely,

GeoTechnologies, Inc.

Ernest L. Stitzinger, P.E.
NC Registration No. 25534



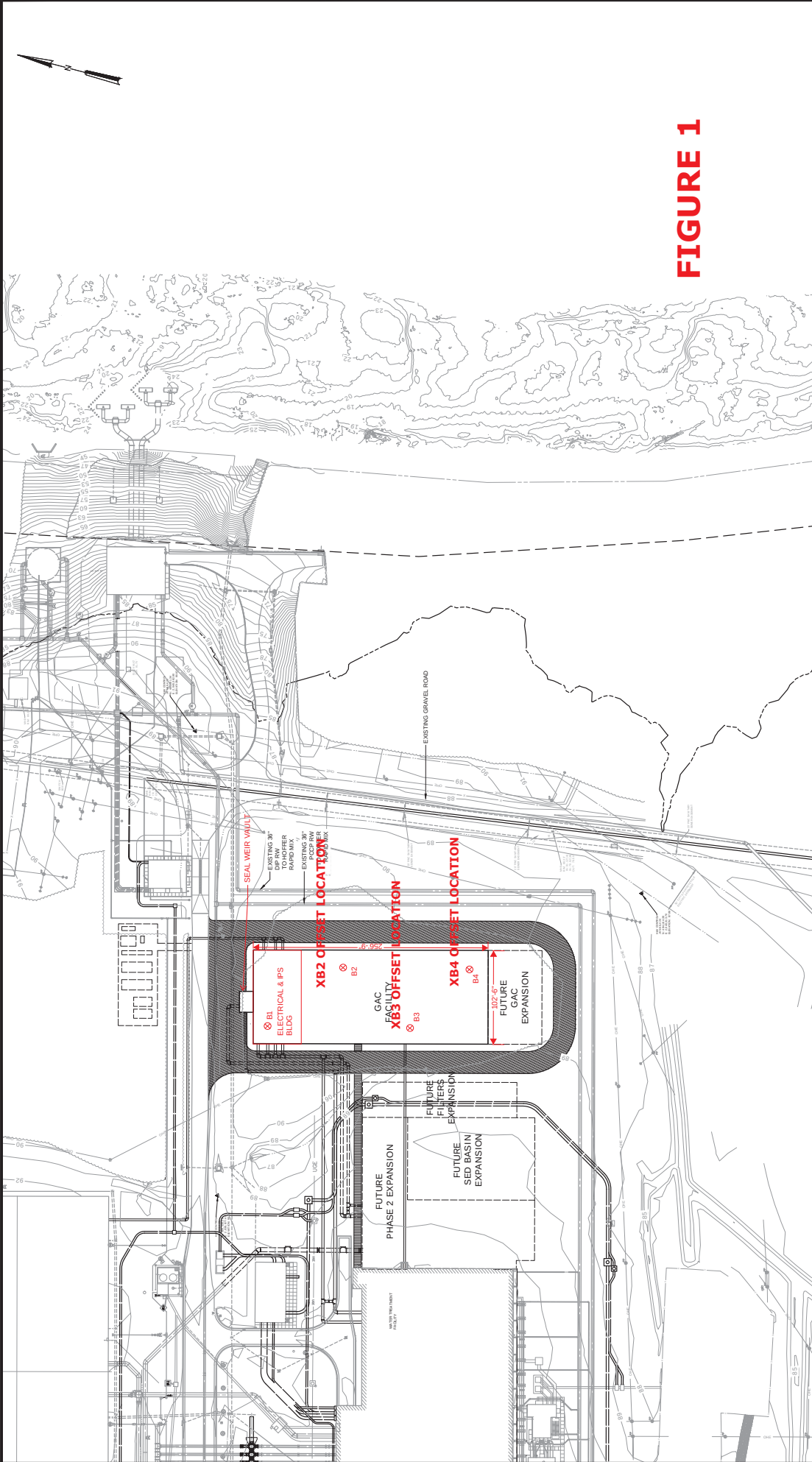


FIGURE 1

SCALE: 1" = 50'



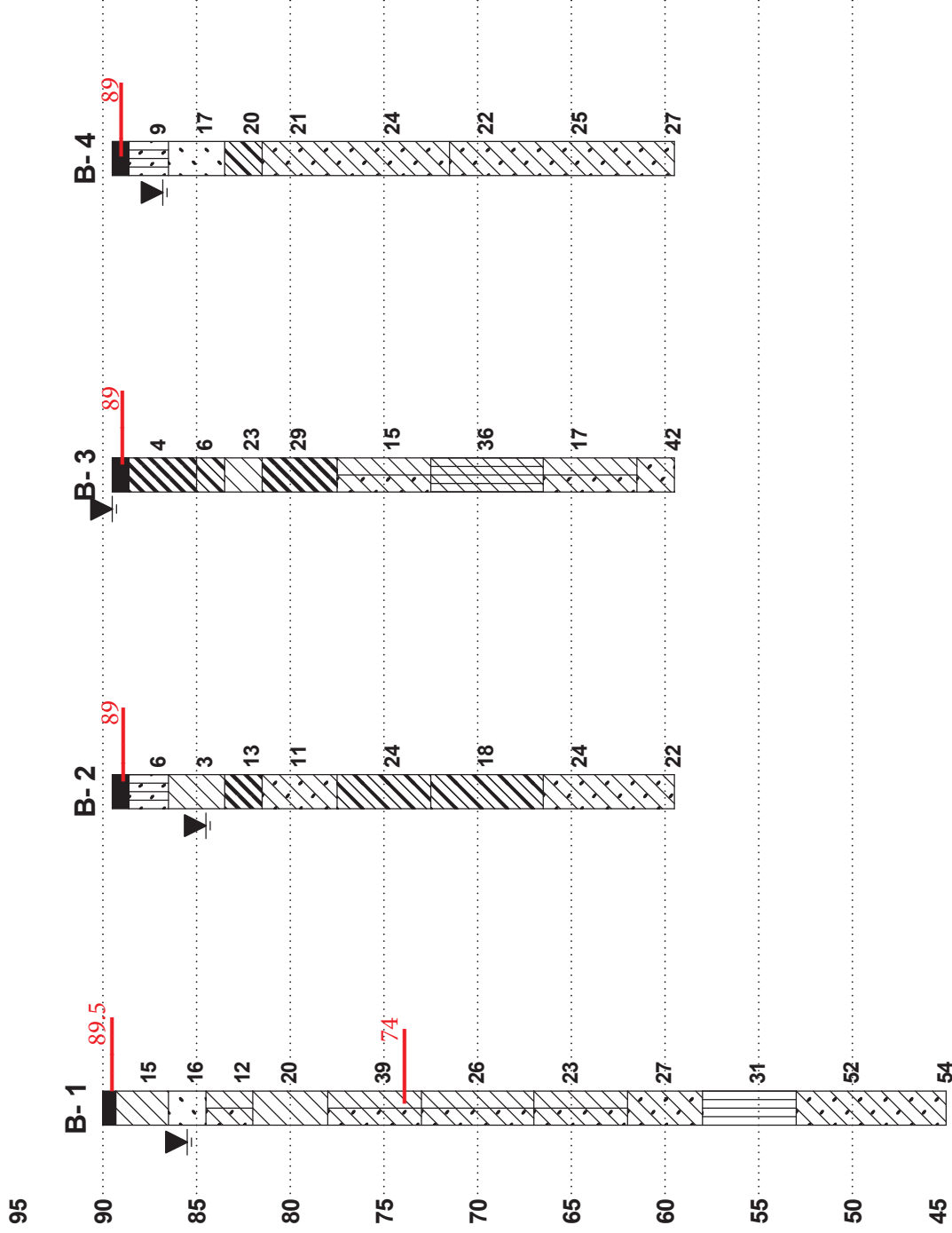
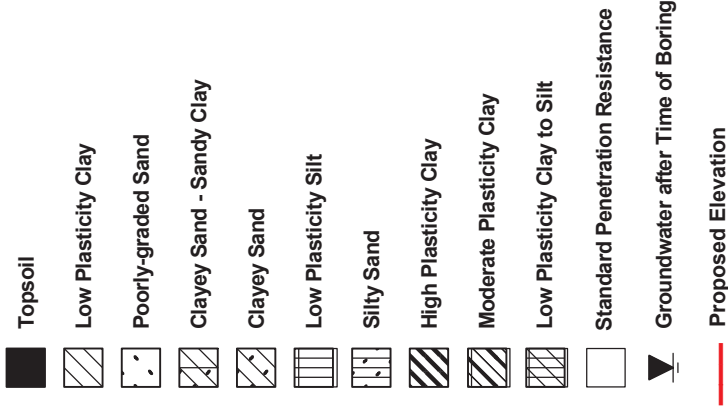
PLAN
SCALE: 1" = 50'

PROJECT ENGINEER C. HOPKINS DESIGNED BY K. THOMPSON DRAWN BY A. MARCH CHECKED BY Value IF THIS BAR DOES NOT MEASURE THE DRAWING IS NOT TO FULL SCALE DATE BY	PRELIMINARY DRAWING DO NOT USE FOR CONSTRUCTION DATE BY	Hazen HAZEN AND SAWYER 4011 WESTCHASE BOULEVARD, SUITE 500 RALEIGH, NORTH CAROLINA 27607 LICENSE NO.: C-03581	PUBLIC WORKS COMMISSION CITY OF FAYETTEVILLE, NORTH CAROLINA GLENVILLE LAKE AND P.O. HOFFER WATER TREATMENT FACILITY POST FILTER GAC ADSORPTION FACILITIES	P.O. HOFFER CIVIL OVERALL PLAN	DATE 2024 HAZEN NO.: 30402-067 CONTRACT NO.: 1 DRAWING NUMBER C100

Elevation (Feet)

GENERALIZED SUBSURFACE PROFILE

LEGEND



PROJECT:

PO Hoffer WTP
GAC Facilities
Fayetteville, North Carolina



SCALE: As Shown

JOB No:124-0773-EA

FIGURE No:2

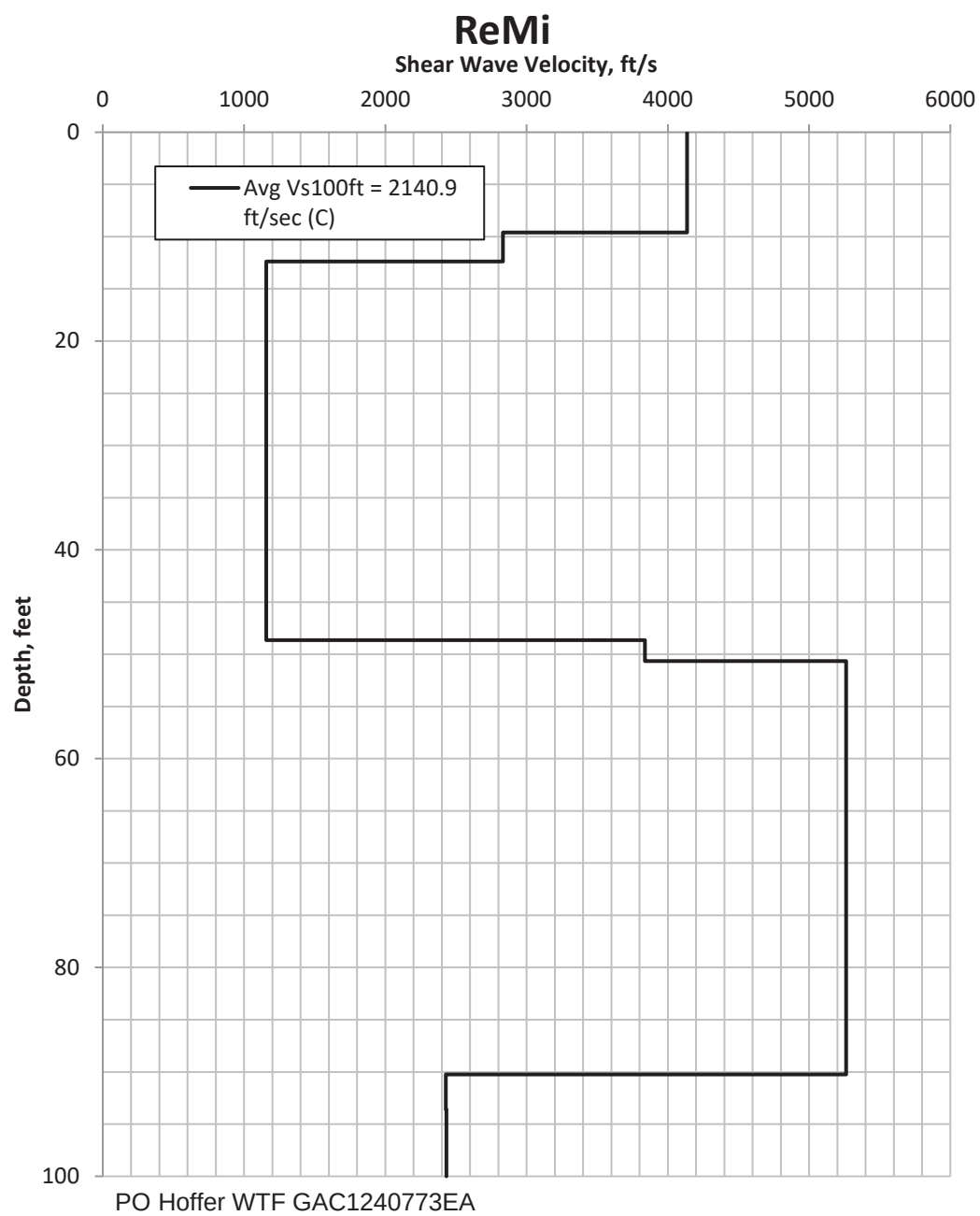


Figure 3

APPENDIX B

LAB DATA

TEST BORING RECORD

DEPTH (FT.)	DESCRIPTION	ELEVATION (FT.)	PENETRATION (BLOWS/FT.)	BLOWS PER SIX INCHES
0.0		90.00	10 20 40 60 100	
0.7	Topsoil			
	Stiff Orange Brown Fine Sandy Silty CLAY	CL		5-6-9
3.5				
5.5	Medium Dense Tan Slightly Silty Fine to Medium SAND	SP		5-8-8
	Medium Dense Grey Silty Clayey Fine to Medium SAND	SC CL		8-3-9
8.0				
	Very Stiff Grey Slightly Fine to Medium Sandy Silty CLAY	CL		7-10-10
12.0				
	Dense Grey Slightly Micaceous Clayey Fine to Medium SAND	SC CL		9-16-23
17.0				
	Medium Dense Brown Clayey Fine to Medium SAND	SC CL		10-12-14
23.0				
	Medium Dense Brown Orange Clayey Fine to Medium SAND	SC CL		11-11-12
28.0				
	Medium Dense Grey Slightly Micaceous Clayey Fine to Medium SAND	SC		9-13-14
32.0				
	Hard Grey Red Slightly Fine Sandy Clayey SILT	ML		13-15-16
37.0				
	Very Dense Grey Slightly Micaceous Clayey Fine to Medium SAND	SC		24-25-27
45.0				
	Boring terminated at 45'			11-25-29

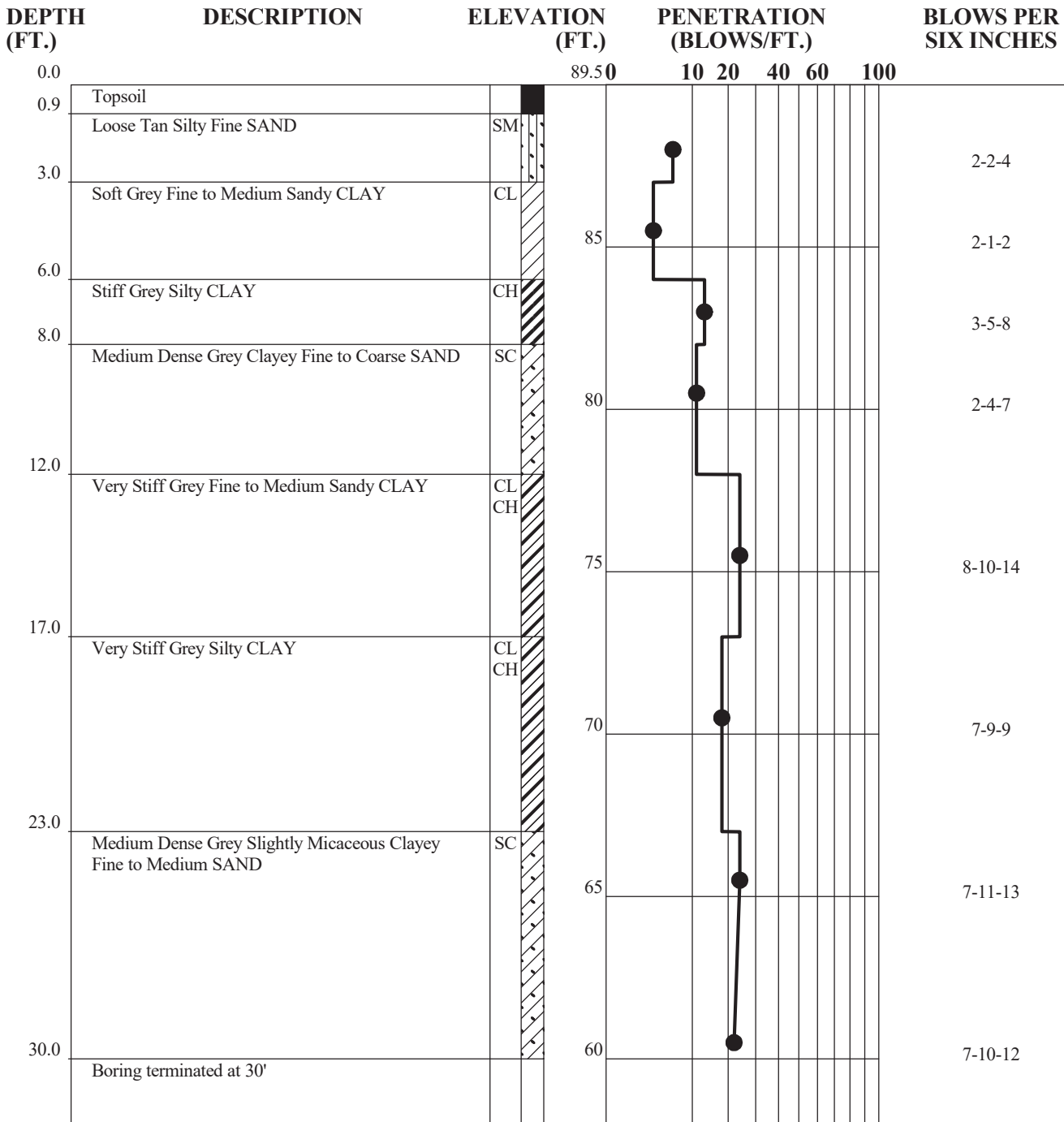
GTI_MAIN 240773.GPJ GTI.GDT 10/2/24

Groundwater encountered at 4.5' at 24 hrs.

JOB NUMBER 124-0773-EA
BORING NUMBER B- 1
DATE 9-18-24



TEST BORING RECORD

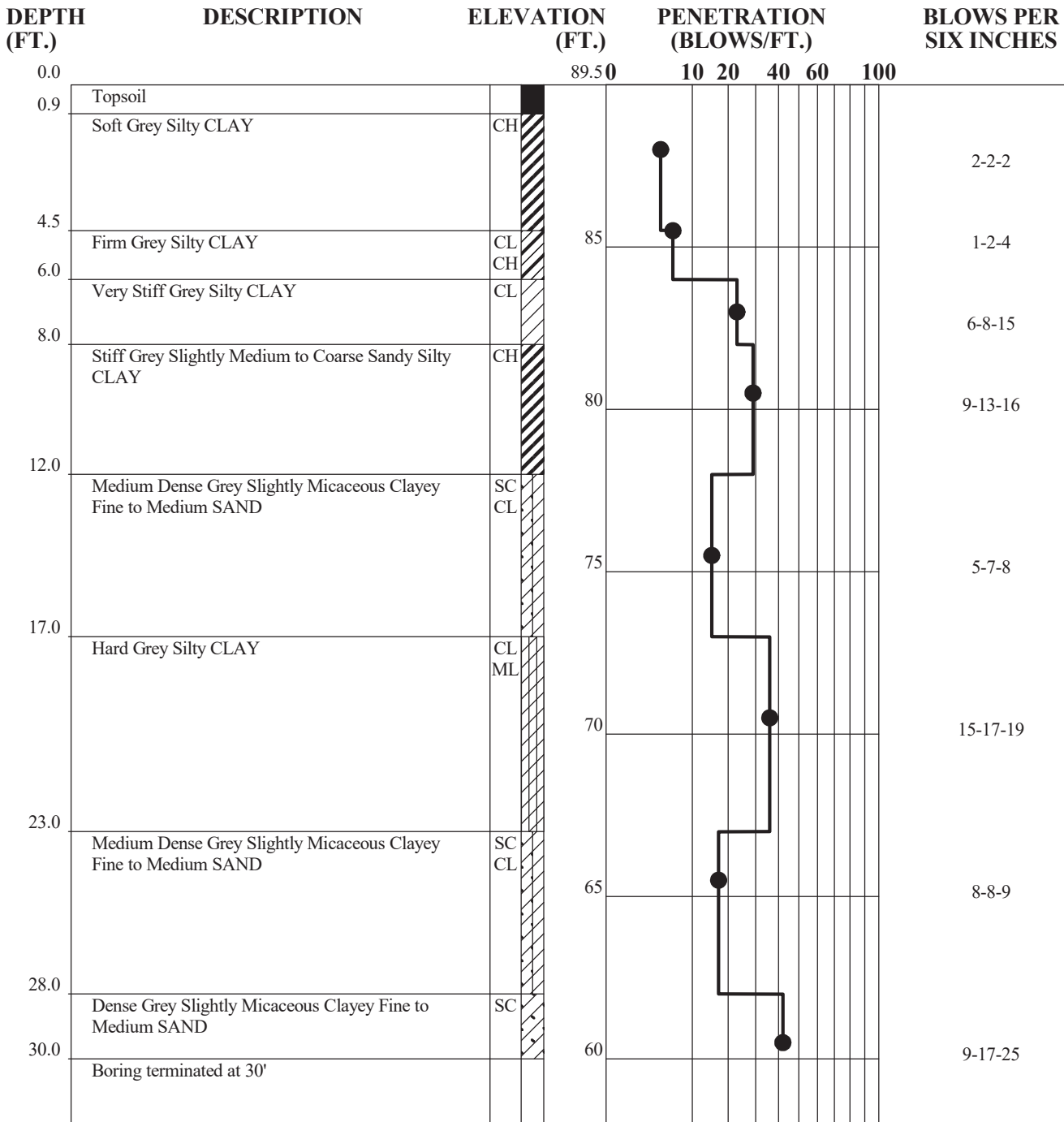


GTI_MAIN 240773.GPJ GTI.GDT 10/2/24

JOB NUMBER 124-0773-EA
BORING NUMBER B- 2
DATE 9-18-24



TEST BORING RECORD



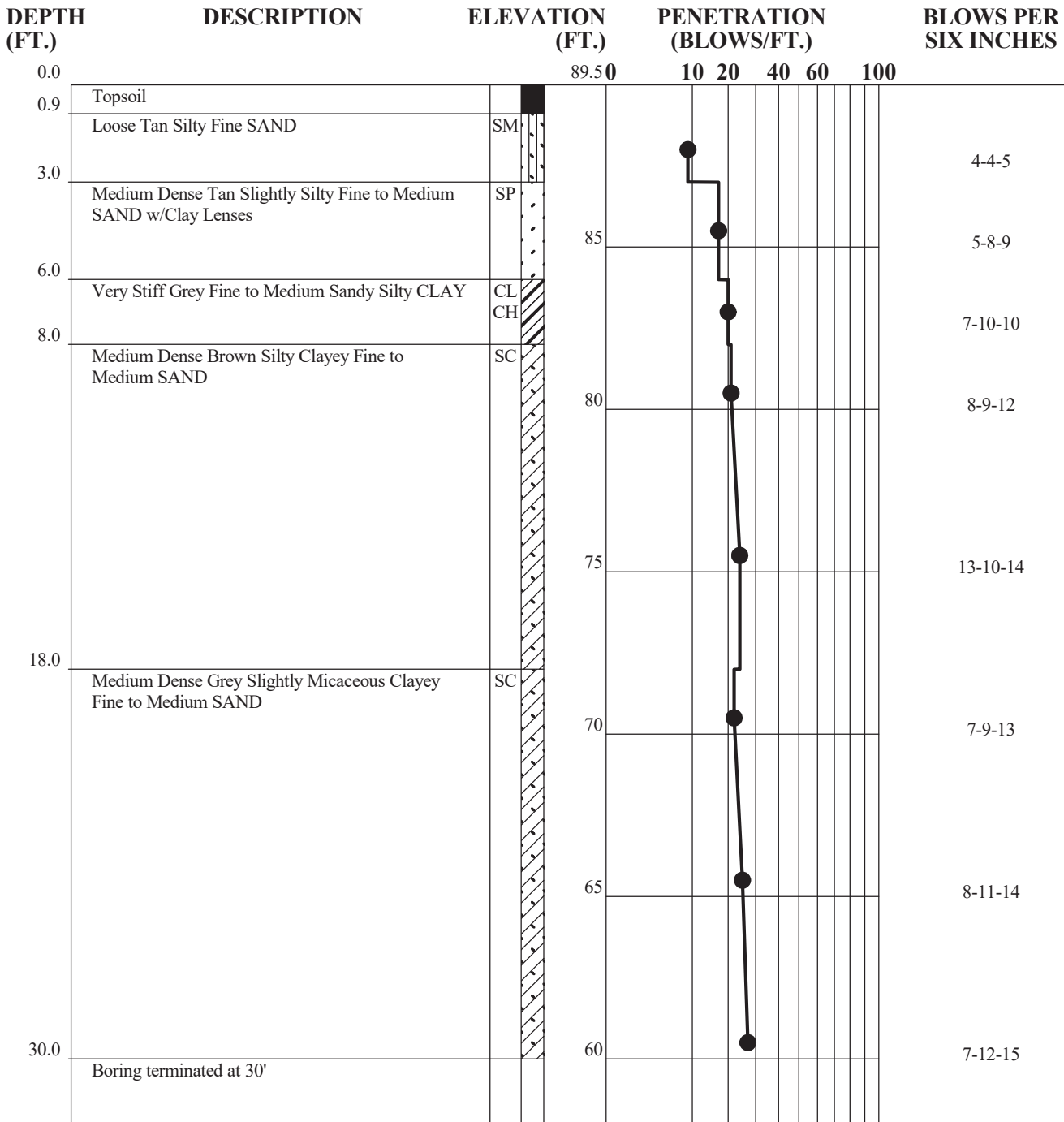
GTI_MAIN 240773.GPJ GTI.GDT 10/2/24

Groundwater encountered at 0.0' at 24 hrs.

JOB NUMBER 124-0773-EA
BORING NUMBER B- 3
DATE 9-18-24



TEST BORING RECORD



GTI_MAIN 240773.GPJ GTI.GDT 10/2/24

Groundwater encountered at 2.7' in piezometer at 24 hrs.

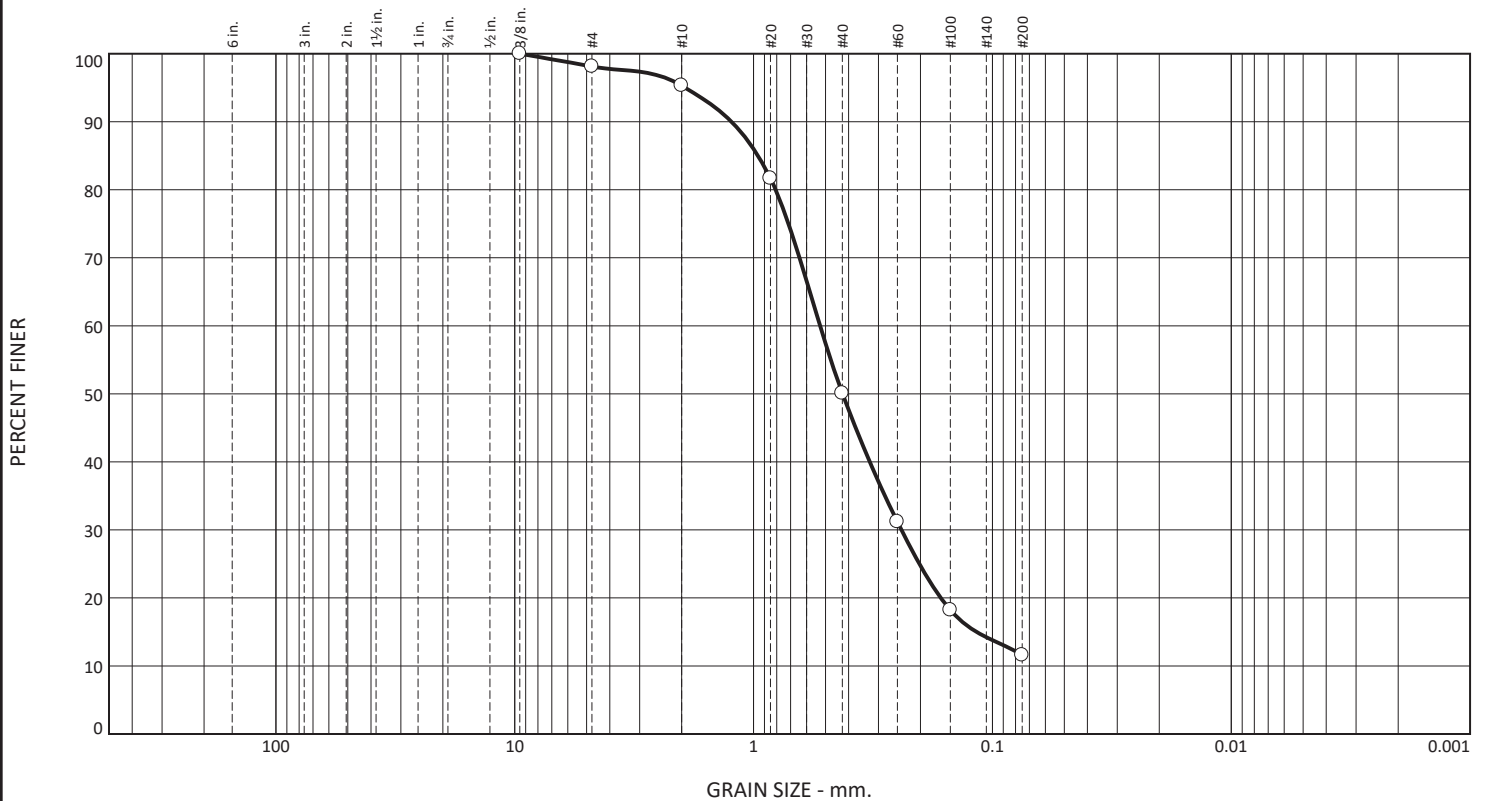
JOB NUMBER 124-0773-EA
BORING NUMBER B- 4
DATE 9-18-24



APPENDIX A
BORING RECORDS

Particle Size Distribution Report

ASTM D422



% +3"	% Gravel		% Sand			% Fines
	Coarse	Fine	Coarse	Medium	Fine	
0.0	0.0	1.9	2.8	45.2	38.5	11.6

Test Results (ASTM D422)				
Sieve Size or Diam. (mm.)	Finer (%)	Spec. * (%)	Out of Spec. (%)	Pct. of Fines
.375	100.0			
#4	98.1			
#10	95.3			
#20	81.7			
#40	50.1			
#60	31.2			
#100	18.2			
#200	11.6			

* (no specification provided)

Material Description

Brown Silty Fine to Medium Sand (SP-SM)

Atterberg Limits		
PL=	LL=	PI=
Coefficients		
D ₉₀ = 1.2365	D ₈₅ = 0.9589	D ₆₀ = 0.5264
D ₅₀ = 0.4241	D ₃₀ = 0.2404	D ₁₅ = 0.1166
D ₁₀ =	C _u =	C _c =
Classification		
USCS= SP-SM	AASHTO=	A-1-b
Test Remarks		

Location: PO Hoffer B-1
Sample Number: S-2

Sample Date: 10/07/24



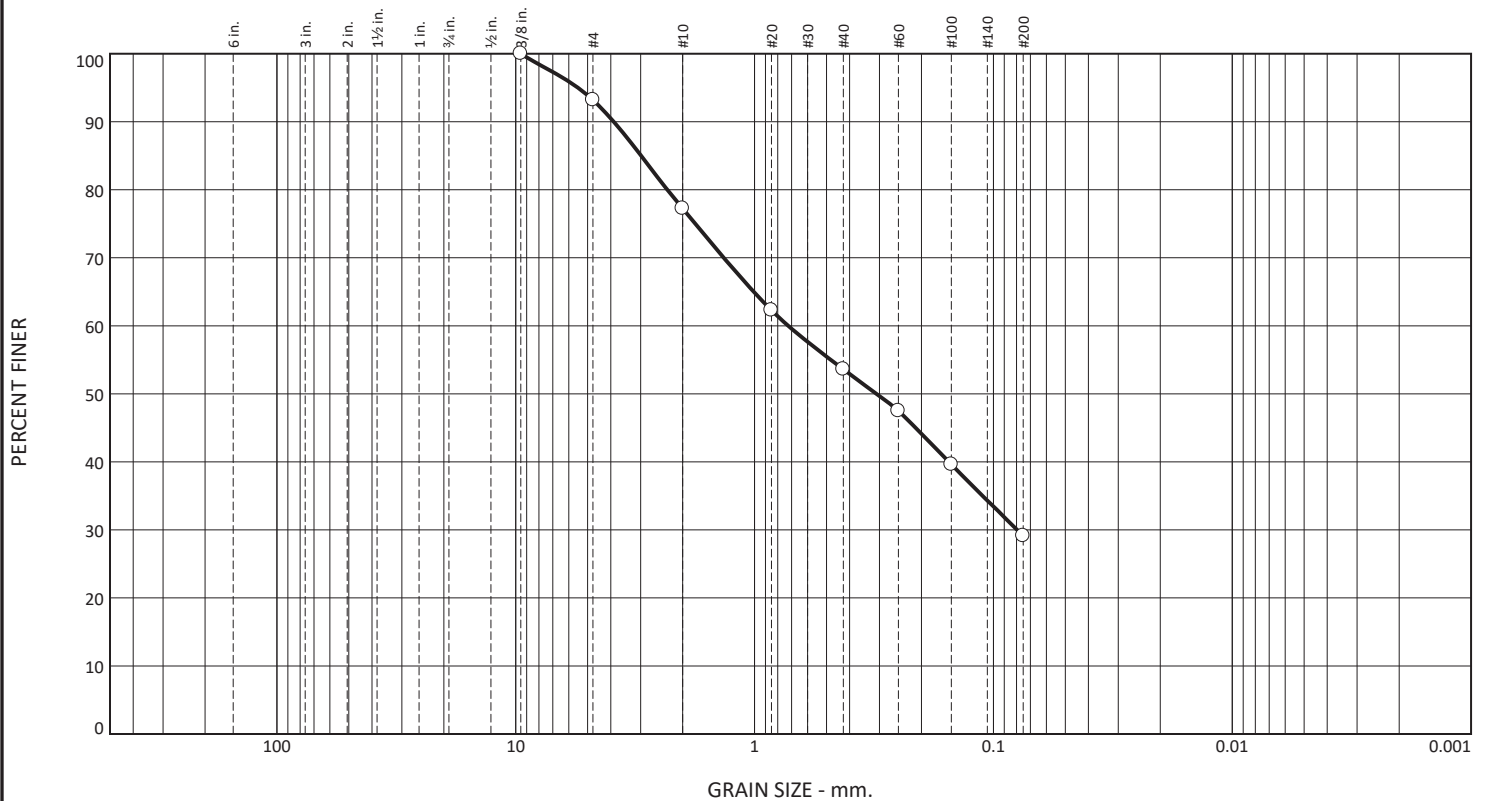
Client:
Project: PO Hoffer WWTP GAC Facility & Glenville Lake WWTP
Project No: 1-24-0773EA

Figure

Checked By: CJ

Particle Size Distribution Report

ASTM D422



% +3"	% Gravel		% Sand			% Fines
	Coarse	Fine	Coarse	Medium	Fine	
0.0	0.0	6.8	16.0	23.6	24.5	29.1

Test Results (ASTM D422)				
Sieve Size or Diam. (mm.)	Finer (%)	Spec. * (%)	Out of Spec. (%)	Pct. of Fines
.375	100.0			
#4	93.2			
#10	77.2			
#20	62.3			
#40	53.6			
#60	47.5			
#100	39.6			
#200	29.1			

* (no specification provided)

Material Description

Brown Clayey Medium to Fine SAND (SC)

Atterberg Limits
 PL= 30 LL= 47 PI= 17
Coefficients
 D₉₀= 3.8908 D₈₅= 2.9866 D₆₀= 0.7226
 D₅₀= 0.3076 D₃₀= 0.0795 D₁₅=
 D₁₀= C_u= C_c=
Classification
 USCS= SM AASHTO= A-2-7(1)
Test Remarks

Location: PO Hoffer B-1
Sample Number: S-6

Sample Date: 9/29/24



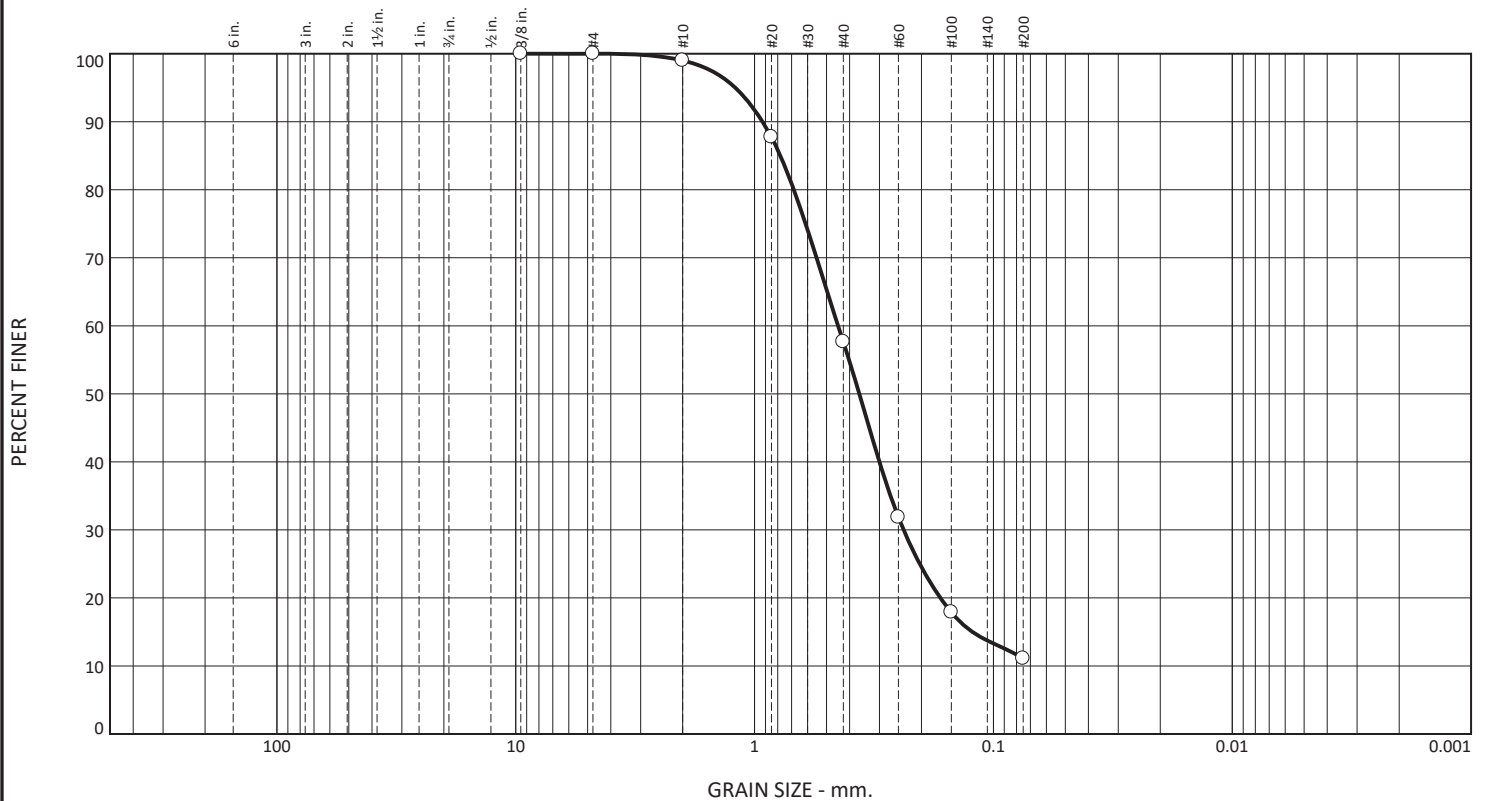
Client:
 Project: PO Hoffer WWTP GAC Facility & Glenville Lake WWTP
 Project No: 1-24-0773EA

Figure

Tested By: CJ Checked By: CJ

Particle Size Distribution Report

ASTM D422



% +3"	% Gravel		% Sand			% Fines
	Coarse	Fine	Coarse	Medium	Fine	
0.0	0.0	0.0	1.0	41.4	46.5	11.1

Test Results (ASTM D422)				
Sieve Size or Diam. (mm.)	Finer (%)	Spec. * (%)	Out of Spec. (%)	Pct. of Fines
.375	100.0			
#4	100.0			
#10	99.0			
#20	87.7			
#40	57.6			
#60	31.9			
#100	17.9			
#200	11.1			

* (no specification provided)

Material Description

Brown Clayey Medium to Fine Sand (SC-SP)

Atterberg Limits		
PL= 27	LL= 39	PI= 12
Coefficients		
D ₉₀ = 0.9266	D ₈₅ = 0.7795	D ₆₀ = 0.4472
D ₅₀ = 0.3642	D ₃₀ = 0.2376	D ₁₅ = 0.1224
D ₁₀ =	C _u =	C _c =
Classification		
USCS= SP-SM	AASHTO=	A-2-6(0)
Test Remarks		

Location: PO Hoffer B-1
Sample Number: S-7

Sample Date: 9/29/24

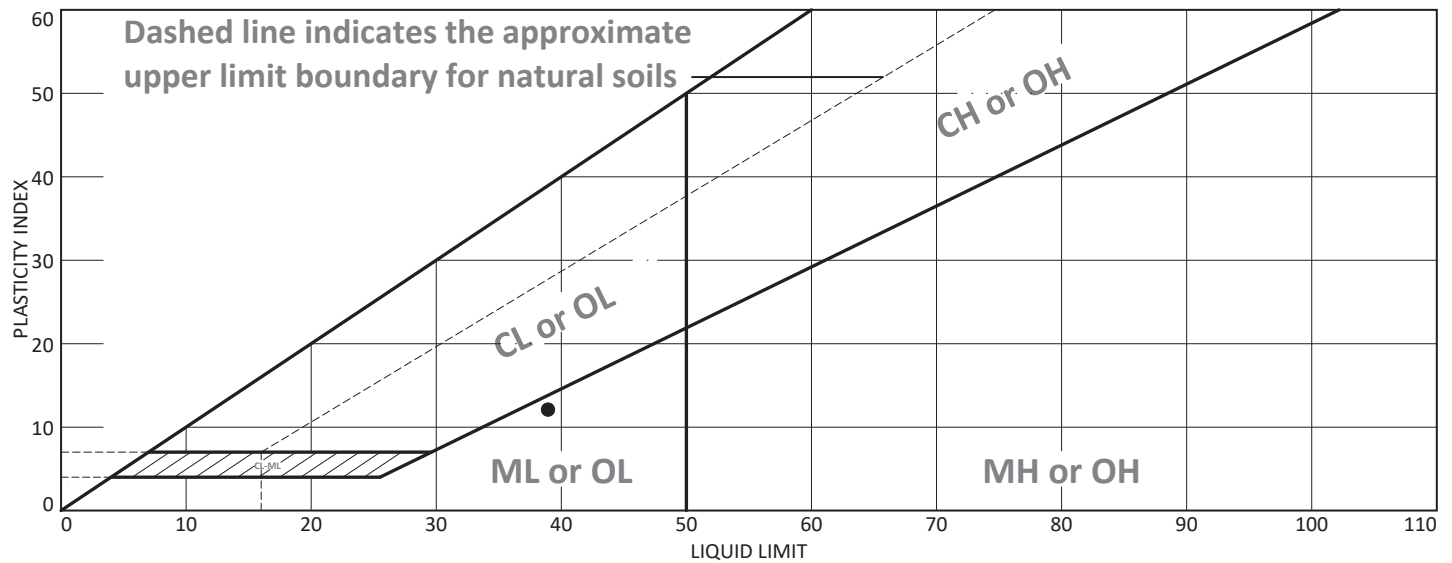


Client:
Project: PO Hoffer WWTP GAC Facility & Glenville Lake WWTP
Project No: 1-24-0773EA

Figure

Tested By: CJ Checked By: CJ

LIQUID AND PLASTIC LIMITS TEST REPORT



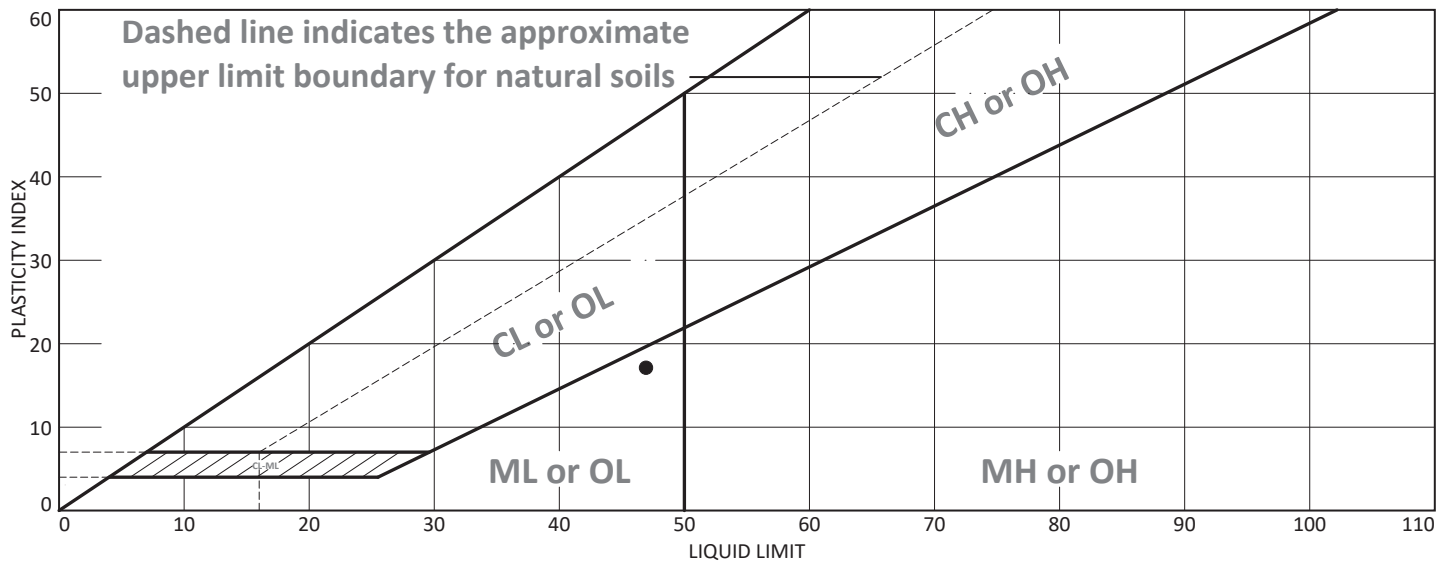
Sample Identification	Sampled	Received	Tested	Technician
● Location: PO Hoffer B-1 Sample Number: S-7	9/29/24	9/20/4	9/30/214	CF

Material Description	USCS	LL	PL	PI	NM	%<#40
● Brown Clayey Medium to Fine Sand (SC-SP)	SC-SP	39	27	12		57.6

PL Rolling Method	LL Device	Grooving Tool	Test Remarks
● Hand rolled	Mechanical	Plastic	

Project No. 1-24-0773EA	Client:	Checked by: CJ
Project: PO Hoffer WWTP GAC Facility & Glenville Lake WWTP		Title: LM
		Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



Sample Identification	Sampled	Received	Tested	Technician
● Location: PO Hoffer B-1 Sample Number: S-6	9/29/24	9/18/24	9/30/24	CF

Material Description	USCS	LL	PL	PI	NM	%<#40
● Brown Clayey Medium to Fine SAND (SC)	SC	47	30	17		53.6

PL Rolling Method	LL Device	Grooving Tool	Test Remarks
● Hand rolled	Mechanical	Plastic	

Project No. 1-24-0773EA Client: Project: PO Hoffer WWTP GAC Facility & Glenville Lake WWTP	Checked by: CJ Title: LM
	

Figure

October 10, 2024

Laura Bobier, P.E.
HAZEN & SAWYER
4011 Westchase Boulevard, Suite 500
Raleigh, NC 27607

Re: Glenville Lake WTP GAC Facility
628 Filter Plant Drive
Fayetteville, North Carolina
GeoTechnologies Project No. 1-24-0773-EA

Ms. Bobier:

GeoTechnologies has completed a subsurface investigation for the referenced project located at 628 Filter Plant Drive in Fayetteville, North Carolina. Subsurface conditions were investigated by completing six soil test borings with a track mounted drill rig as shown on Figure 1. An exception occurred with boring B-10 was performed with a hand auger due to the presence of numerous in-ground utilities. The drill rig test borings were advanced to depths of about 40 to 50 feet with automatic hammer standard penetration testing performed at selected intervals. Boring B-10 was advanced to a depth of 12.5 feet with a hand auger with dynamic hand cone penetrometer (DCP) testing and/or probing with a ½ diameter rod. This report presents the findings of the investigation and our recommendations based on the conditions encountered.

PROJECT AND SITE INFORMATION

Plant improvement information is summarized below:

Facility	Structure	Bearing Elevation	Existing Elevation	Maximum Bearing (psf)	Boring Numbers
Seal Weir Tankage	CIP Tank on a Mat	110	133	2,500	B8
Electrical Building	Masonry on a Mat	131	133	2,500	B8
IPS Building	Slab	108/94/87.33	110	2,500	B9-B10
GAC Tankage	Masonry on a Mat	119.5	126-132	3,000	B5-B7

The area of the new construction is generally open. The area of borings B-5 through B-8 is a storage yard which included a number of soil and aggregate stockpiles. The area around borings B-9 and B-10 includes a significant number of in-ground utilities.

SUBSURFACE CONDITIONS

A generalized subsurface profile prepared from the test boring data is attached to this report as Figure 2 to graphically illustrate subsurface conditions encountered in the borings. More detailed descriptions of the conditions encountered in the boring are then presented on the attached test boring records in Appendix A.

The subsurface profile typically included surface topsoil or gravel which was underlain by fill or possible fill soils consisting of sands and clays to depths of 3 to 12 feet. These materials exhibited penetration resistances of 2 to 10+ blows per foot/blows per increment (bpf/bpi). With depth, the borings encountered a mixture of sands and low to high plasticity clays with penetration resistances of 5 to 50+ bpf/bpi. The drill rig borings were terminated at the plan depths of 40 to 50 feet, while hand auger boring B-10 was terminated at 12.5 feet.

The boreholes included groundwater at 6 to 20+ feet at the time of boring or after a 24+ hour monitoring period, including in piezometers set in borings B-5 and B-9. The piezometers will be monitored over a period of about 4 months and the water level results will be updated after that period. It should be noted that groundwater and perched water levels will vary during different periods of the year and could be higher during construction.

RECOMMENDATIONS

The following recommendations are made based upon a review of the attached test boring data, our understanding of the proposed construction, and experience with similar projects and subsurface conditions. Should the project plans change significantly from those now under consideration, we would appreciate being provided with that information so that these recommendations may be confirmed, extended, or modified as necessary. Additionally, should subsurface conditions adverse to those indicated by this report be encountered during construction, those differences should be reported to us for review and comment.

Site Grading Considerations. Site grading should begin with clearing and stripping of topsoil, excavation to plan grade as necessary, and the removal of any soft soils deemed unsuitable by the geotechnical engineer. This includes old fill/possible fill soils if those soils are found to be soft or unsuitable (boring B-9 had some organics from 3 to 5 feet and boring B-10 had soft fill to at least 6.5 feet). The subgrade soils should be proofrolled for stability with a partially loaded dump truck or similar piece of rubber tired equipment; however, hand auger borings should also be performed as part of the evaluation since any old fill will need to be carefully evaluated and repairs as necessary.

Ideally, site grading and repairs will be implemented during a period of warm and dry weather typical of the months from April into early October.

Backfill Materials/Placement. The on-site soils, excluding topsoil, unsuitable old fill and highly plastic soils, will be suitable for reuse as structural fill if the material can be brought to within about 2% of the optimum moisture content with drying as required. However, some of the near surface soils and the submerged soils were significantly wet of the optimum moisture content at the time of our drilling. As such, the contractor should be prepared to dry any wet of optimum soils unless those soils will be wasted and replaced with imported select fill. Highly plastic soils should not be reused as fill within 3 feet of grade.

Off-site borrow should consist of silty and clayey sands or low plasticity silts and clays having Unified Soil Classifications of SM, SC, ML, or CL. Cleaner (SP/SW) sands should be used where undercut extends below the water table. All fill materials in structural areas should be compacted to not less than 95% of the standard Proctor maximum dry density except in the final foot below any pavements where this requirement should be increased to 98% of the standard Proctor maximum. It is recommended that quality control testing be performed to verify that the proper soil density specifications are being met and to confirm that fill placement is being performed in a controlled manner.

An exception to the above will occur in areas where the placement of new soil fill may result in higher than allowable post-construction settlement (assumed to be 1-1.5 inches total and 0.5-1.0 inches differential for the purpose of this report). In these areas, we recommend that backfill consist of either #57/67 washed stone or CABC stone. Quarry screenings, processed fill or possibly clean sands may also be considered at the discretion of the geotechnical engineer following classification submittals.

Quarry or pit materials should be compacted to the standards previously described except that #57/67 stone may be compacted in 24 inch lifts before compaction with a vibratory roller unless otherwise directed by the geotechnical engineer.

Excavation Considerations. Our borings did not encounter any difficult excavation materials for typical excavation equipment, such as a CAT 330 within the expected depth of excavation.

Dewatering Considerations. Deeper excavations for below grade structures and undercut will encounter groundwater. It may be possible to control groundwater with some type of shallow interior perimeter trench and a sump; however, selection of dewatering methods and depths should be left to the discretion of the contractor. If a sump and trench approach is not effective, a more proactive approach will need to be considered. The grain size data in Appendix B may be used by dewatering contractors.

Uplift Considerations. Excessive hydrostatic uplift can be resisted by increasing the size of the foundation to engage additional soil if desired. Alternatively, soil anchors can be used to provide additional resistance. If soil anchors are used to provide additional resistance to uplift loads, we recommend that the anchors be preliminarily designed for an ultimate grout to soil shear strength of 12 psi. We recommend load testing a few anchors to 2.5 times the design capacity for verification and modifying the design as needed.

We recommend that an exterior well be tied into washed stone below the submerged structures to monitor water pressure. If tank contents will be lowered or removed for maintenance, the water level in the well should be compared to the uplift design water level. If the water level in the well exceeds the design level, the well should be pumped down to reduce water pressures before the tank contents are lowered or emptied.

Below Grade Walls. Below grade walls may be designed using the soil parameters indicated in the table below. Material placed within 4 feet of walls should be compacted with hand held rather than with heavy mechanized equipment. Backfill should be compacted to at least 95% of the standard Proctor maximum dry density, with 98% being achieved within the upper 12 inches of grade in any pavement areas. The values assume level grade behind or in front of the wall and should be modified for sloping grades. At-rest earth pressures should be used for non-yielding walls. Appropriate safety factors should be applied to design calculations.

At-rest EFP Above Water	At-rest EFP Below Water	Active EFP Above Water	Active EFP Below Water	Passive EFP	Base Friction
55 pcf	90 pcf	40 pcf	80 pcf	300 pcf	0.35

Temporary Shoring/Slopes. Means and methods for implementing the required excavations should be left to the discretion of the contractor. There are several alternatives including use of a lagging wall, sheeting, or a soil nail wall if adequate room exists to install the nails.

If sloped excavations are used instead of shoring, the slopes should comply with OSHA guidelines. The slopes should be inspected by the competent person at the time of excavation and at least three times a day during construction to verify that surface sloughs/tension cracks are not developing. If instability is observed, personnel should leave the excavation until it is properly stabilized.

Permanent Slopes. In this geology, dry and well compacted unreinforced fill slopes built at 2.5H:1V or flatter are stable without exception provided that compaction is carried to the face of the slope. Steeper fill slopes can be used with properly designed and installed geosynthetic reinforcement. Cut slopes should also be 2.5H:1V or flatter. Any

water encountered on the face of slopes should be brought to the attention of the geotechnical engineer so that necessary provisions can be made.

Vibrations. We anticipate that minimizing construction vibrations will be important for this project. A common peak particle velocity (PPV) threshold value used to minimize the risk of damage to structures is 2.0 inches per second; however, for sensitive installations we recommend that contractors maintain vibrations at 0.50 inches per second at 10 to 100 cycles per second (Hz). This recommendation should be reviewed by facility personnel in the event that critical and/or highly sensitive structures are located in close proximity to the planned construction.

Shallow Foundations. Shallow foundations may be designed for the indicated maximum soil bearing pressures of 2,500 to 3,000 psf or a subgrade modulus of 150 pci (for a 1 foot by 1-foot area, scale for other dimensions). Higher soil bearing and/or subgrade modulus values can be considered on a case by case basis. All foundations should bear at least 12 inches below grade for frost protection and all subgrades should be evaluated by the geotechnical engineer to determine if repairs are warranted. This includes repairs associated with any highly plastic soils at or near the foundation bearing elevation.

Experience with the on-site soils has demonstrated that these materials are highly overconsolidated and have very high modulus values. As such, even for a large structure with a bearing stress of 3,000 psf, we are estimating total and differential settlements of less than 1.5 inches (total) and 0.75 inch (differential) when accounting for soil unloading to reach plan grade. These values are lowered to about 0.75 inches and 0.50 inches for a bearing stress of 2,000 psf (unloaded to about 1,150 psf). A summary of these analyses and analyses for the other components of the facility are summarized in the table below.

Where settlement estimates are provided below, they should be considered preliminary and should be updated as additional information about construction sequencing and foundation design details become available. A significant portion of the estimated settlement is associated with near surface conditions and therefore structural backfilling associated with undercut, temporary slopes and utilities needs to be considered in final settlement estimates.

STRUCTURE	BEARING STRESS (PSF)	NET STRESS AFTER UNLOADING (PSF)	TOTAL SETTLEMENT (IN)	DIFFERENTIAL SETTLEMENT (IN)
Seal Weir Tankage	2,500	250	<1.0	0.50
Electrical Building	2,500	2,250	1.0*	0.75*
IPS Building	2,500	1,500	<1.0	0.50
GAC Tankage	3,000	2,150	1.3*	0.75*
GAC Tankage	2,000	1,150	0.75*	0.50*

*Assumes undercut/replacement of soft soils as directed.

Aggregate Piers. If finalized settlement estimates are found to be excessive, consideration will need to be given to using intermediate support. A common intermediate system is aggregate piers designed for an allowable bearing pressure of 6 to 8 ksf. These are proprietary design build systems that typically include internal design review and field quality control by the installer. As such, the role of the geotechnical engineer is limited to providing soil data which is interpreted by the specialty contractor. Unlike most conventional pile systems in the area, these foundations do not reduce settlement to some negligible value, but when properly designed are intended to limit settlement to a given criteria. If aggregate piers are used, it is the responsibility of the specialty contractor to verify that the design model selected is appropriate for the foundation configuration, planned grading, groundwater, and site geology. This includes superposition of foundation loading as necessary and accounting for any fill induced settlements.

Using aggregate piers will also help to reduce (but not eliminate) undercut associated with existing near surface fill soils.

Slab-on-Grades. We recommend placing at least 8 to 12 inches of #57 or #67 stone over the subgrade for slabs, especially for below-grade structures, to protect the subgrade and to provide a medium for dewatering as needed prior to concreting. A geotextile fabric separator should be used between the subgrade and stone. If the stone will be subject to traffic before concreting, consideration should be given to using CABC stone instead of, or in conjunction with the washed stone.

Seismic Design Considerations. Our investigation assigned a seismic site class of “D” based on standard penetration resistances. However, because site class assignment based on shear wave velocity data can often provide for a more favorable site classification, GeoTechnologies performed ReMi geophysical testing to evaluate shear wave velocities in the upper 100 feet of grade (near boring B-5). Based on the results of our testing, the average shear wave velocity in the upper 100 feet was found to exceed 1,200 feet per second (Figure 3). Based on this result, a site class of “C” may be used for design.

A short period spectral acceleration (S_s) of 0.153 may be used, and a 1-second period acceleration (S_1) of 0.073 may be used assuming that the 2024 North Carolina Building Code is applicable.

SUMMARY

In summary, site conditions are characterized by the presence of near surface fill/possible fill soils which will likely need to be undercut below grade in some areas. Repairs should be performed as directed by the geotechnical engineer. The contractor should be prepared to dewater below grade excavations. Dewatering and shoring/sloping methods are the responsibility of the contractor. Select backfill will likely be needed to facilitate backfilling near the water table and potentially to help minimize settlements.

Preliminary settlement estimates for expected bearing conditions have been provided; however, these estimates will need to be updated as specific foundation details and construction sequences become available.

We appreciate the opportunity to have provided you with our services during this phase of the project. Please contact us if you have questions regarding this report or if we may be of further assistance.

Sincerely,

GeoTechnologies, Inc.

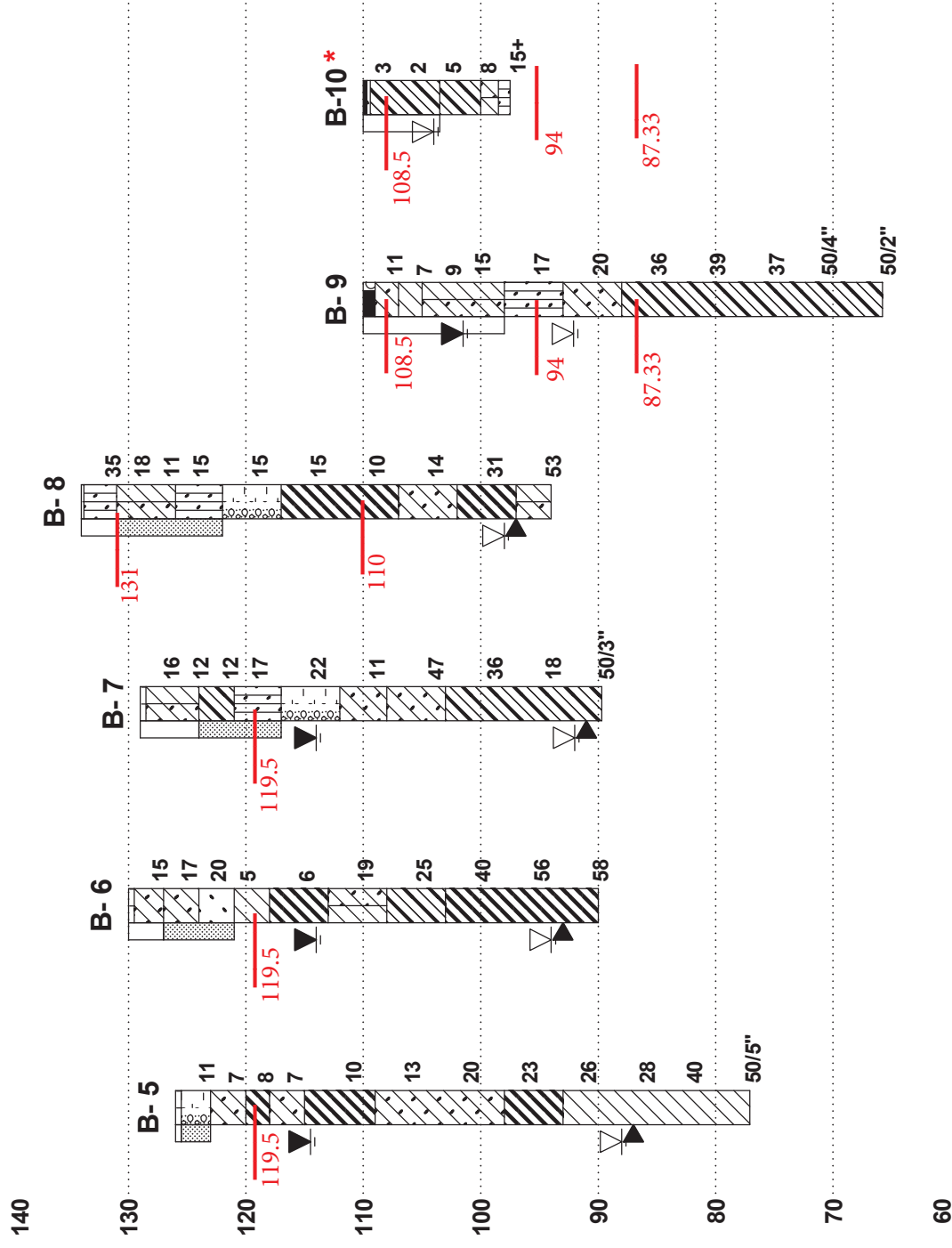
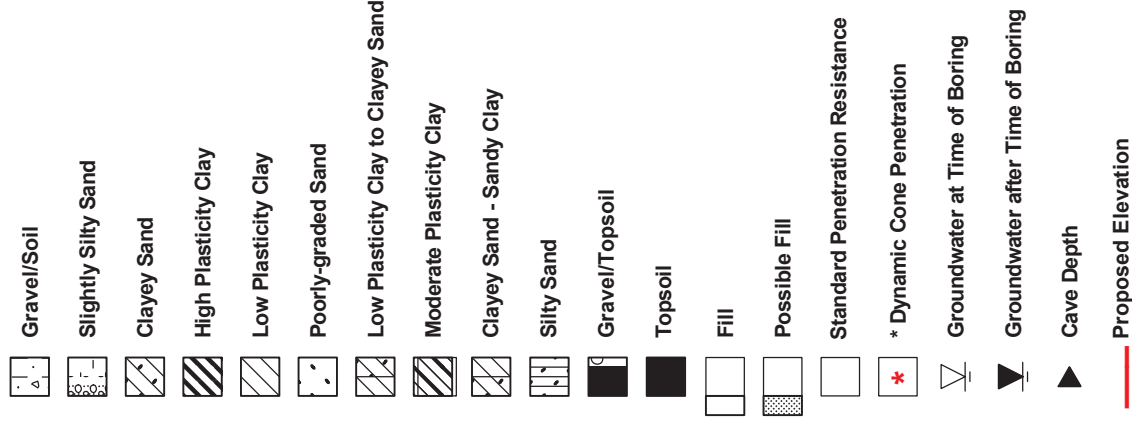
Ernest L. Stitzinger, P.E.
NC Registration No. 25534



Elevation (Feet)

GENERALIZED SUBSURFACE PROFILE

LEGEND



PROJECT:

Glenville Lake WTP
GAC Facilities
Fayetteville, North Carolina

SCALE: As Shown

JOB No:124-0773-EA

FIGURE No:2



ReMi

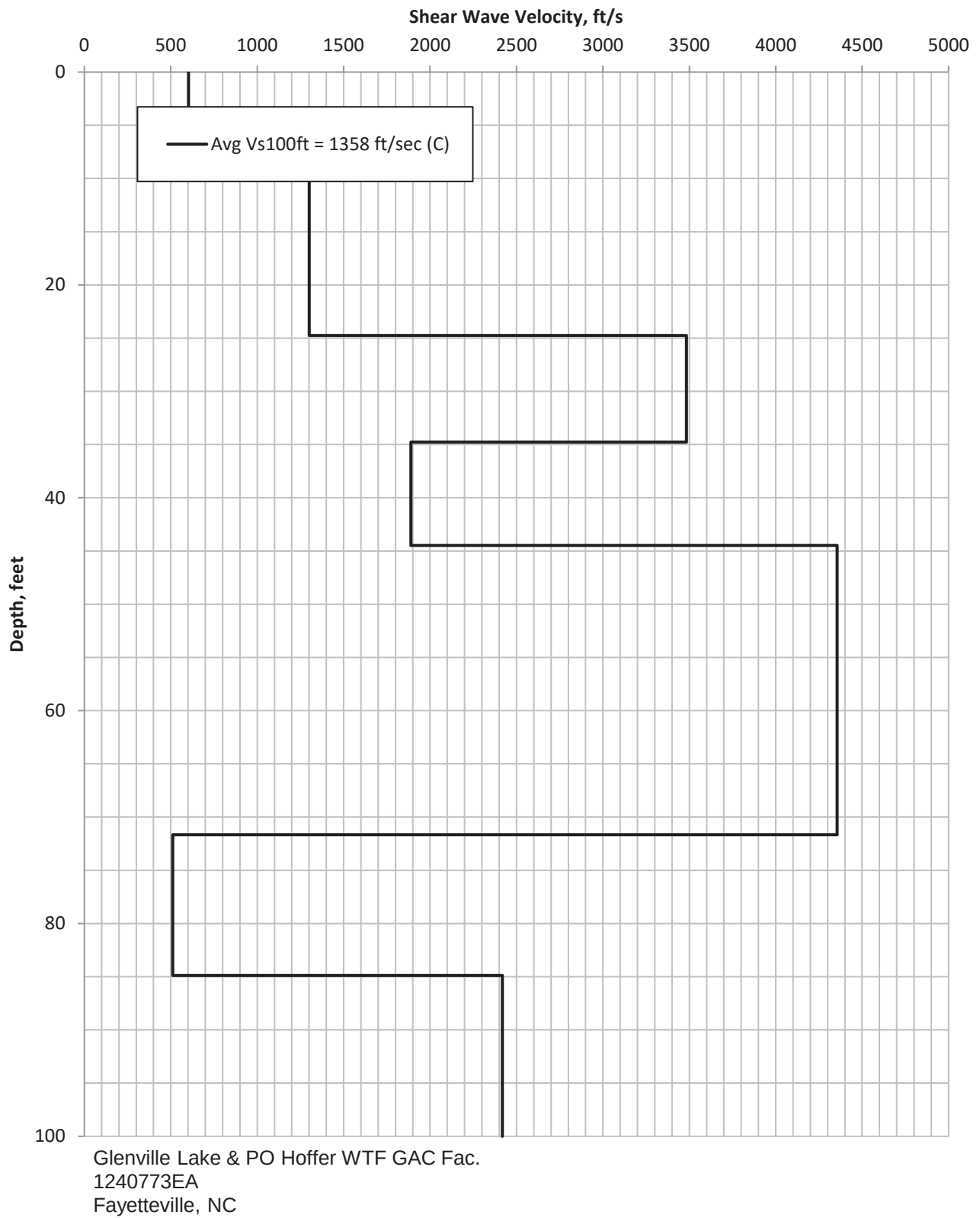
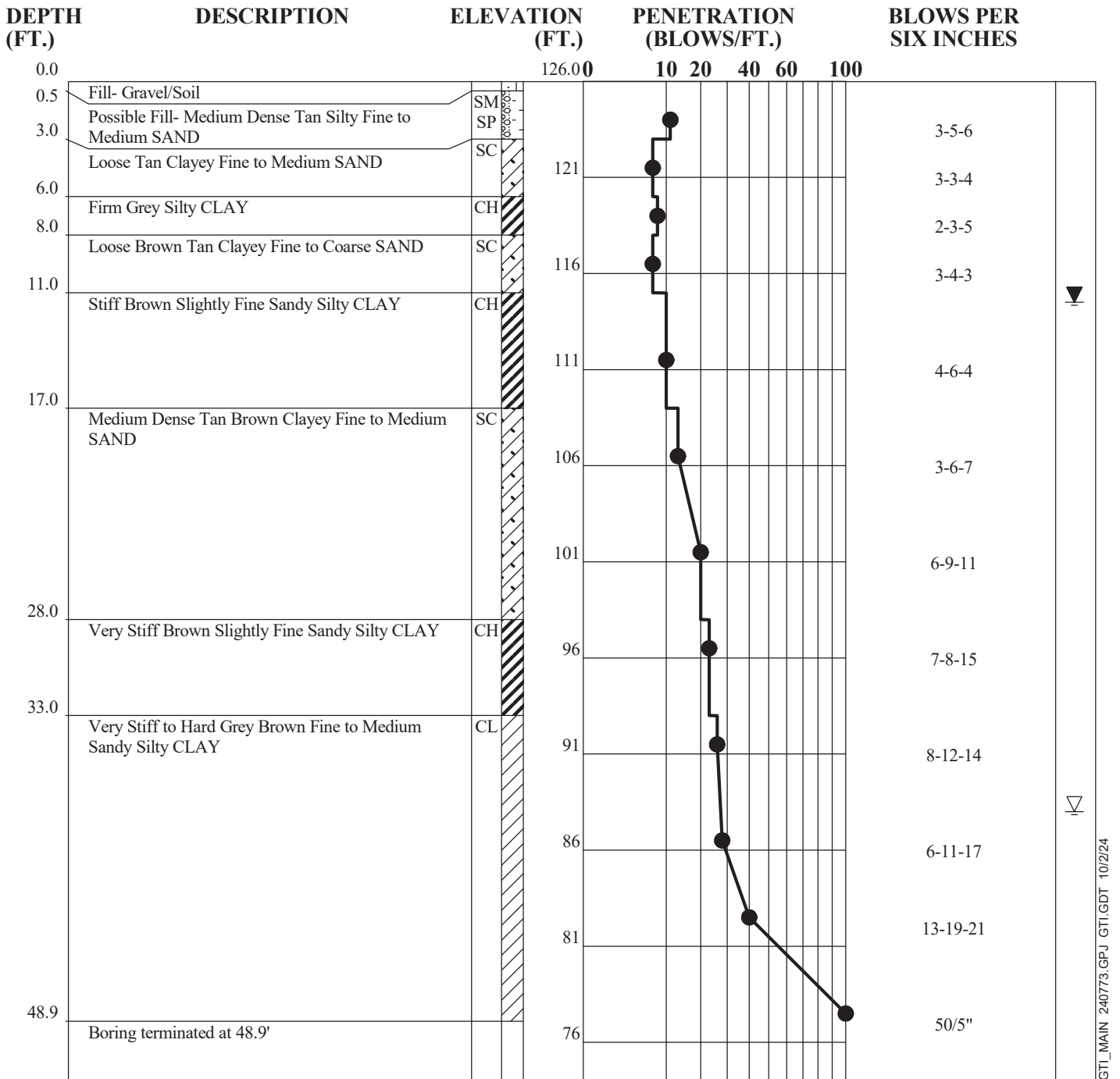


FIGURE 3

APPENDIX A
BORING RECORDS

TEST BORING RECORD



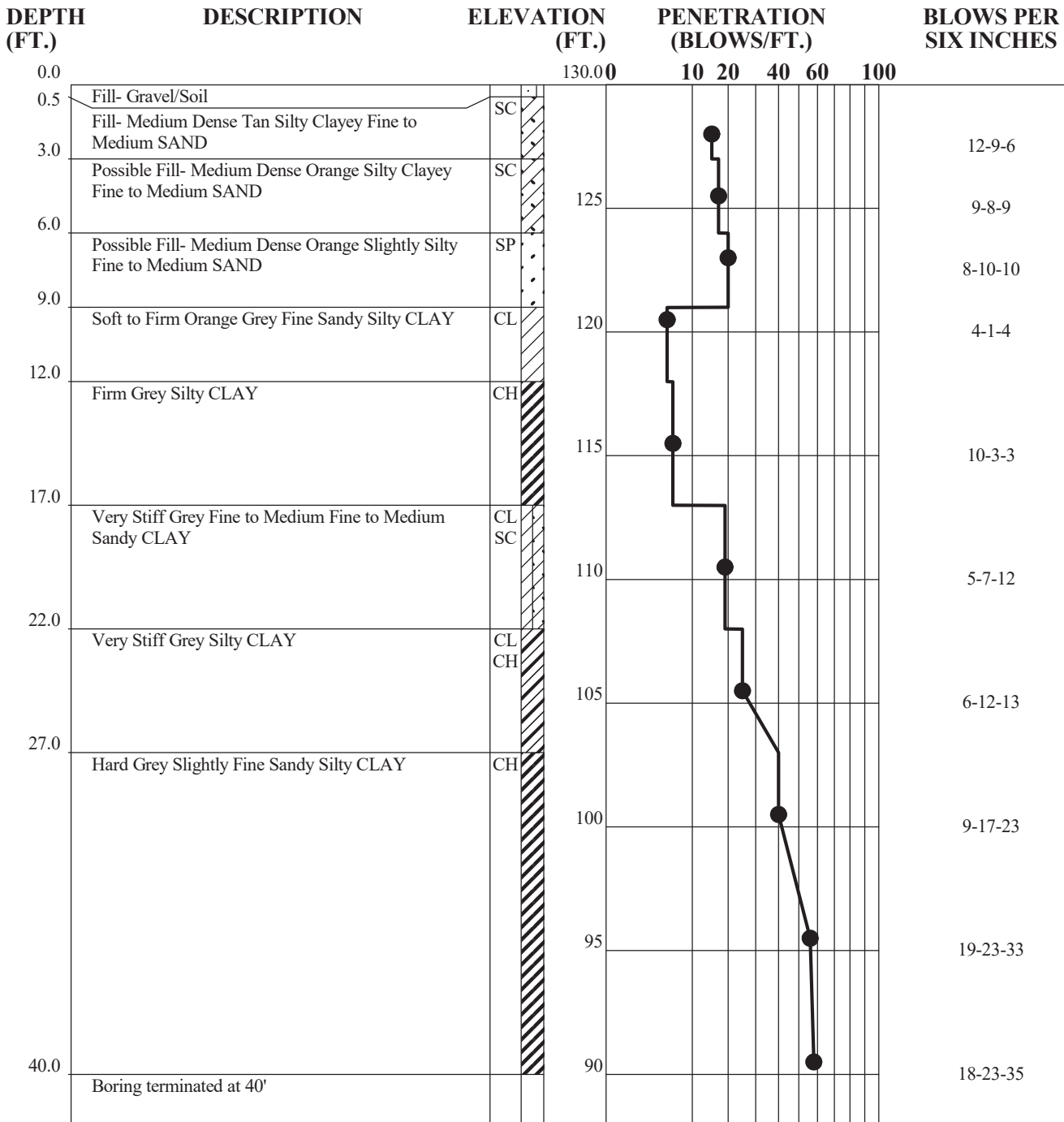
GTI_MAIN 240773.GPJ GTI.GDT 10/2/24

Groundwater encountered at 38' at time of boring and 11.5' at 24 hrs. Set piezometer in borehole. Boring caved at 39'.

JOB NUMBER 124-0773-EA
BORING NUMBER B- 5
DATE 9-12-24



TEST BORING RECORD



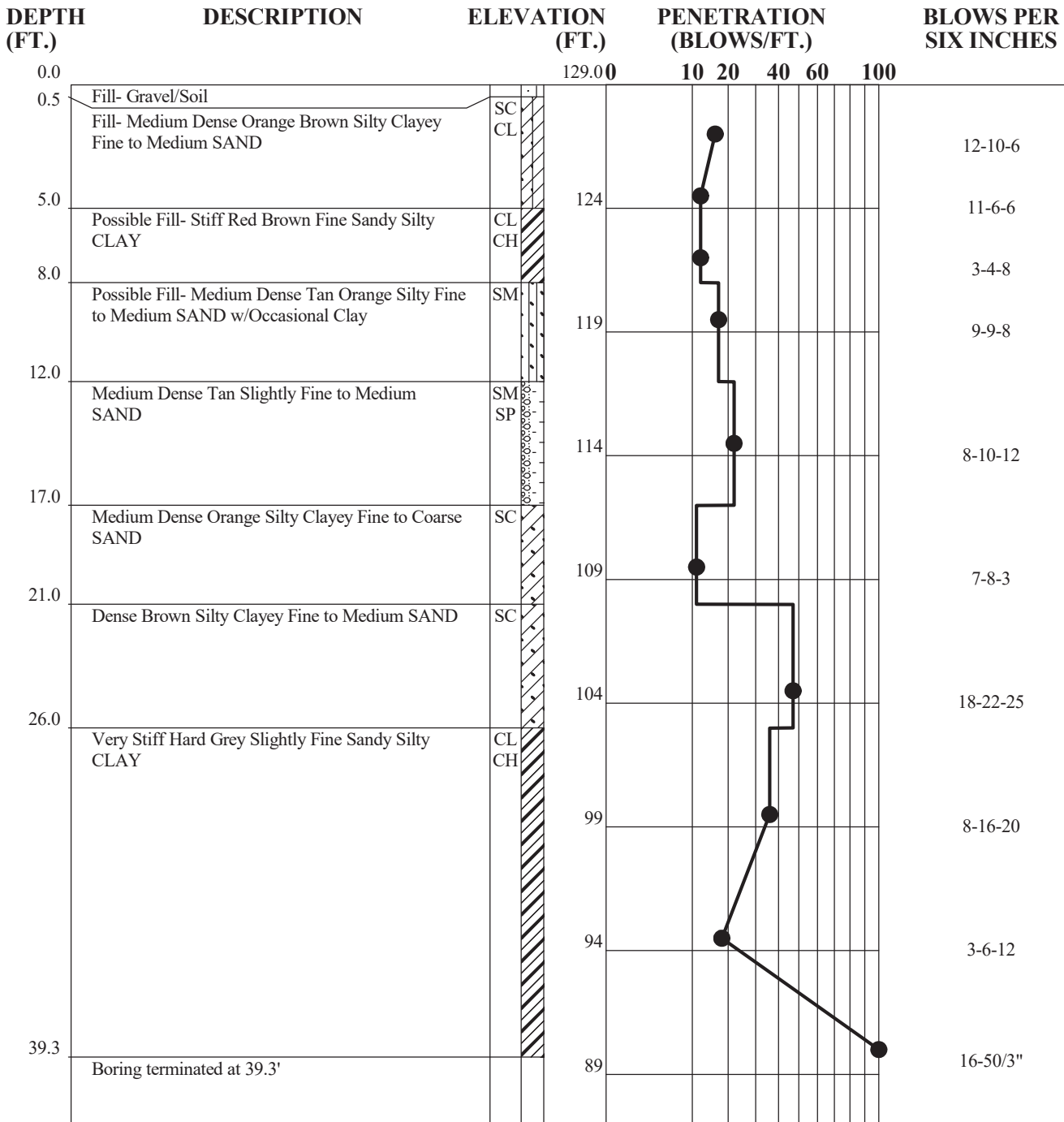
GTI_MAIN 240773.GPJ GTI.GDT 10/2/24

Groundwater encountered at 36' at time of boring and 16' at 24 hrs. Boring caved at 37'.

JOB NUMBER 124-0773-EA
BORING NUMBER B- 6
DATE 9-12-24



TEST BORING RECORD



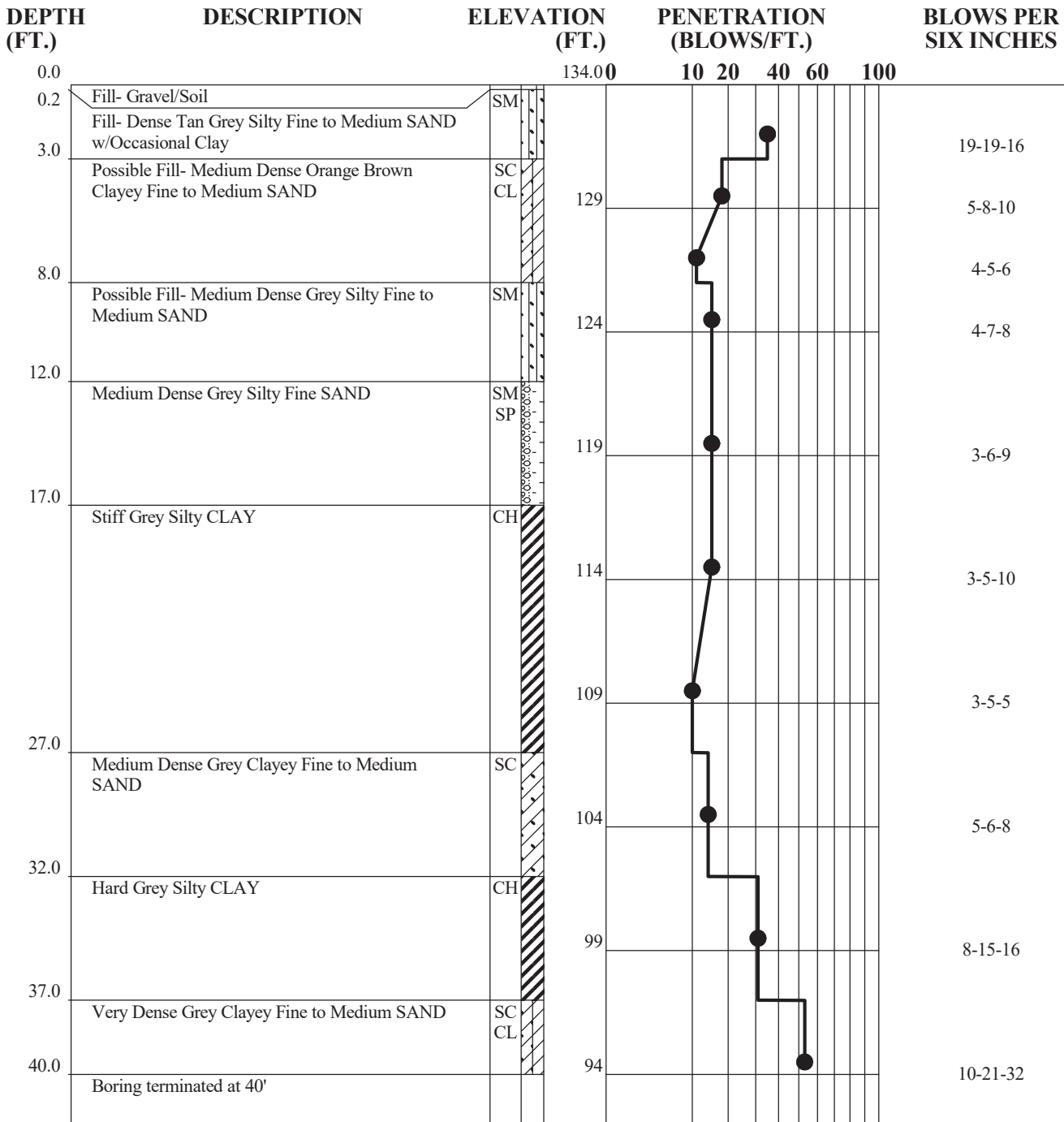
GTI_MAIN 240773.GPJ GTI.GDT 10/2/24

Groundwater encountered at 37' at time of boring and 15' at 24 hrs. Boring caved at 38'.

JOB NUMBER 124-0773-EA
BORING NUMBER B- 7
DATE 9-12-24



TEST BORING RECORD



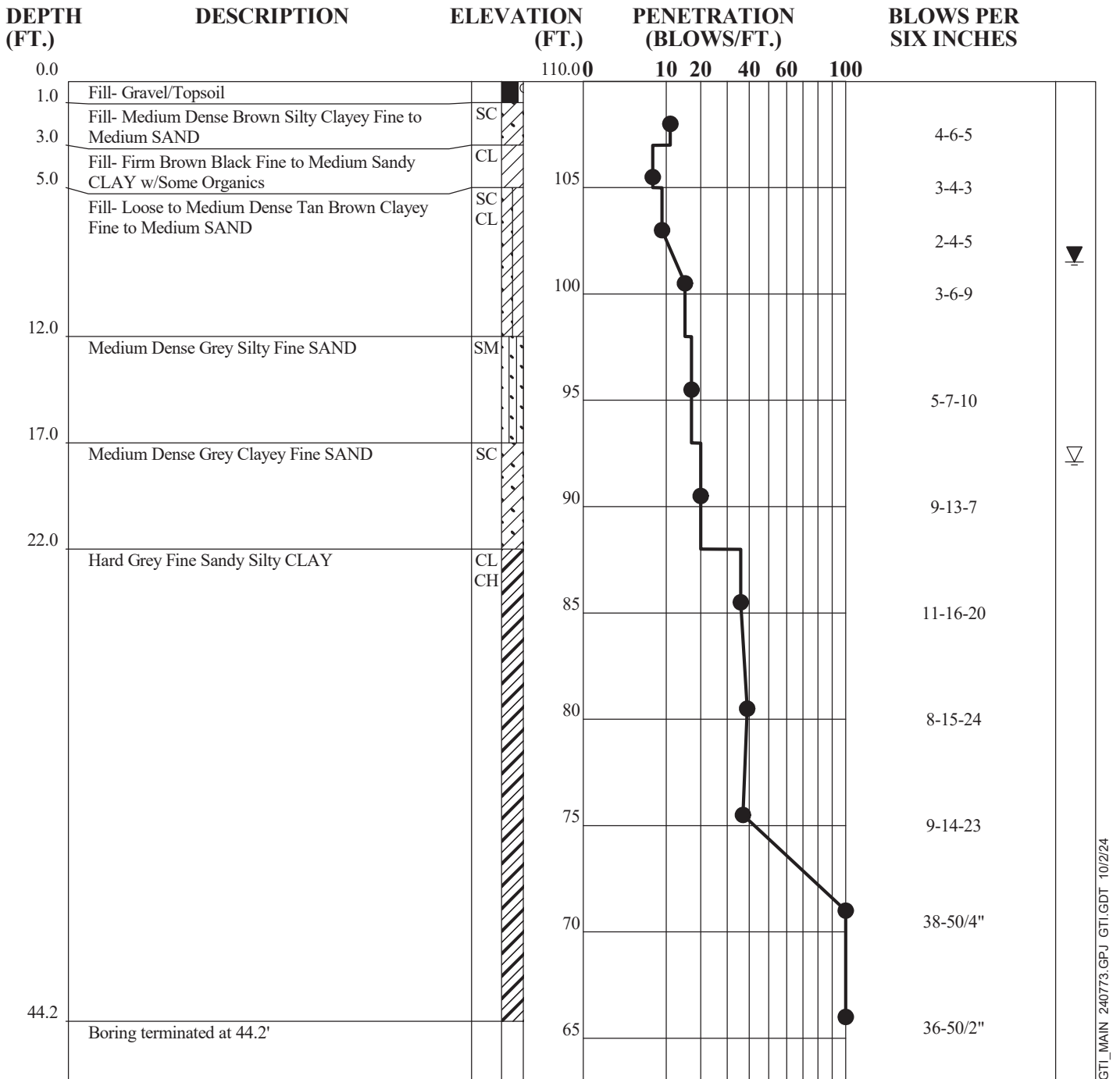
GTI_MAIN 240773.GPJ GTI.GDT 10/2/24

Groundwater encountered at 36' at time of boring. Boring caved at 37'.

JOB NUMBER 124-0773-EA
BORING NUMBER B- 8
DATE 9-12-24



TEST BORING RECORD



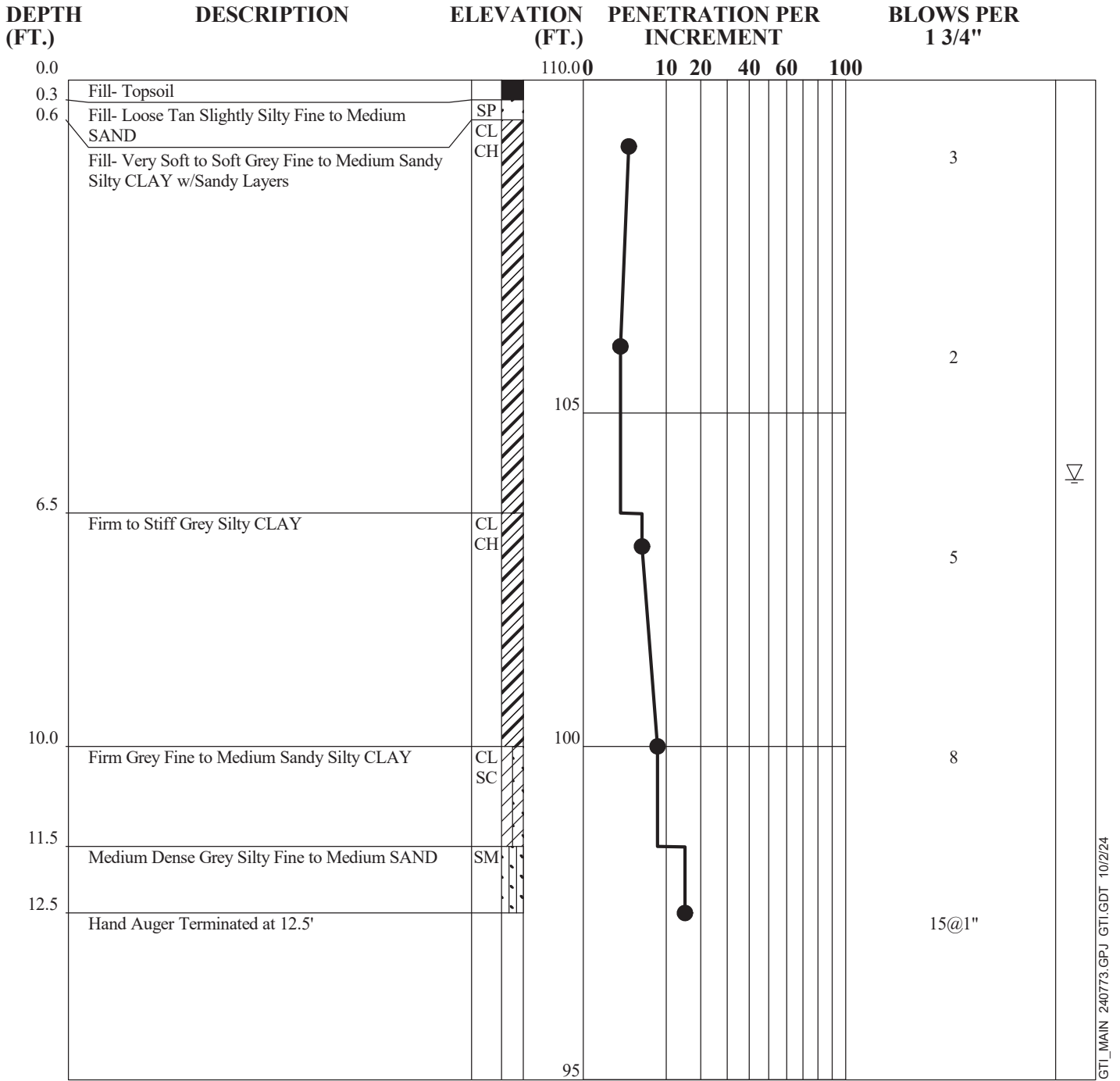
GTI_MAIN 240773.GPJ GTI.GDT 10/2/24

Groundwater encountered at 17.9' at time of boring. Set piezometer in borehole. Groundwater encountered at 8.5' in piezometer at 24 hrs.

JOB NUMBER 124-0773-EA
BORING NUMBER B- 9
DATE 9-12-24



DYNAMIC HAND CONE PENETROMETER RECORD



GTI_MAIN 240773.GPJ GTI.GDT 10/2/24

Perched water encountered at 6' at time of boring.

JOB NUMBER 124-0773-EA
BORING NUMBER B- 10
DATE 9-13-24

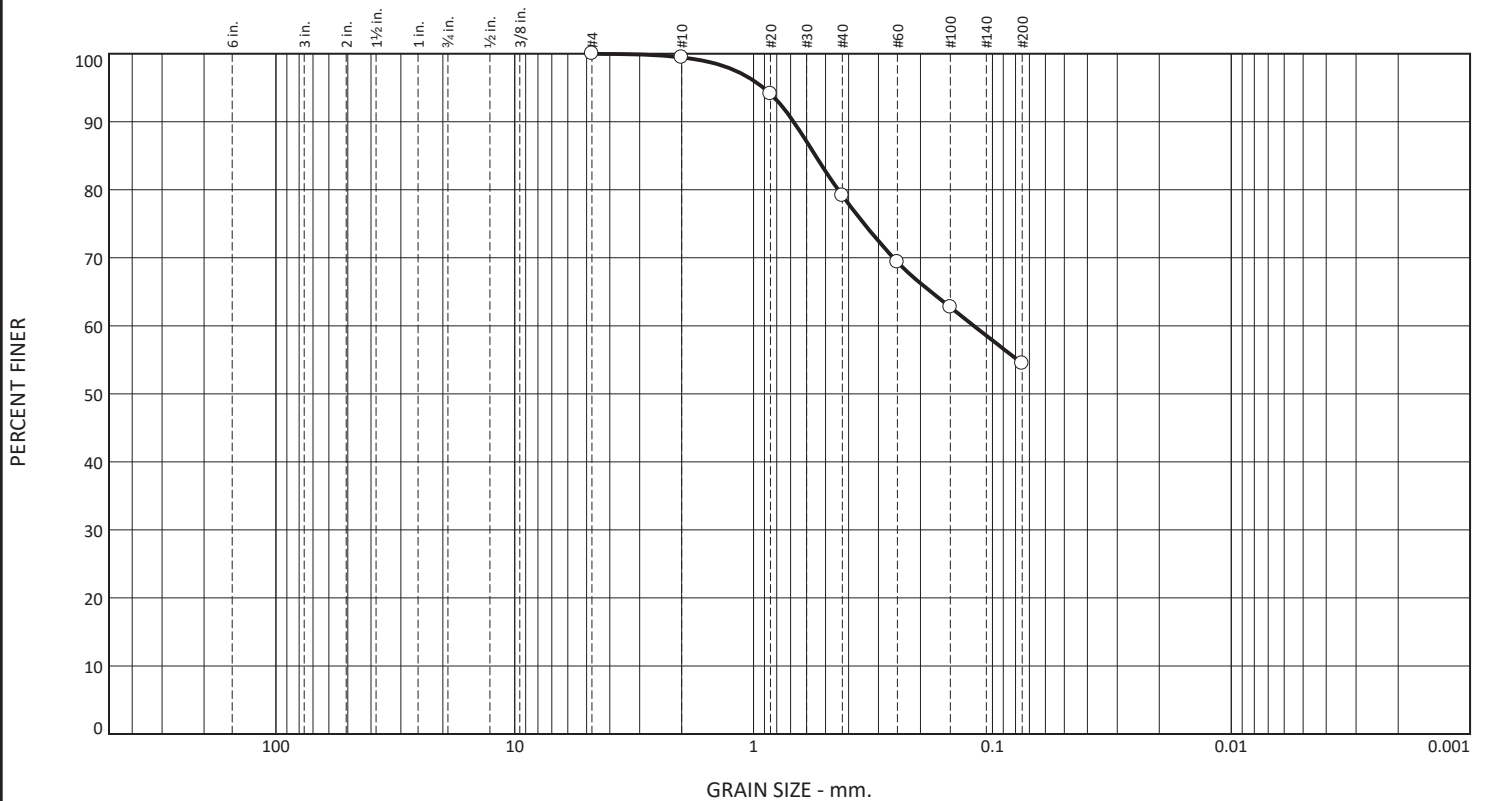


APPENDIX B

LAB DATA

Particle Size Distribution Report

ASTM D422



% +3"	% Gravel		% Sand			% Fines
	Coarse	Fine	Coarse	Medium	Fine	
0.0	0.0	0.0	0.6	20.3	24.6	54.5

Test Results (ASTM D422)				
Sieve Size or Diam. (mm.)	Finer (%)	Spec. * (%)	Out of Spec. (%)	Pct. of Fines
#4	100.0			
#10	99.4			
#20	94.1			
#40	79.1			
#60	69.4			
#100	62.7			
#200	54.5			

* (no specification provided)

Material Description
Brown Medium to Fine Sandy Clayey SILT (MH)

Atterberg Limits
 PL= 30 LL= 57 PI= 27
Coefficients
 D₉₀= 0.6803 D₈₅= 0.5498 D₆₀= 0.1198
 D₅₀= D₃₀= D₁₅=
 D₁₀= C_u= C_c=
Classification
 USCS= MH AASHTO= A-7-5(12)
Test Remarks

Location: Glenville Lake B-5
Sample Number: S-10

Sample Date: 9/25/24

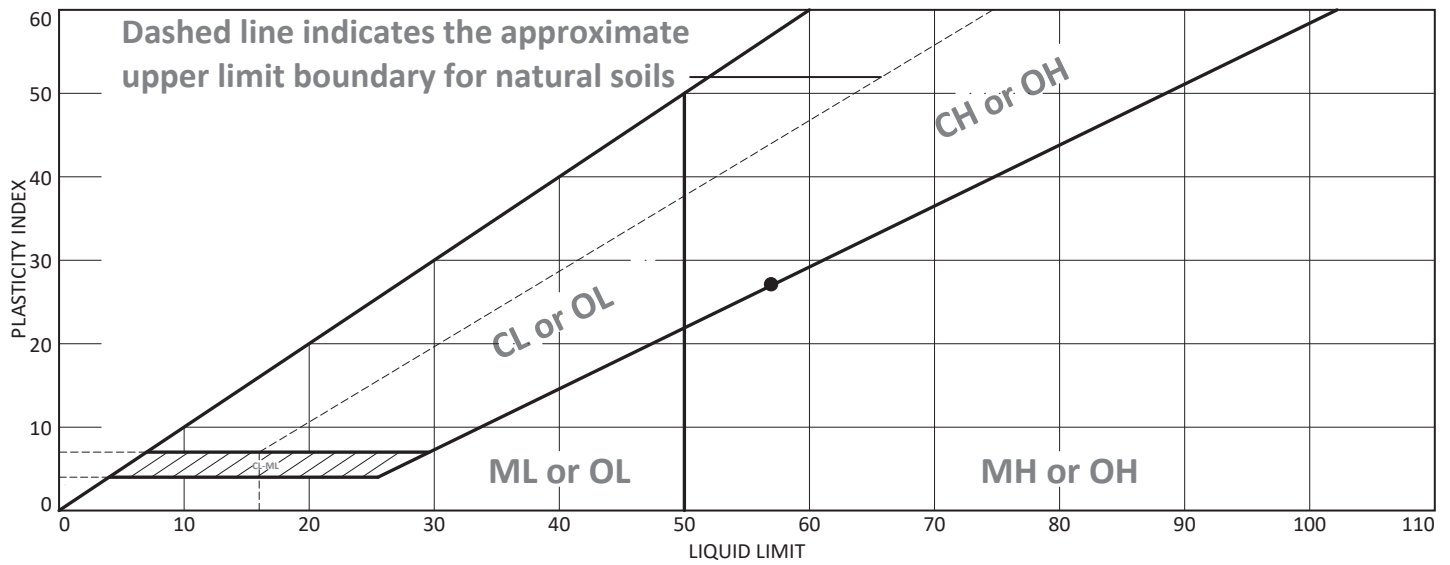


Client:
 Project: PO Hoffer WWTP GAC Facility & Glenville Lake WWTP
 Project No: 1-24-0773EA

Figure

Tested By: CJ

LIQUID AND PLASTIC LIMITS TEST REPORT



Sample Identification	Sampled	Received	Tested	Technician
● Location: Glenville Lake B-5 Sample Number: S-10	9/25/24	9/17/24	9/26/24	MM

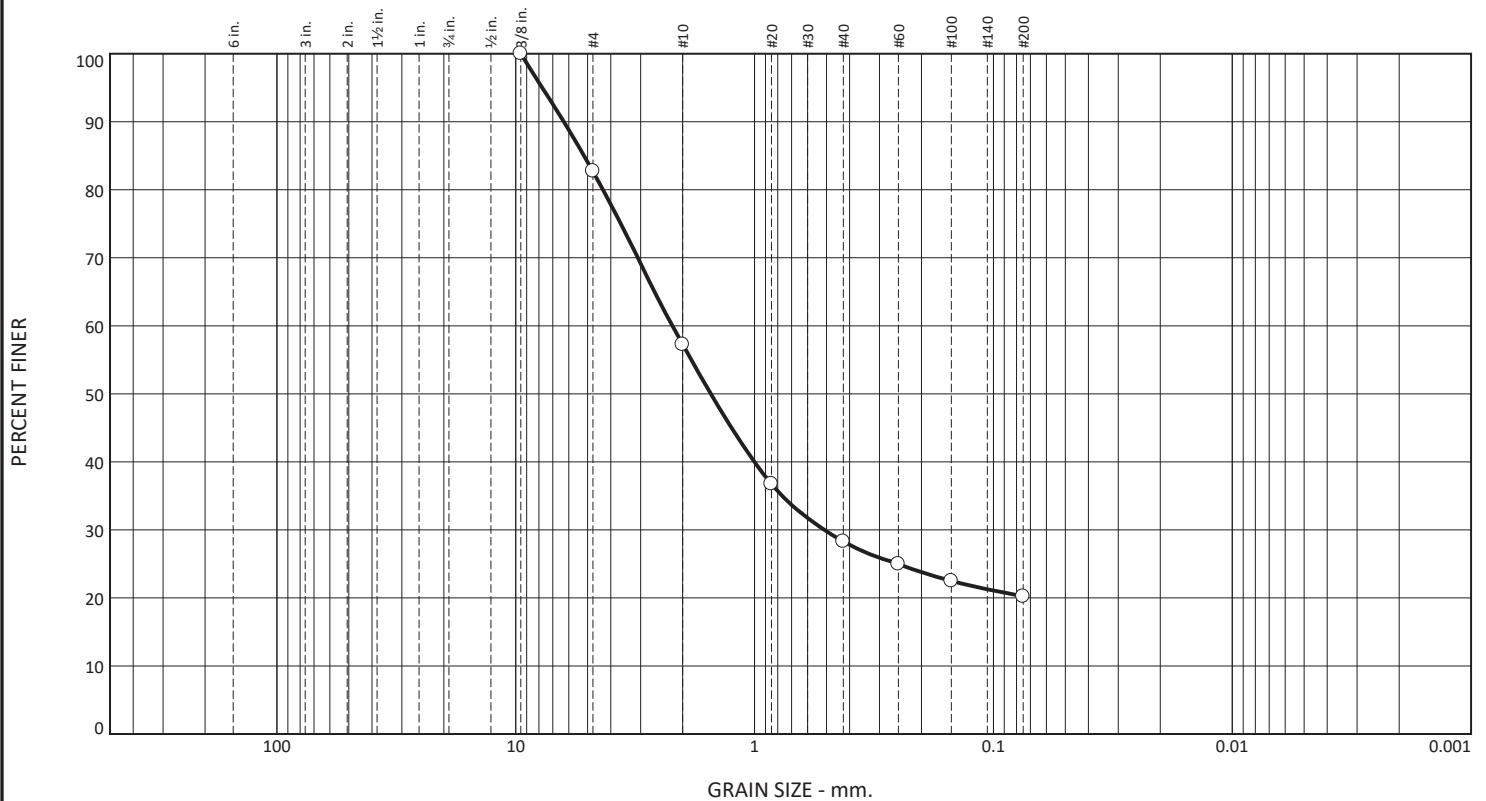
Material Description	USCS	LL	PL	PI	NM	%<#40
● Brown Medium to Fine Sandy Clayey SILT (MH)	MH	57	30	27		79.1

PL Rolling Method	LL Device	Grooving Tool	Test Remarks
● Hand rolled	Mechanical	Plastic	

Project No. 1-24-0773EA	Client:	Checked by: CJ
Project: PO Hoffer WWTP GAC Facility & Glenville Lake WWTP		Title: LM
		Figure

Particle Size Distribution Report

ASTM D422



% +3"	% Gravel		% Sand			% Fines
	Coarse	Fine	Coarse	Medium	Fine	
0.0	0.0	17.3	25.5	28.9	8.1	20.2

Test Results (ASTM D422)				
Sieve Size or Diam. (mm.)	Finer (%)	Spec. * (%)	Out of Spec. (%)	Pct. of Fines
.375	100.0			
#4	82.7			
#10	57.2			
#20	36.8			
#40	28.3			
#60	25.0			
#100	22.5			
#200	20.2			

* (no specification provided)

Material Description
Brown Gray Clayey Coarse to Medium SAND w/ Gravel (SC)

PL= 16 **Atterberg Limits** LL= 33 PI= 17

Coefficients
D₉₀= 6.3066 D₈₅= 5.1722 D₆₀= 2.2115
D₅₀= 1.5224 D₃₀= 0.5090 D₁₅=
D₁₀= C_u= C_c=

USCS= SC **Classification** AASHTO= A-2-6(0)

Test Remarks

Location: Glenville Lake B-7
Sample Number: S-6

Sample Date: 9/25/24



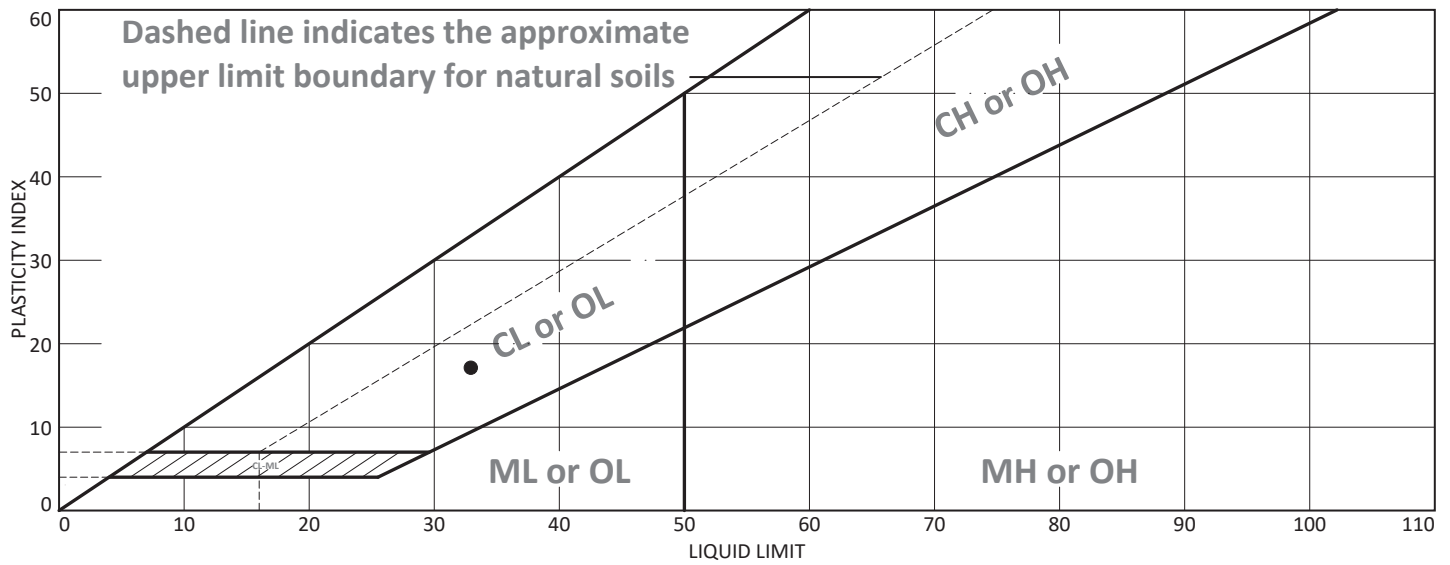
Client:
Project: PO Hoffer WWTP GAC Facility & Glenville Lake WWTP

Project No: 1-24-0773EA

Figure

Tested By: CJ Checked By: CJ

LIQUID AND PLASTIC LIMITS TEST REPORT



Sample Identification	Sampled	Received	Tested	Technician
● Location: Glenville Lake B-7 Sample Number: S-6	9/25/24	9/17/24	9/26/24	MM

Material Description	USCS	LL	PL	PI	NM	%<#40
● Brown Gray Clayey Coarse to Medium SAND w/ Gravel (SC)	SC	33	16	17		28.3

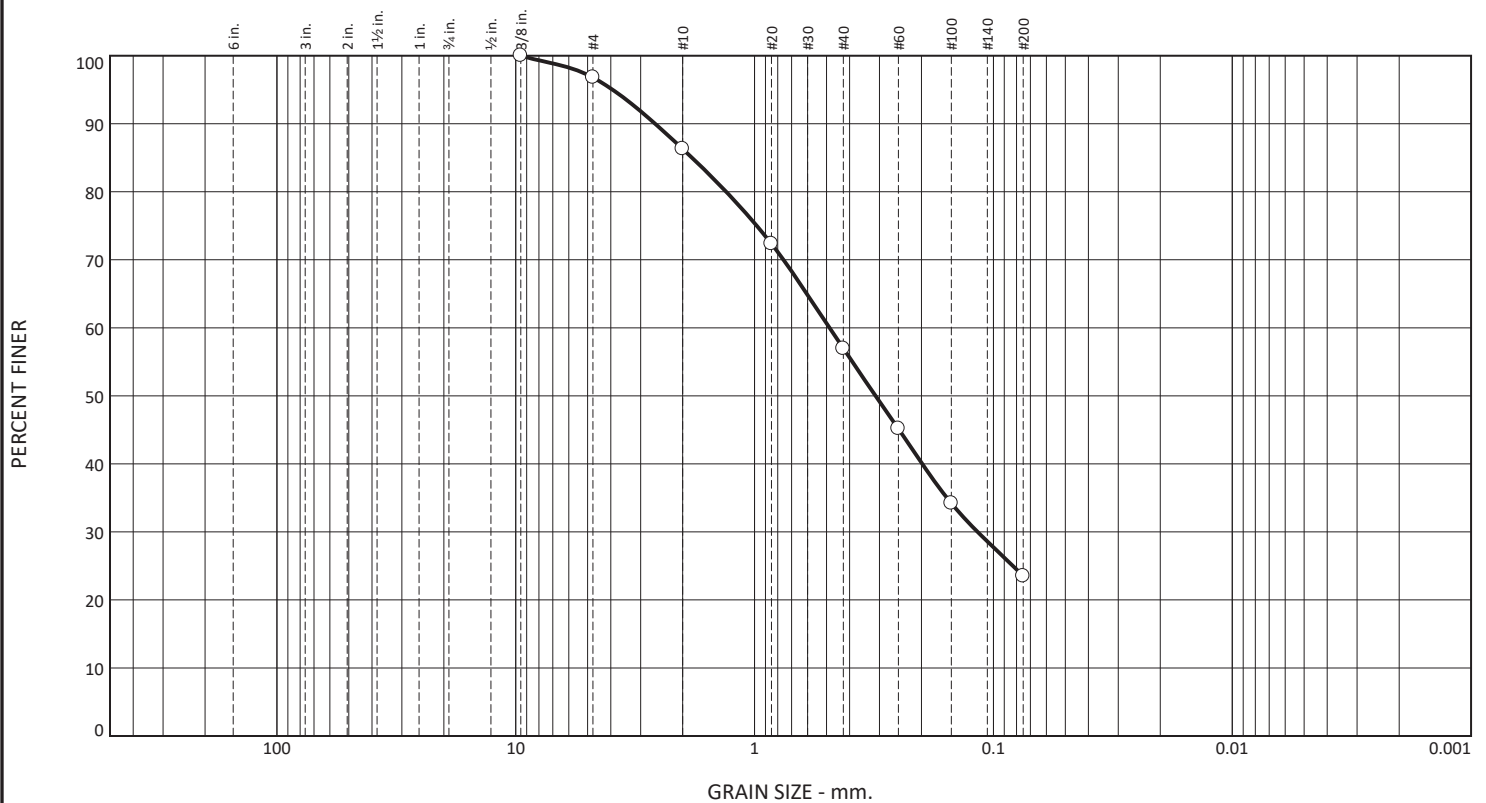
PL Rolling Method	LL Device	Grooving Tool	Test Remarks
● Hand rolled	Mechanical	Plastic	

Project No. 1-24-0773EA Client: Project: PO Hoffer WWTP GAC Facility & Glenville Lake WWTP	Checked by: CJ Title: LM
	

Figure

Particle Size Distribution Report

ASTM D422



% +3"	% Gravel		% Sand			% Fines
	Coarse	Fine	Coarse	Medium	Fine	
0.0	0.0	3.2	10.5	29.4	33.4	23.5

Test Results (ASTM D422)				
Sieve Size or Diam. (mm.)	Finer (%)	Spec. * (%)	Out of Spec. (%)	Pct. of Fines
.375	100.0			
#4	96.8			
#10	86.3			
#20	72.3			
#40	56.9			
#60	45.2			
#100	34.2			
#200	23.5			

* (no specification provided)

Material Description

Gray Clayey Medium to Fine SAND (SC)

PL= 25 LL= 34 PI= 9

Coefficients
D₉₀= 2.6080 D₈₅= 1.8267 D₆₀= 0.4862
D₅₀= 0.3112 D₃₀= 0.1166 D₁₅=
D₁₀= C_u= C_c=

Classification
USCS= SM AASHTO= A-2-4(0)

Test Remarks

Location: Glenville Lake B-8
Sample Number: S-8

Sample Date: 9/25/24



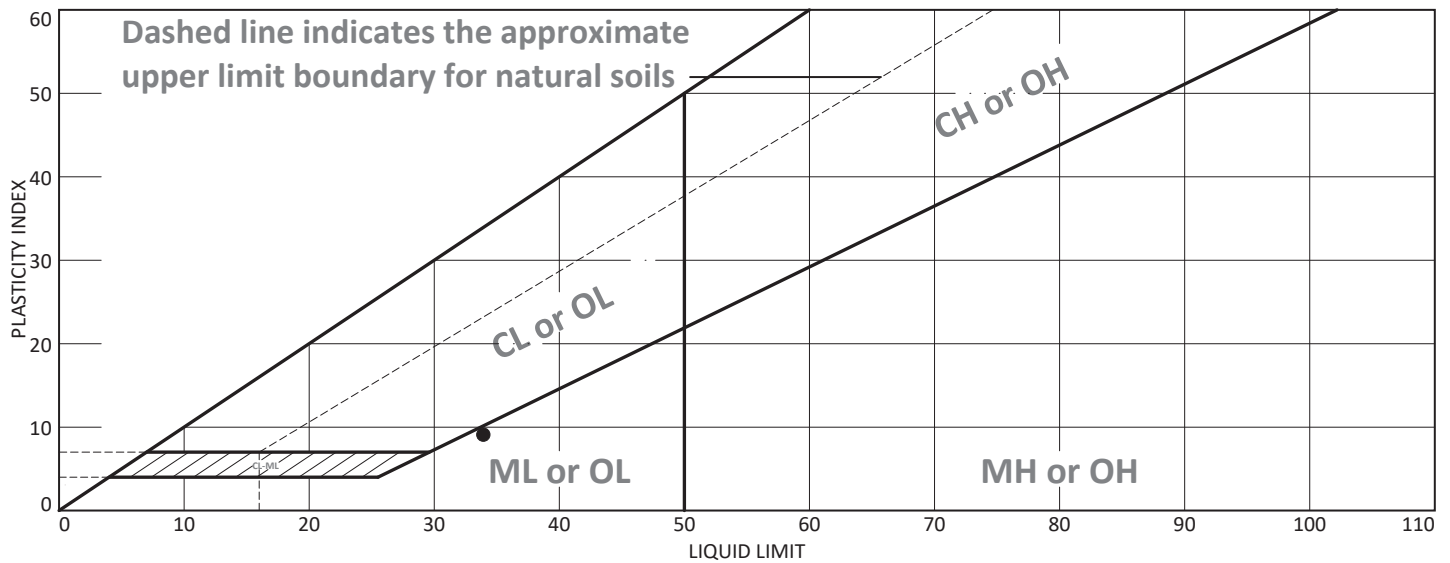
Client:
Project: PO Hoffer WWTP GAC Facility & Glenville Lake WWTP

Project No: 1-24-0773EA

Figure

Checked By: CJ

LIQUID AND PLASTIC LIMITS TEST REPORT



Sample Identification	Sampled	Received	Tested	Technician
● Location: Glenville Lake B-8 Sample Number: S-8	9/25/24	9/17/24	9/26/24	MM

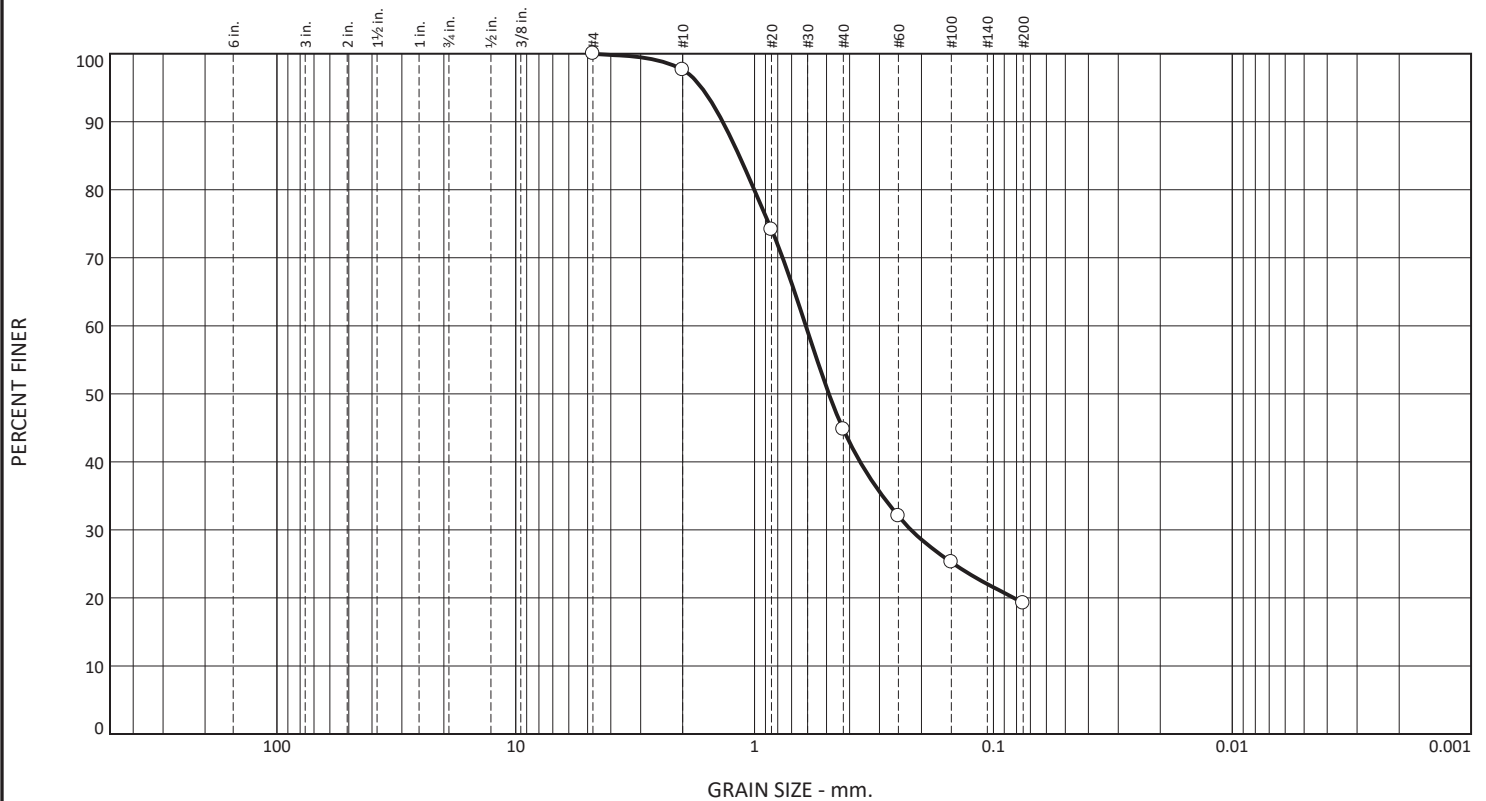
Material Description	USCS	LL	PL	PI	NM	%<#40
● Gray Silty Medium to Fine SAND (SC)	SC	34	25	9		56.9

PL Rolling Method	LL Device	Grooving Tool	Test Remarks
● Hand rolled	Mechanical	Plastic	

Project No. 1-24-0773EA	Client:	Checked by: CJ
Project: PO Hoffer WWTP GAC Facility & Glenville Lake WWTP		Title: LM
		Figure

Particle Size Distribution Report

ASTM D422



% +3"	% Gravel		% Sand			% Fines
	Coarse	Fine	Coarse	Medium	Fine	
0.0	0.0	0.0	2.4	52.8	25.6	19.2

Test Results (ASTM D422)				
Sieve Size or Diam. (mm.)	Finer (%)	Spec. * (%)	Out of Spec. (%)	Pct. of Fines
#4	100.0			
#10	97.6			
#20	74.2			
#40	44.8			
#60	32.1			
#100	25.2			
#200	19.2			

* (no specification provided)

Material Description

Brown Clayey Fine to Medium SAND (SC)

Atterberg Limits		
PL= 26	LL= 44	PI= 18
Coefficients		
D ₉₀ = 1.3598	D ₈₅ = 1.1596	D ₆₀ = 0.6099
D ₅₀ = 0.4882	D ₃₀ = 0.2213	D ₁₅ =
D ₁₀ =	C _u =	C _c =
Classification		
USCS= SC	AASHTO=	A-2-7(0)
Test Remarks		

Location: Glenville Lake B-9
Sample Number: S-10

Sample Date: 9/29/24

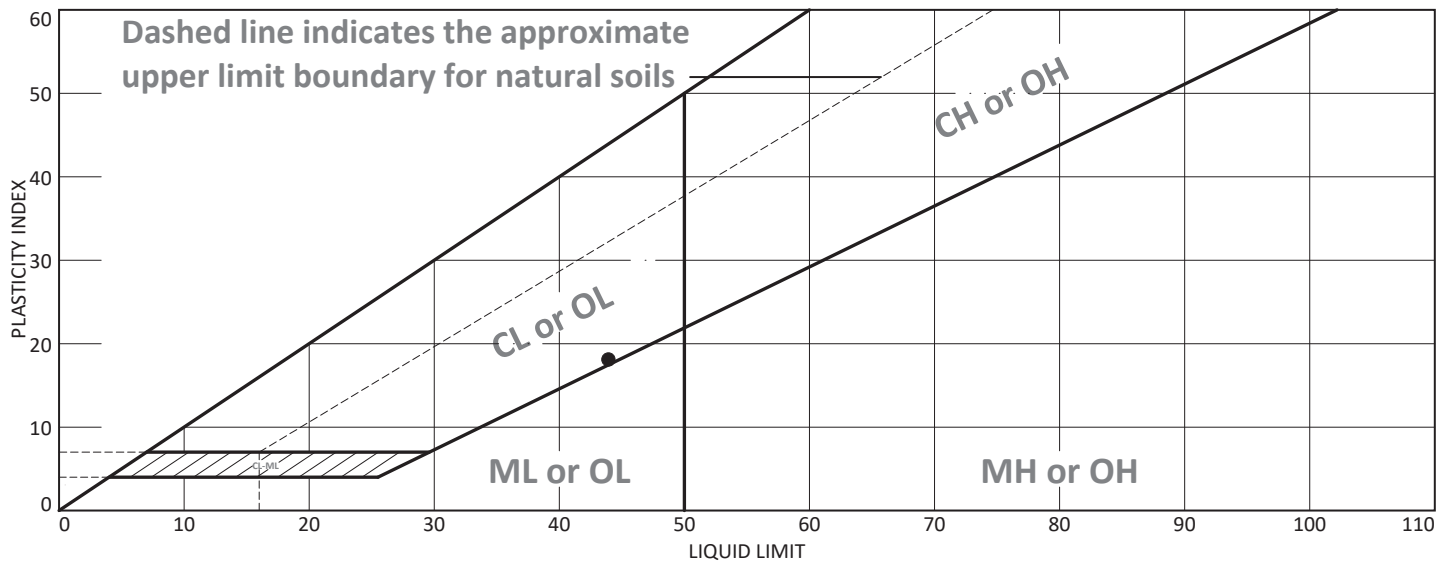


Client:
Project: PO Hoffer WWTP GAC Facility & Glenville Lake WWTP
Project No: 1-24-0773EA

Figure

Tested By: CJ _____ Checked By: CJ _____

LIQUID AND PLASTIC LIMITS TEST REPORT



Sample Identification	Sampled	Received	Tested	Technician
● Location: Glenville Lake B-9 Sample Number: S-10	9/29/24	9/17/24	9/30/24	MM

Material Description	USCS	LL	PL	PI	NM	%<#40
● Brown Clayey Fine to Medium SAND (SC)	SC	44	26	18		44.8

PL Rolling Method	LL Device	Grooving Tool	Test Remarks
● Hand rolled	Mechanical	Plastic	

Project No. 1-24-0773EA Client: Project: PO Hoffer WWTP GAC Facility & Glenville Lake WWTP	Checked by: CJ Title: LM

Figure

APPENDIX C

PROJECT PERMITS

NC DEQ
Division of Water Resources
Authorization to Construct

JOSH STEIN
Governor

D. REID WILSON
Secretary

RICHARD E. ROGERS, JR.
Director



NORTH CAROLINA
Environmental Quality

November 14, 2025

Fayetteville Public Works Commission
Attention: Kevin Howell, Engineering Manager
955 Old Wilmington Road
Fayetteville, NC 28301

Re: Engineering Plans and Specifications Approval
Surface Water System
P.O. Hoffer WTF/Glenville Lake WTF GAC Fac Con Prj
FAYETTEVILLE PUBLIC WORKS COMM
Water System No.: NC0326010
Cumberland County
Serial No.: 24-01307
Funding No.: D-EC-0003 & D-2052

Dear Applicant:

Enclosed please find one copy of the "Application for Approval..." together with one copy of the referenced engineering plans and specifications bearing the Division of Water Resources stamp of approval for the referenced project. These engineering plans and specifications are approved under Division of Water Resources Serial Number, 24-01307 dated November 14, 2025.

Engineering plans prepared by D. Cory Hopkins, P.E. and L. Michael Santowasso, P.E., and specifications prepared by D. Cory Hopkins, P.E., call for the installation of post-filter granular activated carbon (GAC) gravity-fed contactors at the P.O. Hoffer Water Treatment Facility (WTF) and Glenville Lake WTF to treat six (6) PFAS compounds and trace organic compounds. All existing chemical types and dosages will not be changed.

System improvements at the P.O. Hoffer Water Treatment Facility located at 508 Hoffer Drive, Fayetteville NC 28301 include:

1. The installation of twelve (12) single cell - 30 feet long by 17 feet 9 inches wide GAC contactors, GAC contactors backwash system, backwash/cleaning waste piping and other related appurtenances. The GAC contactors will be located downstream of the existing filters and upstream of the existing clearwell. Please note the overall treatment capacity of the P.O. Hoffer WTF will remain unchanged at 32 MGD. Each GAC contactor is proposed with 10.5 feet of GAC media with a maximum hydraulic loading rate of 4.2 gpm/sq ft. (when two contactors are out of service and the WTF is operating to treat 32 MGD) and empty bed contact time (EBCT) of 23 minutes with all contactors operating at 32 MGD WTF capacity.



North Carolina Department of Environmental Quality | Division of Water Resources
512 North Salisbury Street | 1634 Mail Service Center | Raleigh, North Carolina 27699-1634
919.707.9100

2. Four (4) (3 duty, 1 standby) - 8,333 gpm, 49.9 feet TDH, 150 hp each vertical turbine contactor influent pumps with VFDs and three (3) (2 duty, 1 standby) - 4,000 gpm, 35.9 feet TDH, 75 hp vertical turbine backwash pumps and other related appurtenances. Each contactor unit shall be equipped with an ultrasonic level sensor, loss-of-head differential pressure transmitter, and effluent flow control valve. The effluent control valve shall maintain a constant flowrate through the contactor based on the Intermediate Pump Station discharge flow rate, the level in the contactor influent channel, and the number of contactors in service. A magnetic flow meter shall be provided for contactor effluent and GAC-to-waste. The contactors are washed using backwash pumps located within the GAC 1 Facility. The programming for all contactors shall be the same.

System improvements at the Glenville Lake WTF located at 628 Filter Plant Drive, Fayetteville NC 28301 include:

1. The installation of ten (10) dual cell - 18 feet long by 11 feet 3 inches wide GAC contactors, GAC contactors backwash system, backwash/cleaning waste piping and other related appurtenances. The GAC contactors will be located downstream of the existing filters and upstream of the existing clearwell. Please note the overall treatment capacity of the Glenville Lake WTF will remain unchanged at 18 MGD. Each GAC contactor is proposed with 11 feet of GAC media with a maximum hydraulic loading rate of 4.6 gpm/sq ft. (when one contactor is out of service and the WTF is operating to treat 18 MGD) and EBCT of 20 minutes with all contactors operating at 18 MGD WTF capacity.
2. Three (3) (2 duty, 1 standby) - 8,333 gpm, 48.9 feet TDH, 150 hp each vertical turbine contactor influent pumps with VFDs and two (2) (1 duty, 1 standby) - 3,111 gpm, 54.8 feet TDH, 75 hp vertical turbine backwash pumps and other related appurtenances. Each contactor cell shall be equipped with an ultrasonic level sensor and loss-of-head differential pressure transmitter. A common effluent flow control valve will serve both cells. The effluent control valve shall maintain a constant flowrate through the contactor based on the Intermediate Pump Station discharge flow rate, the level in the contactor influent channel, and the number of contactors in service. A magnetic flow meter shall be provided for contactor effluent and GAC-to-waste. The contactors are washed using backwash pumps co-located with the Intermediate Pumps. The programming for all contactors shall be the same.
3. In addition, alterations to the post-filter chemical feed system and piping will include a new injection point for sodium hypochlorite, hydrofluosilicic acid, and zinc orthophosphate downstream of the GAC facility including the installation of a static in-line mixer and chemical injection assemblies in a new chemical injection vault to the north of the current operations building. Valves will be installed into the existing chemical lines in order to use the existing diffusers as chemical injection points in the event the GAC facility is bypassed.

Please note that in accordance with 15A NCAC 18C .0309(a), no construction, alteration, or expansion of a water system shall be placed into service or made available for human consumption until the Public Water Supply Section has issued Final Approval. Final Approval will be issued and mailed to the applicant upon receipt of both an Engineer's Certification and an Applicant's Certification submitted in accordance with 15A NCAC 18C .0303 (a) and (c).



Fayetteville Public Works Commission
Attention: Kevin Howell, Engineering Manager
Page 3 of 3
November 14, 2025

These plans and specifications in the foregoing application are approved insofar as the protection of public health is concerned as provided in the rules, standards and criteria adopted under the authority of Chapter 130A-317 of the General Statutes. This approval does not constitute a warranty of the design, construction or future operation of the water system.

One copy of the "Application for Approval..." and a copy of the plans and specifications with a seal of approval from the department are enclosed. One copy of the approved documents in a digital format is being forwarded to our Fayetteville Regional Office. Another copy is being retained in our records.

If the Public Water Supply Section can be of further service, please call (919) 707-9100.

Sincerely,



Rebecca Sadosky, Ph.D., Chief
Public Water Supply Section
Division of Water Resources

RS/SGM

Enclosures: Approval Documents

cc: Heidi Cox, Fayetteville Regional Office
Cumberland County Health Department
Hazen and Sawyer
David Giachini, P.E., Division of Water Infrastructure



North Carolina Department of Environmental Quality | Division of Water Resources
512 North Salisbury Street | 1634 Mail Service Center | Raleigh, North Carolina 27699-1634
919.707.9100

JOSH STEIN
Governor

D. REID WILSON
Secretary

RICHARD E. ROGERS, JR.
Director



November 17, 2025

FAYETTEVILLE PUBLIC WORKS COMMISSSION
ATTN: KEVIN HOWELL, ENGINEERING MANAGER
955 OLD WILMINGTON RD
FAYETTEVILLE, NC 28301

Re: **Authorization to Construct (This is not a Final Approval)**
Issue Date: November 17, 2025
PO HOFFER WTF/GLENVILLE LAKE GAC FAC CONST
Serial No.: 24-01307 Water System No.: NC0326010
Cumberland County

Dear Applicant:

This letter is to confirm that a complete Engineer's Report and a Water System Management Plan have been received, and that engineering plans and specifications have been approved by the Department for **PO HOFFER WTF/GLENVILLE LAKE GAC FAC CONST, Serial No.: 24-01307.**

The "Authorization to Construct" is valid for 36 months from the issue date. Authorization to construct may be extended if the Rules Governing Public Water Systems [15A NCAC 18C] and site conditions have not changed (see Rule .0305). The "Authorization to Construct" and the engineering plans and specifications approval letter shall be posted at the primary entrance of the job site before and during construction.

Upon completion of the construction or modification, **and prior to placing the new construction or modification into service**, the applicant must submit an Engineer's Certification and Applicant's Certification to the Public Water Supply Section.

- **Engineer's Certification:** in accordance with Rule .0303(a), the applicant shall submit a certification statement signed and sealed by a registered professional engineer stating that construction was completed in accordance with approved engineering plans and specifications, including any provisions stipulated in the Department's engineering plan and specification approval letter.
- **Applicant's Certification:** in accordance with Rule .0303(c), the applicant shall submit a signed certification statement indicating that the requirements for an Operation and Maintenance Plan and Emergency Management Plan have been satisfied in accordance with Rule .0307(d) and (e) and that the system has a certified operator in accordance with Rule .1300. The "Applicant's Certification" form is available at <http://www.ncwater.org/> (click on Public Water Supply Section, Plan Review, Plan Review Forms).

Certifications can be sent by mail or attachment to an e-mail message to **PWSSection.PlanReview@deq.nc.gov**.

If this "Authorization to Construct" is for a new public water system, the owner must submit a completed **application for an Operating Permit** and the appropriate fee. For a copy of the application for an Operating Permit please call (919) 707-9076.

Once the certifications and permit application and fee (if applicable) are received and determined adequate, the Department will issue a Final Approval letter to the applicant. In accordance with Rule .0309(a), **no portion of this project shall be placed into service until the Department has issued Final Approval.**

Please contact us at (919) 707-9100 if you have any questions or need additional information.

Sincerely,

A handwritten signature in black ink that reads 'Rebecca Sadosky'.

Rebecca Sadosky, Ph.D., Chief
Public Water Supply Section
Division of Water Resources, NCDEQ

cc: HEIDI COX, Regional Engineer
HAZEN AND SAWYER



North Carolina Department of Environmental Quality | Division of Water Resources
512 North Salisbury Street | 1634 Mail Service Center | Raleigh, North Carolina 27699-1634
919.707.9100

North Carolina Department of Environmental Quality
Division of Water Resources

Authorization to Construct

Project Applicant:	FAYETTEVILLE PUBLIC WORKS COMMISSION
Public Water System Name:	FAYETTEVILLE PUBLIC WORKS COMM
Water System No.:	NC0326010
Project Name:	PO HOFFER WTF/GLENNVILLE LAKE GAC FAC CONST
Serial No.:	24-01307
Issue Date:	November 17, 2025
Expiration Date:	36 Months after Issue Date

In accordance with 15A NCAC 18C .0305, this Authorization to Construct must be posted
at the primary entrance to the job site during construction.

D. CORY HOPKINS
HAZEN AND SAWYER
4011 WESTCHASE BLVD, SUITE 500
RALEIGH, NC 27607

NC DEQ
Division of Energy, Mineral, and
Land Resources
Erosion and Sediment Control

JOSH STEIN
Governor

D. REID WILSON
Secretary

WILLIAM E. TOBY VINSON, JR.
Director



10-30-2025

LETTER OF APPROVAL

Fayetteville PWC
955 Old Wilmington Road
Fayetteville, NC 28301

RE: Project Name: Glenville Lake Water Treatment Plant
Permit Number: CUMBE-2026-0463
Acres Approved: 4.95
County: Cumberland
City: Fayetteville
Address: 628 Filter Plant Drive
River Basin: Cape Fear
Stream Classification: C: Aquatic Life, Secondary Contact Recreation, Fresh water
Plan Type: New Plan (Express)

Dear Fayetteville PWC,

This office has received and reviewed the subject erosion and sedimentation control plan. We find the plan to be acceptable and hereby issue this Letter of Approval. The enclosed Certificate of Approval must be posted at the job site. This plan shall expire three (3) years following the date of approval, if no land disturbing activity has been undertaken, as is required by Title 15A NCAC 4B .0129.

As of April 1, 2019, all new construction activities are required to complete and submit an electronic Notice of Intent (eNOI) form requesting a COC under the NCG010000 Construction Stormwater General Permit. You must apply for coverage by submitting a "Construction Stormwater – NCG01 (Subject to the SPCA) in the [AccessDEQ Portal](#). Once your application is complete, you will receive an invoice for the \$127 annual permit fee and can submit payment through the AccessDEQ Portal. Once the fee is processed and the application approved, you will receive the COC via email. As the Financially Responsible Party shown on the FRO form submitted for this project, you MUST obtain the COC prior to commencement of any land disturbing activity. Please direct questions about the eNOI form to the [Stormwater Program staff](#) in the Raleigh central office. If the owner/operator of this project changes in the future, the new responsible party must obtain a new COC.



North Carolina Department of Environmental Quality
Division of Energy, Mineral and Land Resources
512 North Salisbury Street | 1612 Mail Service Center
Raleigh, North Carolina 27699-1612

Title 15A NCAC 4B .0118(a) and the NCG01 permit require that the following documentation be kept on file at the job site:

1. The approved E&SC plan as well as any approved deviation.
2. The NCG01 permit and the COC, once it is received.
3. Records of inspections made during the previous 12 months.

Also, this letter gives the notice required by G.S. 113A-61.1(a) of our right of periodic inspection to ensure compliance with the approved plan.

North Carolina's Sedimentation Pollution Control Act is performance-oriented, requiring protection of existing natural resources and adjoining properties. If, following the commencement of this project, the erosion and sedimentation control plan is inadequate to meet the requirements of the Sedimentation Pollution Control Act of 1973 (North Carolina General Statute 113A-51 through 66), this office may require revisions to the plan and implementation of the revisions to ensure compliance with the Act.

Acceptance and approval of this plan is conditioned upon your compliance with Federal and State water quality laws, regulations, and rules. In addition, local city or county ordinances or rules may also apply to this land-disturbing activity. This approval does not supersede any other permit or approval.

Please note that this approval is based in part on the accuracy of the information provided in the Financial Responsibility Form and on the plan, which you provided. You are requested to file an amended form if there is any change in the information included on the form.

Your cooperation is appreciated.

Sincerely,

Jodi Pace

Land Quality Section

JOSH STEIN
Governor

D. REID WILSON
Secretary

WILLIAM E. TOBY VINSON, JR.
Director



10-30-2025

LETTER OF APPROVAL

Fayetteville PWC
955 Old Wilmington Road
Fayetteville, NC 28301

RE: Project Name: P. O. Hoffer Water Treatment Plant
Permit Number: CUMBE-2026-0464
Acres Approved: 6.84
County: Cumberland
City: Fayetteville
Address: 508 Hoffer Dr
River Basin: Cape Fear
Stream Classification: C: Aquatic Life, Secondary Contact Recreation, Fresh water
Plan Type: New Plan (Express)

Dear Fayetteville PWC,

This office has received and reviewed the subject erosion and sedimentation control plan. We find the plan to be acceptable and hereby issue this Letter of Approval. The enclosed Certificate of Approval must be posted at the job site. This plan shall expire three (3) years following the date of approval, if no land disturbing activity has been undertaken, as is required by Title 15A NCAC 4B .0129.

As of April 1, 2019, all new construction activities are required to complete and submit an electronic Notice of Intent (eNOI) form requesting a COC under the NCG010000 Construction Stormwater General Permit. You must apply for coverage by submitting a "Construction Stormwater – NCG01 (Subject to the SPCA) in the [AccessDEQ Portal](#). Once your application is complete, you will receive an invoice for the \$127 annual permit fee and can submit payment through the AccessDEQ Portal. Once the fee is processed and the application approved, you will receive the COC via email. As the Financially Responsible Party shown on the FRO form submitted for this project, you MUST obtain the COC prior to commencement of any land disturbing activity. Please direct questions about the eNOI form to the [Stormwater Program staff](#) in the Raleigh central office. If the owner/operator of this project changes in the future, the new responsible party must obtain a new COC.



North Carolina Department of Environmental Quality
Division of Energy, Mineral and Land Resources
512 North Salisbury Street | 1612 Mail Service Center
Raleigh, North Carolina 27699-1612

Title 15A NCAC 4B .0118(a) and the NCG01 permit require that the following documentation be kept on file at the job site:

1. The approved E&SC plan as well as any approved deviation.
2. The NCG01 permit and the COC, once it is received.
3. Records of inspections made during the previous 12 months.

Also, this letter gives the notice required by G.S. 113A-61.1(a) of our right of periodic inspection to ensure compliance with the approved plan.

North Carolina's Sedimentation Pollution Control Act is performance-oriented, requiring protection of existing natural resources and adjoining properties. If, following the commencement of this project, the erosion and sedimentation control plan is inadequate to meet the requirements of the Sedimentation Pollution Control Act of 1973 (North Carolina General Statute 113A-51 through 66), this office may require revisions to the plan and implementation of the revisions to ensure compliance with the Act.

Acceptance and approval of this plan is conditioned upon your compliance with Federal and State water quality laws, regulations, and rules. In addition, local city or county ordinances or rules may also apply to this land-disturbing activity. This approval does not supersede any other permit or approval.

Please note that this approval is based in part on the accuracy of the information provided in the Financial Responsibility Form and on the plan, which you provided. You are requested to file an amended form if there is any change in the information included on the form.

Your cooperation is appreciated.

Sincerely,

Jodi Pace

Land Quality Section

CERTIFICATE OF PLAN APPROVAL



The posting of this certificate certifies that an erosion and sedimentation control plan has been approved for this project by the North Carolina Department of Environmental Quality in accordance with North Carolina General Statute 113A – 57 (4) and 113A – 54 (d) (4) and North Carolina Administrative Code, Title 15A, Chapter 4B.0107 (c). This certificate must be posted at the primary entrance of the job site before construction begins and until establishment of permanent groundcover as required by North Carolina Administrative Code, Title 15A, Chapter 4B.0127 (b).

Glenville Lake Water Treatment Plant
628 Filter Plant Drive Fayetteville, NC 28301

10/30/2025

Date of Plan Approval

CUMBE-2026-0463

Project Identifier



Certificate of Coverage Number: _____

CERTIFICATE OF PLAN APPROVAL



The posting of this certificate certifies that an erosion and sedimentation control plan has been approved for this project by the North Carolina Department of Environmental Quality in accordance with North Carolina General Statute 113A – 57 (4) and 113A – 54 (d) (4) and North Carolina Administrative Code, Title 15A, Chapter 4B.0107 (c). This certificate must be posted at the primary entrance of the job site before construction begins and until establishment of permanent groundcover as required by North Carolina Administrative Code, Title 15A, Chapter 4B.0127 (b).

P. O. Hoffer Water Treatment Plant
508 Hoffer Dr Fayetteville, NC 28301

10/30/2025

Date of Plan Approval

CUMBE-2026-0464

Project Identifier



Certificate of Coverage Number: _____

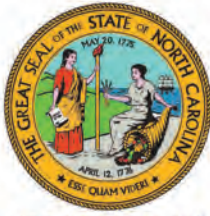
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NC DEQ
Division of Water Resources
401 Water Quality Certification

JOSH STEIN
Governor

D. REID WILSON
Secretary

RICHARD E. ROGERS, JR.
Director



NORTH CAROLINA
Environmental Quality

November 24, 2025

DWR # 20251437 version 1
Cumberland County

Fayetteville Public Works Commission
Attn: Kevin Howell, PE
955 Old Wilmington Road
Fayetteville, NC 28301

Delivered via email to: kevin.howell@faypwc.com

Subject: Approval of Individual 401 Water Quality Certification
PO Hoffer Water Treatment Facility Post-Filter
GAC Adsorption Facility

Dear Mr. Howell:

Attached hereto is a copy of Certification No. WQC008517 issued to Kevin Howell, PE and Fayetteville Public Works Commission, dated November 24, 2025. This approval is for the purpose and design described in your application.

This Water Quality Certification does not relieve the permittee of the responsibility to obtain all other required Federal, State, or Local approvals before proceeding with the project, including those required by, but not limited to, Sediment and Erosion Control, Non-Discharge, Water Supply Watershed, and Trout Buffer regulations.

Upon the presentation of proper credentials, the Division may inspect the property.

This Water Quality Certification shall expire on the same day as the expiration date of the corresponding Section 404 Permit. The conditions shall remain in effect for the life of the project, regardless of the expiration date of this Water Quality Certification.

Non-compliance with or violation of the conditions herein set forth may result in revocation of this Water Quality Certification for the project and may also result in criminal and/or civil penalties.

This approval and its conditions are final and binding unless contested [G.S. 143-215.5]

This Certification can be contested as provided in Chapter 150B of the North Carolina General Statutes by filing a Petition for a Contested Case Hearing (Petition) with the North Carolina Office of Administrative Hearings (OAH) **within sixty (60) calendar days**. Requirements for filing a Petition are set forth in Chapter 150B of the North Carolina General Statutes and Title 26 of the North Carolina Administrative Code.



North Carolina Department of Environmental Quality | Division of Water Resources
Fayetteville Regional Office | 225 Green Street, Suite 714 | Fayetteville, North Carolina 28301
910.433.3300

Additional information regarding requirements for filing a Petition and Petition forms may be accessed at <http://www.ncoah.com/> or by calling the OAH Clerk's Office at (919) 431-3000.

A party filing a Petition must serve a copy of the Petition on:

Dan Hirschman, General Counsel
Department of Environmental Quality
1601 Mail Service Center
Raleigh, NC 27699-1601

If the party filing the Petition is not the permittee, then the party must also serve the recipient of the Certification in accordance with N.C.G.S 150B-23(a).

This letter completes the Division's review under section 401 of the Clean Water Act and 15A NCAC 02H .0500. Please contact Kirsten Steininger at (910) 433-3339 or kirsten.steininger@deq.nc.gov if you have any questions or concerns.

Sincerely,

DocuSigned by:



CCA0697813D247D...

Chad Turlington
Assistant Regional Supervisor
Division of Water Resources
Water Quality Regional Operations Section

Electronic cc: Keven Duerr, Hazen and Sawyer, at kduerr@hazenandsawyer.com
Liz Hair, USACE at sarah.e.hair@usace.army.mil
DWR 401 & Buffer Permitting Branch Electronic file



NORTH CAROLINA 401 WATER QUALITY CERTIFICATION

CERTIFICATION #WQC008517 is issued in conformity with the requirements of Section 401, Public Laws 92-500 and 95-217 of the United States and subject to North Carolina's Regulations in 15 NCAC 02H .0500 and 15A NCAC 02B .0200, Kevin Howell, PE and Fayetteville Public Works Commission, who have authorization for the impacts listed below, as described within your application received by the N.C. Division of Water Resources (Division) on October 22, 2025 and by Public Notice issued by the Division on October 22, 2025, and within the *Reasonable Period of Time* pursuant to 40 CFR Part 121.6.

The State of North Carolina certifies that this activity will comply with water quality requirements and the applicable portions of Sections 301, 302, 303, 306, 307 of the Public Laws 92-500 and PL 95-217 if conducted in accordance with the application, the supporting documentation, and conditions hereinafter set forth.

The following impacts are hereby approved. No other impacts are approved, including incidental impacts. [15A NCAC 02H .0506(b)]

Type of Impact	Amount Approved Permanent	Amount Approved Temporary	Mitigation Amount Required
Wetlands			
W1-Drainage Swale, Fill	0.006 acres	0 acres	0 credits
W2- Construction Access	0 acres	0.024 acres	0 credits
<i>Totals:</i>	<i>0.006 acres</i>	<i>0.024 acres</i>	<i>0 credits</i>

This approval requires you to follow the conditions listed in the certification below.

CONDITIONS OF CERTIFICATION [15A NCAC 02H .0507(c)]:

1. The plans and specifications for this project are incorporated by reference as part of this Water Quality Certification. If you change your project, you must notify the Division and you may be required to submit a new application package with the appropriate fee.

If the property is sold, the Permittee shall provide the new owner must with a copy of this Water Quality Certification and all plans and specifications incorporated by reference. The Permittee may transfer this Water Quality Certification to the new owner by submitting a letter to the Division with the following statement: *"At the time the property is transferred, the terms and conditions of this 401 Individual Water Quality Certification, including the responsibility to ensure compliance, are binding on the new owner(s) of the property."* The letter shall be signed and dated by both the transferee and the new owner.

Citation: 15A NCAC 02H .0507(d)(2)

2. If this Water Quality Certification is used to access residential, commercial or industrial building sites, then all parcels owned by the permittee that are part of the single and complete project authorized by this Certification must be buildable without additional impacts to streams or wetlands.



Citation: 15A NCAC 02H .0502{a}; 15A NCAC 02H .0506{b}; 15A NCAC 02H .0507{c}

3. Deed notifications or similar mechanisms shall be placed on all lots/parcels with retained jurisdictional wetlands, waters, and state regulated riparian buffers within the project boundaries in order to assure compliance with NC Water Quality Certification Rules {15A NCAC 02H .0500}, NC Isolated Wetland Rules {15A NCAC 02H .1300}, and/or State Regulated Riparian Buffer Rules (15A NCAC 02B .0200). These mechanisms shall be put in place at the time of recording of the property or individual parcels, whichever is appropriate.

Citation: 15A NCAC 02H .0502{a}; 15A NCAC 02H .0506{b}; 15A NCAC 02H .0507{c}

4. All wetlands, streams, and surface waters located within 50 feet of the construction area on the project site shall be clearly marked (example- orange fabric fencing) prior to any land disturbing activities and must be maintained on the property until the project phase is completed.

Citation: 15A NCAC 02H .0506{b}(2); 15A NCAC 02H .0507{c}

5. The permittee shall report to the DWR Fayetteville Regional Office any noncompliance with, and/or any violation of, stream or wetland standards [15A NCAC 02B .0200], including but not limited to sediment impacts to streams or wetlands. Information shall be provided orally within 24 hours (or the next business day if a weekend or holiday) from the time the permittee became aware of the non-compliance circumstances.

Citation: 15A NCAC 02H .0506{b}; 15A NCAC 02H .0507{c}

6. No waste, spoil, solids, or fill of any kind shall occur in wetlands or waters beyond the footprint of the approved impacts (including temporary impacts).

Citation: 15A NCAC 02H .0506; 15A NCAC 02H .0507{c}

7. When applicable, all construction activities shall be performed and maintained in full compliance with G.S. Chapter 113A Article 4 (Sediment and Pollution Control Act of 1973). Regardless of applicability of the Sediment and Pollution Control Act, all projects shall incorporate appropriate Best Management Practices for the control of sediment and erosion so that no violations of state water quality standards, statutes, or rules occur.

Design, installation, operation, and maintenance of all sediment and erosion control measures shall be equal to or exceed the requirements specified in the most recent version of the *North Carolina Sediment and Erosion Control Manual*, or for linear transportation projects, the *North Carolina Department of Transportation Sediment and Erosion Control Manual*.

All devices shall be maintained on all construction sites, borrow sites, and waste pile (spoil) sites, including contractor-owned or leased borrow pits associated with the project. Sufficient materials required for stabilization and/or repair of erosion control measures and stormwater routing and treatment shall be on site at all times.

For borrow pit sites, the erosion and sediment control measures shall be designed, installed, operated, and maintained in accordance with the most recent version of the *North Carolina Surface Mining Manual*. Reclamation measures and implementation shall comply with the reclamation in accordance with the requirements of the Sedimentation Pollution Control Act and the Mining Act of 1971.



Citation: 15A NCAC 02H .0506(b); 15A NCAC 02H .0507(c); 15A NCAC 02B .0200; 15A NCAC 02B .0231

8. Sediment and erosion control measures shall not be installed in wetland or waters except within the footprint of temporary or permanent impacts otherwise authorized by this Certification. If placed within authorized impact areas, then placement of such measures shall not be conducted in a manner that results in dis-equilibrium of any wetlands, streambeds, or streambanks. Any silt fence installed within wetlands shall be removed from wetlands and the natural grade restored within two (2) months of the date that DEMLR or locally delegated program has released the specific area within the project to ensure wetland standards are maintained upon completion of the project.

Citation: 15A NCAC 02H .0506(b); 15A NCAC 02H .0507(c); 15A NCAC 02B .0200; 15A NCAC 02B .0231

9. Erosion control matting that incorporates plastic mesh and/or plastic twine shall not be used along streambanks or within wetlands.

Citation: 15A NCAC 02H .0506(b); 15A NCAC 02H .0507(c)

10. If the project is covered by NPDES Construction Stormwater Permit Number NCG010000 or NPDES Construction Stormwater Permit Number NCG250000, full compliance with permit conditions including the erosion & sedimentation control plan, inspections and maintenance, self-monitoring, record keeping and reporting requirements is required.

Citation: 15A NCAC 02H .0506(b); 15A NCAC 02H .0507(c); 15A NCAC 02B .0200; 15A NCAC 02B .0231

11. All work in or adjacent to streams shall be conducted so that the flowing stream does not come in contact with the disturbed area. Approved best management practices from the most current version of the NC Sediment and Erosion Control Manual, or the NC Department of Transportation Construction and Maintenance Activities Manual, such as sandbags, rock berms, cofferdams, and other diversion structures shall be used to minimize excavation in flowing water.

Citation: 15A NCAC 02H .0506(b); 15A NCAC 02H .0507(c); 15A NCAC 02B .0200

12. Application of fertilizer to establish planted/seeded vegetation within disturbed riparian areas and/or wetlands shall be conducted at agronomic rates and shall comply with all other Federal, State and Local regulations. Fertilizer application shall be accomplished in a manner that minimizes the risk of contact between the fertilizer and surface waters.

Citation: 15A 02H .0506(b); 15A NCAC 02H .0507(c); 15A NCAC 02B .0200; 15A NCAC 02B .0231

13. If concrete is used during construction, then all necessary measures shall be taken to prevent direct contact between uncured or curing concrete and waters of the state. Water that inadvertently contacts uncured concrete shall not be discharged to waters of the state.

Citation: 15A 02H .0506(b); 15A NCAC 02H .0507(c); 15A NCAC 02B .0200; 15A NCAC 02B .0231

14. All proposed and approved temporary fill and culverts shall be removed and the impacted area shall be returned to natural conditions within 60 calendar days after the temporary impact is no longer necessary. The impacted areas shall be restored to original grade, including each stream's original



cross-sectional dimensions, planform pattern, and longitudinal bed profile. All temporarily impacted sites shall be restored and stabilized with native vegetation.

Citation: 15A NCAC 02H.0506(b); 15A NCAC 02H.0507(c)

15. All proposed and approved temporary pipes/culverts/rip-rap pads etc. in streams shall be installed as outlined in the most recent edition of the North Carolina Sediment and Erosion Control Planning and Design Manual or the North Carolina Surface Mining Manual or the North Carolina Department of Transportation Best Management Practices for Construction and Maintenance Activities so as not to restrict stream flow or cause dis-equilibrium.

Citation: 15A NCAC 02H.0506(b); 15A NCAC 02H.0507(c)

16. Any rip-rap required for proper culvert placement, stream stabilization, or restoration of temporarily disturbed areas shall be restricted to the area directly impacted by the approved construction activity. All rip-rap shall be placed such that the original streambed elevation and streambank contours are restored and maintained and shall consist of clean rock or masonry material free of debris or toxic pollutants. Placement of rip-rap or other approved materials shall not result in destabilization of the stream bed or banks upstream or downstream of the area or be installed in a manner that precludes aquatic life passage.

Citation: 15A NCAC 02H.0506(b); 15A NCAC 02H.0507(c)

17. Any rip-rap used for streambank stabilization shall be of a size and density to prevent movement by wave, current action, or stream flows, and shall consist of clean rock or masonry material free of debris or toxic pollutants. Rip-rap shall not be installed in the streambed except in specific areas required for velocity control and to ensure structural integrity of bank stabilization measures.

Citation: 15A NCAC 02H.0506(b); 15A NCAC 02H.0507(c); 15A NCAC 02B.0201

18. All mechanized equipment operated near surface waters shall be inspected and maintained regularly to prevent contamination of surface waters from fuels, lubricants, hydraulic fluids, or other toxic materials. Construction shall be staged in order to minimize the exposure of equipment to surface waters to the maximum extent practicable. Fueling, lubrication, and general equipment maintenance shall be performed in a manner to prevent, to the maximum extent practicable, contamination of surface waters by fuels and oils.

Citation: 15A NCAC 02H.0506(b); 15A NCAC 02H.0507(c); 15A NCAC 02B.0200; 15A NCAC 02B.0231

19. Heavy equipment working in wetlands shall be placed on mats or other measures shall be taken to minimize soil disturbance and compaction.

Citation: 15A NCAC 02H.0506(b); 15A NCAC 02H.0507(c); 15A NCAC 02B.0231

20. In accordance with 143-215.85(b), the permittee shall report any petroleum spill of 25 gallons or more; any spill regardless of amount that causes a sheen on surface waters; any petroleum spill regardless of amount occurring within 100 feet of surface waters; and any petroleum spill less than 25 gallons that cannot be cleaned up within 24 hours.

Citation: 15A NCAC 02H.0507(c); N.C.G.S 143-215.85(b)



21. The permittee and their authorized agents shall conduct all activities in a manner consistent with State water quality standards (including any requirements resulting from compliance with §303(d) of the Clean Water Act), and any other appropriate requirements of State and Federal Law.

Citation: 15A NCAC 02H .0506(b); 15A NCAC 02H .0507(c)

22. The permittee shall require its contractors and/or agents to comply with the terms and conditions of this certification in the construction and maintenance of this project, and shall provide each of its contractors and/or agents associated with the construction or maintenance of this project with a copy of this Water Quality Certification. A copy of this Water Quality Certification shall be available at the project site during the construction and maintenance of this project.

Citation: 15A NCAC 02H .0506(b); 15A NCAC 02H .0507(c)

23. This Water Quality Certification neither grants nor affirms any property right, license, or privilege in any lands or waters, or any right of use in any waters. This Water Quality Certification does not authorize any person to interfere with the riparian rights, littoral rights, or water use rights of any other person and does not create any prescriptive right or any right of priority regarding any usage of water. This Water Quality Certification shall not be interposed as a defense in any action respecting the determination of riparian or littoral rights or other rights to water use. No consumptive user is deemed by virtue of this Water Quality Certification to possess any prescriptive or other right of priority with respect to any other consumptive user.

This approval to proceed with your proposed impacts or to conduct impacts to waters as depicted in your application shall expire upon expiration of the 404 Permit. The conditions in effect on the date of issuance shall remain in effect for the life of the project, regardless of the expiration date of this Certification. [15A NCAC 02H .0507(c)]

This, the 24th day of November 2025

DocuSigned by:

Chad Turlington

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Chad Turlington
Assistant Regional Supervisor
Division of Water Resources
Water Quality Regional Operations Section

