

The Town of Frisco

Technical Specifications (VOLUME II)

Bid Set

**Well 7 PFAS Mitigation
Improvements**

October 2025

Project #: 4131-002-09



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**CONTRACT DOCUMENTS AND SPECIFICATIONS FOR
THE TOWN OF FRISCO
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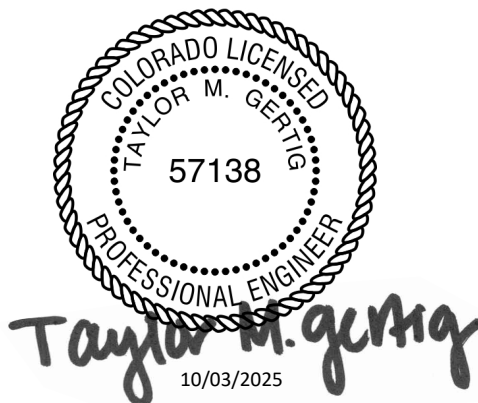
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Plummer Associates, Inc.
1221 Auraria Parkway
Denver, CO 80204

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SEALED BY:
Taylor M. Gertig, P.E.
PE #57138



Plummer Associates, Inc.
1221 Auraria Parkway
Denver, CO 80204

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SEALED BY:

Luis M. Cantu, P.E.
PE # 66311



Repella Consulting Engineers, Inc.

6444 Willow Broom Trail
Littleton, CO 80125

SPECIFICATIONS:

Division 03

04 20 00 Unit Masonry

05 05 19 Post-Installed Concrete Anchors

05 12 00 Structural Steel

05 21 00 Steel Joists

05 31 00 Steel Deck

05 40 00 Cold Formed Metal Framing

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05 50 00 Metal Fabrications

SEALED BY:

Gregory Repella, PE

PE #27990



Eidos Architects

5400 Greenwood Plaza Boulevard
Greenwood Village, CO 80111

SPECIFICATIONS:

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09 29 00 Gypsum Board
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BY:

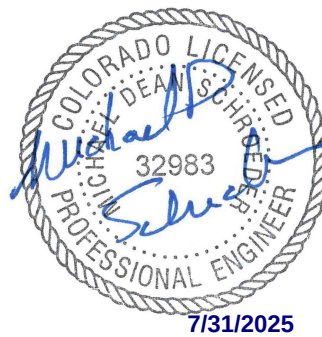
Lori Hanson
ARC-400684



BCER
14143 Denver West Parkway
Suite 550
Golden, CO 80401

SPECIFICATIONS:
Division 22
Division 23

SEALED BY:
Michael Schroeder, PE
PE #32983



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**SECTION 01 10 00
SUMMARY OF WORK**

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes the following:
 - 1. Project Identification and Contact Information.
 - 2. Scope of Work.
 - 3. Type of Contract.
 - 4. Work under other contracts.
 - 5. Limits of subcontractor participation.
 - 6. Use of premises.
 - 7. Owner's occupancy requirements.
 - 8. Work restrictions.
 - 9. Special Formats and Conventions.
 - 10. Permits.
 - 11. Other professional services.

1.2 REFERENCES

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 1, apply to this Section.
- B. Related Sections
 - 1. Section 01 12 16 "Sequence of Construction" for requirements for the construction sequence of work during the construction of improvements at the existing facility.
 - 2. Section 01 50 00 "Temporary Facilities and Controls" for limitations and procedures governing temporary use of Owner's facilities.

1.3 PROJECT IDENTIFICATION AND CONTACT INFORMATION

- A. Project Identification:
 - 1. Project Location: Well No. 7
- B. OWNER: Town of Frisco
 - 1. OWNER'S Representative: Ryan Thompson
- C. ENGINEER: Plummer Associates
 - 1. ENGINEER'S Representative: Taylor Gertig

1.4 SCOPE OF WORK

- A. The Work, under this Contract, consists of furnishing all labor, supervision, equipment, tools, materials, transportation, services, and related items necessary for the construction and completions, start-up and placing in service the Project described in the following paragraphs.
 - 1. The Work includes, but not necessarily limited to, construction of the following new

facilities:

- a. Driveway improvements.
 - b. Site grading and landscaping.
 - c. New treatment building.
 - d. New adsorption media treatment vessels.
 - e. Raw water piping modifications and a connection to the new vessels.
 - f. Chemical storage relocation.
 - g. Piping modifications at the existing Well 7 facility.
 - h. Miscellaneous Yard Piping, Instrumentation, and Electrical.
2. The Work includes the following items:
 - a. Clearing as required to complete the work.
 - b. Trench safety systems, groundwater dewatering, shoring, sheet piling, and earthwork required.
 - c. Site work, including clearing, stripping, grading, excavating, backfilling, compacting, and seeding.
 - d. Prior to final walk-through, the CONTRACTOR shall clean dirt and construction debris from the facilities including building electrical manholes and MCCs, walkways, and vaults and shall clean and touch-up paint all painted items.
 - e. Other facilities and services necessary for proper execution and completion of this Project.
 3. Testing of all systems to ensure performance in accordance with manufacturer's design and as specified herein; perform necessary adjustment as required, reporting proper functioning to ENGINEER; and all required plant start-up services in accordance with Section 01 75 00 "Starting and Adjusting".
 4. Unless otherwise specified, CONTRACTOR shall provide the following:
 - a. Temporary facilities and controls as specified in Section 01 50 00 "Temporary Facilities and Controls".
 - b. Provide quality control, material testing, field-testing, and related services in accordance with Section 01 40 00 "Quality Requirements".
 - c. Provide training of OWNER'S operation and maintenance personnel in accordance with Section 01 78 23 "Operation and Maintenance Data".
 - d. Field surveying required for support of construction operations.
 - e. Applicable permits, licenses and jurisdictional inspections, certificate of occupancy, and related work as necessary for OWNER to assume operation of facility.
 5. CONTRACTOR shall adhere to the requirements of the "Town of Frisco Water Construction Standards" and the Town of Frisco Code, Chapter 180 "Unified Development Code," as applicable.

1.5 TYPE OF CONTRACT

- A. Project will be constructed under a single prime Construction Manager at Risk contract.

1.6 WORK UNDER OTHER CONTRACTS (NOT USED)

1.7 LIMITS OF SUBCONTRACTOR PARTICIPATION PM TO DESIGNATE PARTICIPATION (NOT USED)

1.8 USE OF PREMISES

- A. General: CONTRACTOR shall have limited use of premises for construction operations as indicated on Drawings by the Contract limits.
- B. Use of Site: Limit use of premises to areas within the Contract limits indicated. Do not disturb portions of Project site beyond areas in which the Work is indicated.
 - 1. Limits: Confine construction operations to areas where work is permitted.
 - 2. OWNER Occupancy: Allow OWNER occupancy of Project site.
 - 3. Driveways and Entrances: Keep driveways and entrances serving facilities clear and available to OWNER, OWNER'S employees, and emergency vehicles at all times. Do not use these areas for parking or storage of materials.

1.9 OWNER'S OCCUPANCY REQUIREMENTS

- A. OWNER Occupancy of Completed Areas of Construction: OWNER reserves the right to occupy and to place and install equipment in completed areas of Project, before Substantial Completion, provided such occupancy does not interfere with completion of the Work. Such placement of equipment and partial occupancy shall not constitute acceptance of the total Work.
 - 1. ENGINEER will prepare a Certificate of Substantial Completion for each specific portion of the Work to be occupied before OWNER occupancy for beneficial use.
 - 2. Obtain a Certificate of Occupancy from authorities having jurisdiction before OWNER occupancy.
 - 3. Before partial OWNER occupancy, mechanical and electrical systems shall be fully operational, and required tests and inspections shall be successfully completed. On occupancy, OWNER will operate and maintain mechanical and electrical systems serving occupied portions of facilities.
 - 4. On occupancy, OWNER will assume responsibility for maintenance and custodial service for occupied portions of building.
 - 5. Maintain access to walkways, corridors, and other adjacent occupied or used facilities. Do not close or obstruct walkways, corridors, or other occupied or used facilities without written permission from OWNER and authorities having jurisdiction.
 - 6. Provide not less than 72 hours' notice to OWNER of activities that will affect OWNER'S operations.

1.10 WORK RESTRICTIONS PM TO CONFIRM HOURS AND HOLIDAYS

- A. On-Site Work Hours: Refer to the Supplementary Conditions for working hours.
 - 1. Saturday Hours: with written notification to OWNER 48 hours in advance.
 - 2. Early Morning Hours: CONTRACTOR shall minimize early morning hours or late evening hours of work and shall comply with local requirements of authorities having jurisdiction for restrictions on noisy work. A variance shall be obtained before proceeding with the work.
 - 3. Hours for Utility Shutdowns: The Well No. 7 facility is currently offline and is anticipated to remain offline for the duration of the project construction, until facility

startup. Therefore, utility shutdowns for water delivery are not anticipated. Refer to section 01 12 16 "Sequence of Construction" for other utility shutdowns which will require coordination and approval from the OWNER.

4. Work shall not be performed on Sundays or OWNER Holidays. Refer to the Supplementary Conditions for the OWNER Holidays.
- B. Existing Utility Interruptions: Do not interrupt utilities serving facilities occupied by OWNER or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:
 1. Notify ENGINEER not less than two working days in advance of proposed utility interruptions.
 2. Do not proceed with utility interruptions without ENGINEER'S written permission.

1.11 SPECIFICATION FORMATS AND CONVENTIONS

- A. Specification Format: The Specifications are organized into Divisions and Sections using a 50-division format and CSI "Master Format" numbering system.
 1. Division 1: Sections in Division 1 govern the execution of the Work of all Sections in the Specifications.
- B. Specification Content: The Specifications use certain conventions for the style of language and the intended meaning of certain terms, words, and phrases when used in particular situations. These conventions are as follows:
 1. Abbreviated Language: Language used in the Specifications and other Contract Documents is abbreviated. Words and meanings shall be interpreted as appropriate. Words implied, but not stated, shall be inferred, as the sense requires. Singular words shall be interpreted as plural and plural words shall be interpreted as singular where applicable as the context of the Contract Documents indicates.
 2. Imperative mood and streamlined language are generally used in the Specifications. Requirements expressed in the imperative mood are to be performed by CONTRACTOR. Occasionally, the indicative or subjunctive mood may be used in the Section Text for clarity to describe responsibilities that must be fulfilled indirectly by CONTRACTOR or by others when so noted.
 - a. The words "shall," "shall be," or "shall comply with," depending on the context, are implied where a colon (:) is used within a sentence or phrase.
 3. Additional meaning of language used may be found in the General Conditions Article "Defined Terms and Terminology."

1.12 PERMITS

- A. Attention is directed to the requirements of the General Conditions regarding obtaining permits. The CONTRACTOR shall obtain and pay for all applicable permits in connection with the Work including a stormwater discharge permit. The Bid Prices shall include the costs for obtaining all required permits, as well as performing the work in accordance with the permit requirements. The fees associated with OWNER permits will be waived; however, the CONTRACTOR shall be required to obtain the permits.

1.13 OTHER PROFESSIONAL SERVICES

- A. Other Professional Services: ENGINEER(s) or engineering firms which may be retained by the

CONTRACTOR or his subcontractors or vendors to fulfill engineering requirements of the Project during the construction phase.

- B. When professional engineering services are required during the course of the Project, the CONTRACTOR shall comply with the requirements of Local Government Code and shall select and award on the basis of demonstrated competence and qualifications to perform the services for a fair and reasonable price and shall not select services or award contracts on the basis of competitive bidding.

1.14 SUBSTANTIAL COMPLETION

- A. The definition of SUBSTANTIAL COMPLETION in the General Conditions shall be modified to include the following.
 - 1. "Substantial Completion is further defined as (i) that degree of completion of the Project's operating facilities or systems sufficient to provide Owner the full time, uninterrupted, and continuous beneficial operation of the Work; and (ii) all required functional, performance, and acceptance or startup testing has been successfully demonstrated for all components, devices, equipment, and instrumentation, controls, and any required SCADA automation to the satisfaction of ENGINEER in accordance with the requirements of the Specifications.
 - 2. All items shall be placed into operation prior to the date specified for substantial completion and shall remain continuously on-line following the date specified for substantial completion. The components shall not have any work items remaining that require the final items to be taken out of service following substantial completion, but still may require minor miscellaneous work and adjustment which does not prevent OWNER'S use of the project for its intended purpose.
 - 3. To be considered as substantially complete and ready for operation, the following requirements shall be met:
 - a. Equipment shall be installed complete with the permanent electrical and instrumentation items complete and operable. Suppliers' installation report shall be complete and furnished to ENGINEER.
 - b. Normal mode of operation shall be utilized including all automatic control features with associated interlocks and protection systems.
 - c. Structural and architectural items shall be sufficiently complete for the intended service and shall provide adequate protection of electrical and instrumentation equipment placed into operation."

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION

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SECTION 01 12 16
SEQUENCE OF CONSTRUCTION

PART 1 - GENERAL

1.1 SUMMARY

- A. The Well No. 7 facility is currently offline and is anticipated to remain offline for the duration of the project construction, until facility startup. Therefore, shutdowns for construction are not anticipated for the Well No. 7 water production facility. However, the Owner maintains first right to bring the facility into service. Additionally, the water distribution system, electrical supply, and sewer are in service and may require shutdowns for construction activities. The following requirements herein are specific to shutdown activities and apply if each respective utility is in service. Requirements not specific to shutdown activities apply to the project.**
- B. Schedules of connections, renovations and modifications required shall be submitted to the OWNER for approval and shall be coordinated throughout the entire construction period.
- C. The CONTRACTOR shall prepare and submit a project schedule within 15 days of the preconstruction meeting or within 7 days of notice to proceed, whichever comes first, outlining the schedule and time requirements for each item involving an existing treatment unit, piece of equipment, and conveyance system. No payment shall be made until these items are received.
- D. The CONTRACTOR shall notify the OWNER at least 14 days in advance and again 3 days prior to beginning work on a particular area, and coordinate with the OWNER the specific items to be isolated and duration for each. Obtain written approval from the OWNER prior to each shutdown. High flow conditions or equipment outages may require the rescheduling of an approved shutdown. Cost associated with rescheduling will be subsidiary to Project.
- E. After startup and transfer of operation to the OWNER, the CONTRACTOR shall not operate valves or equipment in the facility unless directed to do so by the OWNER.
- F. Prior to beginning work, the CONTRACTOR shall have onsite materials, equipment, and personnel necessary to complete the work in the time scheduled. The

CONTRACTOR shall also perform tasks to the most complete state possible prior to shutdowns. Exposed bolts and nuts on valves or fittings which are to be disassembled shall be removed and replaced one at a time prior to shutdown to assure timely progress.

- G. Access to components of the facility must be maintained at all times.
- H. In general, new and existing equipment cannot be offline longer than 1 hour while piping and electrical connections are being made. Longer shutdowns for equipment may be possible. Coordinate with OWNER.
- I. Existing plugged pipelines, in which water has been standing, shall be cleaned of debris prior to connecting to a new pipeline.
- J. The CONTRACTOR shall coordinate and schedule each task necessary to complete work within the time allowed for the project. Specific connection coordination, shutdown, and out of service (downtime) limitations, are described, but not limited to, the specific items listed in PART 3.
- K. The sequencing may require the CONTRACTOR to perform work such as installing temporary or permanent plugs, or diversion facilities in structures that are online. The specifics related to flow diversion and temporary plugging means and methods are the responsibility of the CONTRACTOR; however, the CONTRACTOR'S proposed work operations and schedules shall be submitted to the OWNER for review. Costs for temporary piping and pumping, pipe connections, and related work shall be included in the scope of the project.
- L. Facility Piping Interconnections Requirements:
 - 1. Testing of pipes to be connected shall be completed and test reports furnished to the ENGINEER prior to making connections.
 - a. Plant water, drain, and potable water connections require advance notification and concurrence from the OWNER prior to isolating or shutting down the system for connection. Potable pipes should be flushed, and pressure tested prior to connection and disinfected following the connection. CONTRACTOR shall coordinate these items.
 - b. Reduce the number of shutdowns required for piping systems by combining connections at the same time, as feasible.

- c. Facility process piping connections are critical and shall be fully coordinated, expedited, and done in a continuous manner upon initiation. These pipes generally do not have isolation valves or parallel pipes and require shutting down the treatment process for connection.
- d. Time shall be allowed for shutting down the process and dewatering the existing pipe and basin in addition to the actual connection time. CONTRACTOR shall provide equipment, tools and labor to dewater the pipes for connections. This process water shall be contained in the facilities and not allowed to discharge over the ground or to the surface drainage systems.
- e. Facility shutdowns must be coordinated with and approved by the OWNER.
- f. Potable water piping shall be cleaned, disinfected, and tested prior to placing into service. CONTRACTOR shall provide taps, flushing, and blow-off connections to flush and disinfect each pipe section and treatment unit.

1.2 RELATED SECTIONS

- A. Division 0
- B. Division 1

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 SUBSTANTIAL COMPLETION

- A. CONTRACTOR shall be responsible for and shall coordinate the startup of the new facilities.
 - 1. CONTRACTOR shall coordinate equipment startup activities with all suppliers.
 - 2. CONTRACTOR shall be responsible for the work defined in Table A.1. and Table B.1. below.

3. **Ultimate responsibility for startup operations and schedule is the responsibility of the CONTRACTOR.** Delays caused by equipment suppliers will not be grounds for additional contract days or financial compensation to the CONTRACTOR.

- B. CONTRACTOR shall startup the new treatment facilities within the first 30 days of Substantial Completion. After startup the new treatment facilities shall operate continuously for 30 days without significant failures requiring the system to be offline for longer than 8 hours.

3.2 FINAL COMPLETION

- A. Work associated with the project scope shall be complete.

3.3 FACILITY OPERATION

- A. CONTRACTOR responsibility of operation of new or modified treatment facilities until substantially complete.
 1. The CONTRACTOR will be solely responsible for the startup and operation of new treatment facilities until they are determined to be substantially complete and are turned over to the OWNER. The CONTRACTOR shall fill vessels, regulate flows, control the operation of equipment in the new facilities, and in other ways shall be responsible for overall operation during startup of new or modified treatment units. The CONTRACTOR shall consult with the OWNER's staff about the impacts of the operation on the rest of the plant and on finished water quality. No flow may be delivered to the distribution system that does not meet the requirements of the EPA and CDPHE water quality regulations from treatment units under the operation of the CONTRACTOR. Violations of water quality regulations for units under the operation of the CONTRACTOR that result in fines shall be paid by the CONTRACTOR.

3.4 POTABLE WATER REQUIREMENTS (NOT USED)

END OF SECTION

Table A.1: Anticipated Electrical Shutdowns

Item No.	Construction Activity
1	Electrical connection to Well 7 building: Tie in new power panel PP-2 to existing power panel PP-1 per drawings. Tie-in includes conduit installation, wire pulling, breaker installation, termination, load balancing if required, and testing. All associated work to be completed in accordance with NFPA 70E, NFPA 70, and project specifications.

Table B.1: Anticipated Coordination Activities

Item No.	Construction Activity¹
1	Coordinate with Owner and Frisco Sanitation District prior to the installation of sewer manholes and/or interruption of sewer service, if applicable.

¹ OWNER maintains the right to enforce unplanned Coordination Activities.

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**SECTION 01 21 01
UNIT BID ITEMS**

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. This Section includes administrative and procedural requirements governing unit bid items.
 - 1. Certain items are specified in the Contract Documents by unit bid item. Unit bid items have been established in lieu of additional requirements and to defer selection of actual materials and equipment to a later date when additional information is available for evaluation. If necessary, additional requirements will be issued by Change Order.
- B. Types of allowances include the following:
 - 1. Unit-price bid item.
 - 2. Contingency bid item.
- C. Related Sections include the following:
 - 1. Division 0 and Division 1 for procedures for submitting and handling Change Orders for unit bid items.
 - 2. Divisions 2 through 50 Sections for items of Work covered by unit bid item.

1.3 SELECTION AND PURCHASE

- A. At the earliest practical date after award of the Contract, advise ENGINEER of the date when final selection and purchase of each product or system described by a unit bid item must be completed to avoid delaying the Work.
- B. At ENGINEER's request, obtain proposals for each unit bid item for use in making final selections. Include recommendations that are relevant to performing the Work.
- C. Purchase products and systems selected by ENGINEER from the designated supplier.

1.4 SUBMITTALS

- A. Submit proposals for purchase of products or systems included in unit bid items, in the form specified for Change Orders.
- B. Submit invoices or delivery slips to show actual quantities of materials delivered to the site for use in fulfillment of each unit bid item.
- C. Coordinate and process submittals for unit bid items in same manner as for other portions of the Work.

1.5 COORDINATION

- A. Coordinate unit bid items with other portions of the Work. Furnish templates as required to coordinate installation.

1.6 UNIT BID ITEMS

- A. Unit Bid Items shall include cost to CONTRACTOR of specific products and materials ordered by OWNER and/or selected by ENGINEER under unit bid item and shall include taxes, freight, and delivery to Project site.
- B. Unless otherwise indicated, CONTRACTOR's costs for receiving and handling at Project site, labor, installation, overhead and profit, and similar costs related to products and materials ordered by OWNER and/or selected by ENGINEER under unit bid item shall be included as part of the Contract Sum and not part of the unit bid item.

1.7 CONTINGENCY BID ITEM

- A. CONTRACTOR agrees that a contingency, if any, is for the sole use of the OWNER to cover unanticipated costs.
- B. Use the contingency bid item only as directed in writing by ENGINEER for OWNER's purposes and only by Change Orders that indicate amounts to be charged to the bid item.
- C. CONTRACTOR's overhead, profit, and related costs for products and equipment ordered under the contingency bid item are included in the unit bid items and are not part of any other Bid Item. These costs include delivery, installation, taxes, insurance, equipment rental, and similar costs. The contingency bid item is to be an all-inclusive cost for the work described in the Contingency Bid Item.
- D. At Project closeout, credit unused amounts remaining in the contingency unit item to OWNER by Change Order.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine products covered by a unit bid item promptly on delivery for damage or defects. Return damaged or defective products to manufacturer for replacement.

3.2 PREPARATION

- A. Coordinate materials and their installation for each unit bid item with related materials and installations to ensure that each unit bid item is completely integrated and interfaced with related work.

3.3 SCHEDULE OF UNIT BID ITEMS

- A. **Bid Item No. 1** –A unit price bid item for additional split rail fence as described in Drawings , which shall include insurance, supervision, labor, materials, equipment, tools, incidentals and related items required for the fence, including, but not limited to, treated lumber, piers, and hardware, as specified and ordered in writing by the Owner. Payment will be made at the respective unit price set forth in the Contract. Refer to the Contract Drawings for approximate quantities.
- B. **Bid Item No. 2** – A unit price bid item for landscape rock as described in Drawings, which shall include insurance, supervision, labor, materials, equipment, tools, incidentals and related items required, including, but not limited to 3-inch to 6-inch river rock, as specified

and ordered in writing by the Owner. Payment will be made at the respective unit price set forth in the Contract. Refer to the Contract Drawings for approximate quantity and additional information.

- C. **Bid Item No. 3** – A unit price bid item for removing trees as described in Drawings, which shall include all insurance, supervision, labor, materials, equipment, tools, incidentals and related items required, ordered in writing by the Owner. Payment will be made at the respective unit price set forth in the Contract. Refer to the Contract Drawings for approximate quantity.
- D. **Bid Item No. 4** – A unit price bid item for planting trees as described in Drawings, which shall include all insurance, supervision, labor, materials, equipment, tools, incidentals and related items required, ordered in writing by the Owner. Payment will be made at the respective unit price set forth in the Contract. Refer to the Contract Drawings for approximate quantity

END OF SECTION

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SECTION 01 31 00
PROJECT MANAGEMENT AND COORDINATION

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes administrative provisions for coordinating construction operations on the Project including project meetings.

1.2 REFERENCES

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 1 Specification Sections, apply to this Section.
- B. Related Sections include the following:
 - 1. Section 01 12 16 Sequence of Construction.
 - 2. Section 01 31 26 Electronic Communication Protocols.
 - 3. Section 01 32 16 Construction Progress Schedule.
 - 4. Section 01 32 33 Photographic Documentation.
 - 5. Section 01 33 00 Submittal Procedures.
 - 6. Section 01 70 00 Execution Requirements.
 - 7. Section 01 77 00 Closeout Procedures.
 - 8. Section 01 79 00 Demonstration and Testing.

1.3 PROJECT COORDINATION

- A. Construction Operations:
 - 1. Coordinate construction operations, included in different Sections, which depend on each other for proper installation, connection, and operation.
 - a. Schedule construction operations in sequence required obtaining the best results where installation of one part of the Work depends on installation of other components, before or after its own installation.
 - b. Coordinate installation of different components with other contractors to facilitate maximum accessibility for required maintenance, service, and repair.
 - c. Make adequate provisions to accommodate items scheduled for later installation.
 - d. Where availability of space is limited, coordinate installation of different components to facilitate maximum performance and accessibility for required maintenance, service, and repair of all components, including mechanical and electrical.
- B. Administrative Procedures:
 - 1. Coordinate scheduling and timing of required administrative procedures with other construction activities and activities of other contractors to avoid conflicts and to maintain orderly progress of the Work. Such administrative activities include, but are not limited to, the following:
 - a. Preparation of Contractor's Construction Schedule.

- b. Preparation of the Schedule of Values.
 - c. Installation and removal of temporary facilities and controls.
 - d. Delivery and processing of submittals.
 - e. Progress meetings.
 - f. Project closeout activities.
2. Startup and adjustment of systems.

1.4 PROJECT MEETINGS

A. ENGINEER

1. The ENGINEER will schedule and conduct meetings and conferences at Project site, or virtually using Microsoft Teams or equivalent meeting platforms unless otherwise indicated.
- a. Attendees: Inform participants, others involved, and individuals whose presence is required, of the date and time of each meeting.
 - b. Agenda: Prepare the meeting agenda. Distribute the agenda to all invited attendees no later than 24 hours before meeting.
 - c. Minutes: Record significant discussions and agreements achieved. Distribute the meeting notes to those in attendance, those who are assigned action items, those from whom information is requested, and other project team members within 7 calendar days of the meeting.

B. Preconstruction Conference:

1. ENGINEER will schedule a preconstruction conference before starting construction, at a time convenient to OWNER and CONTRACTOR, but no later than 15 calendar days after execution of the Agreement. Hold the conference at Project site or another convenient location. Provide remote attendance via Microsoft Teams or equivalent meeting platform if desired by ENGINEER or OWNER. Conduct the meeting to review responsibilities and personnel assignments.
- a. Attendees: Authorized representatives of OWNER, ENGINEER, and their consultants; CONTRACTOR and its superintendent; major subcontractors; suppliers; and other concerned parties shall attend the preconstruction conference. All participants at the conference shall be familiar with Project and authorized to conclude matters relating to the Work.
 - b. Minutes: ENGINEER will record and distribute meeting notes.

C. Pre-installation, Milestone or Shutdown Meetings:

1. CONTRACTOR will conduct a pre-installation meeting at Project site before each construction activity that requires coordination with OWNER, operations or outside entities.
- a. Record significant meeting discussions, agreements, and disagreements, including required corrective measures and actions.
 - b. Reporting: CONTRACTOR shall distribute minutes of the meeting to each party present and to parties who should have been present, as well as to the OWNER and ENGINEER.

D. Progress Meetings:

1. Unless otherwise specified, CONTRACTOR shall conduct progress meetings at monthly intervals. Coordinate dates of meetings with OWNER and ENGINEER.
 - a. Attendees: In addition to representatives of OWNER and ENGINEER, each contractor, subcontractor, supplier, and other entity concerned with current progress or involved in planning, coordination, or performance of future activities shall be represented at these meetings. All participants at the conference shall be familiar with Project and authorized to conclude matters relating to the Work.
 - b. Agenda: Review and correct or approve minutes of previous progress meeting. Review other items of significance that could affect progress. Include topics for discussion as appropriate to status of Project such as submittals, RFI's, change orders, old business, new business, and other topics as directed by ENGINEER.
 - 1) Contractor's Construction Schedule: Review progress since the last meeting. Determine whether each activity is on time, ahead of schedule, or behind schedule, in relation to Contractor's Construction Schedule. Determine how construction behind schedule will be expedited; secure commitments from parties involved to do so. Discuss whether schedule revisions are required to ensure that current and subsequent activities will be completed within the Contract Time.
 - c. Minutes: ENGINEER will record and distribute to CONTRACTOR the meeting notes.
 - d. Reporting: CONTRACTOR shall distribute ENGINEER's notes of the meeting to each subcontractor present and to parties who should have been present.
 - 1) Schedule Updating: Revise Contractor's Construction Schedule after each progress meeting where revisions to the schedule have been made or recognized. Issue revised schedule concurrently with the report of each meeting.

E. Facility Startup Meetings:

1. Schedule a minimum of two facility startup meetings. The initial meeting will be held prior to submitting Facility Startup and Performance Demonstration Plan as specified in Section 01 79 00 Demonstration and Testing." The meeting shall initiate the preliminary discussions regarding the Plan.
2. Agenda items will include at a minimum: the objectives of the equipment testing and facility startup, what actions and work will be included, the coordination between the various parties, and potential problems associated with startup.
3. Attendees will include:
 - a. CONTRACTOR.
 - b. CONTRACTOR'S designated quality control representative.
 - c. Subcontractors and manufacturer's representatives designate by CONTRACTOR.
 - d. ENGINEER'S representatives.
 - e. OWNER'S operating and maintenance personnel.
 - f. Others as required by Contract Documents.
 - g. Other Meetings: As requested by OWNER, ENGINEER, and CONTRACTOR.

PART 2 - PRODUCTS – NOT USED

PART 3 - EXECUTION – NOT USED

END OF SECTION

SECTION 01 31 26
ELECTRONIC COMMUNICATION PROTOCOLS

PART 1 - GENERAL

1.1 SUMMARY

- A. The ENGINEER will subscribe to and manage an Internet-based construction document management software system specific to this project.
- B. The project website will provide server or secure internet space and secured access to staff members representing the OWNER, ENGINEER, and CONTRACTOR. Each user will have a separate log-in name and password to access the website.
- C. Contract management related documents will be submitted, tracked, responded to, and made available to the OWNER, ENGINEER, and CONTRACTOR electronically.

1.2 REFERENCES

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 1 Specification Sections, apply to this Section.
- B. Related Sections include the following:
 - 1. Section 01 31 00 Project Management and Coordination.
 - 2. Section 01 32 16 Construction Progress Schedule.
 - 3. Section 01 32 33 Photographic Documentation.
 - 4. Section 01 33 00 Submittal Procedures.
 - 5. Section 01 70 00 Execution Requirements.
 - 6. Section 01 77 00 Closeout Procedures.
 - 7. Section 01 79 00 Demonstration and Testing.

1.3 REQUIREMENTS

- A. The CONTRACTOR will be required to make all submittals in electronic format, unless additional hard copies are requested. The required format will be confirmed and discussed at the pre-construction meeting. The chosen software product will support multiple file formats and provide viewing and markup capability. See software products in "Part 2 - Products" below.
- B. The website includes a secure document management system for storing and making available to the project team the following:
 - 1. Ability to store files and correspondence.
 - 2. Latest drawings and specifications.
 - 3. Project progress photos.
- C. The website will include the following database driven applications. The system is designed to inform team members regarding new or updated documents and automatic task assignment and overdue notifications. The following items shall be entered, submitted, tracked, and responded to online.
 - 1. Meeting Notes
 - 2. Supplemental Instructions

3. Field Reports
4. CTR (Certified Test Reports)
5. RFIs (Requests For Information)
6. CMR (Contract Modification Request)
7. Shop Drawings and Submittals
8. PCMs (Proposed Contract Modifications)
9. Change Orders
10. Field Orders
11. Contractor's Daily Reports
12. RPR's Daily Field Report
13. Testing Agency Reports
14. Contractor's Storm Water Pollution Prevention Inspections
15. Applications for Payment with Schedule of Values
16. Payment Forecast Schedules
17. Construction Schedule
18. Other items necessary for successful completion of the Project

1.4 ARCHIVES

- A. The chosen electronic project management application is capable of archiving all files on the website at a frequency desired by OWNER and ENGINEER.
- B. All data from the website, such as RFIs, Submittals, etc. will be available in the archive for a period of 3 months past final completion of Project. OWNER and ENGINEER will maintain permanent electronic Project records in secure location(s) and format.

PART 2 - PRODUCTS

2.1 GENERAL

- A. General information on the software product to be used can be obtained at the following website:

Procore

www.procore.com

E-mail: support@procore.com

2.2 SPECIFIC

- A. The specific site used by the ENGINEER and administered by Procore, Inc., is located at:
<https://login.procore.com/>

PART 3 - EXECUTION

3.1 TRAINING:

- A. One training session by the ENGINEER will be provided to the team members at the beginning of the project. Expenses for additional training, if desired by CONTRACTOR or necessary for effective use of the software, will be borne by the CONTRACTOR.

3.2 SUPPORT:

- A. Software support will be available from the software vendor to all users of the Project.

3.3 OPERATION:

- A. CONTRACTOR shall maintain a PC system on the jobsite including high-speed internet access , the ability to scan documents, and the latest versions of software necessary for using Procore project management software.

3.4 DURATION:

- A. The website will be active during construction and for a minimum of 3 months past final completion. The OWNER will have the option to continue using the website for the 3 month period after completion of the Project.

3.5 ARCHIVES:

- A. All files on the website will be archived at the end of the Project. These archives will be made available to the OWNER to electronically download for permanent records.

END OF SECTION

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SECTION 01 32 33
PHOTOGRAPHIC DOCUMENTATION

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes administrative and procedural requirements for the following:
 - 1. Preconstruction photographs.
 - 2. Periodic construction photographs.
 - 3. Final completion construction photographs.

1.2 REFERENCES

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 1 Specification Sections, apply to this Section.
- B. Related Sections include the following:
 - 1. Section 01 31 26 Electronic Communication Protocols.
 - 2. Section 01 32 16 Construction Progress Schedule.
 - 3. Section 01 33 00 Submittal Procedures.
 - 4. Section 01 70 00 Execution Requirements.
 - 5. Section 01 77 00 Closeout Procedures.
 - 6. Section 01 79 00 Demonstration and Testing.

1.3 SUBMITTALS

- A. Key Plan:
 - 1. Electronically submit key plan of Project site with notation of vantage points marked for location and direction of each photograph. Indicate elevation or stage of construction of structure or area. Include same label information as corresponding set of photographs.
- B. Construction Photographs:
 - 1. Electronically submit a video and digital photographic view of key components within 7 calendar days of taking photographs.
 - a. Identification: For each photo, provide the following information in a consistent format:
 - 1) Name of Project.
 - 2) Name of ENGINEER.
 - 3) Name of CONTRACTOR.
 - 4) Date photograph was taken if not date stamped by camera.
 - 5) Description of vantage point, indicating location, direction (by compass point), and elevation or stage of construction.
 - 6) Stationing or northing and easting of major pipe, valves, or structures.
 - 7) Unique sequential identifier.
 - b. Digital Images: Submit a complete set of digital image, electronic files with each

submittal as a Project Record Document electronically. Identify electronic media with date photographs were taken. Submit images that have same aspect ratio as the sensor, uncropped.

1.4 COORDINATION

A. Auxiliary Services:

1. Cooperate with Project photographer and provide auxiliary services requested, including access to Project site and use of temporary facilities, including temporary lighting required to produce clear, well-lit photographs without obscuring shadows.

1.5 USAGE RIGHTS

- ##### A.
1. Obtain and transfer copyright usage rights from photographer to OWNER AND ENGINEER for unlimited reproduction of photographic documentation.

PART 2 - PRODUCTS

2.1 PHOTOGRAPHIC MEDIA

A. Digital Images:

1. Provide images in JPEG format, produced by a digital camera with minimum sensor size of 10.0 mega-pixels.

PART 3 - EXECUTION

3.1 CONSTRUCTION PHOTOGRAPHS

- ##### A. Photographer:
- A commercial photographer or a member of the CONTRACTOR'S staff may take the initial, monthly, and final progress photographs.
- ##### B. General:
- Take photographs using the maximum range of depth of field, and that are in focus, to clearly show the Work. Photographs with blurry or out-of-focus areas will not be accepted.
1. Maintain key plan with each set of construction photographs that identifies each photographic location.
- ##### C. Digital Images:
- Submit digital images exactly as originally recorded in the digital camera, without alteration, manipulation, editing, or modifications using image-editing software.
1. Date and Time: Include date and time in filename for each image.
 2. Field Office Images: Maintain one set of images in the field office at Project site, available at all times for reference. Identify images same as for those submitted to ENGINEER.
- ##### D. Preconstruction Photographs:
- Before starting construction, take color photographs of Project site and surrounding properties, including existing items to remain during construction, from different vantage points, as directed by ENGINEER. Preconstruction photographs must be submitted to OWNER prior to mobilization.
1. Flag construction limits before taking construction photographs.
 2. Take a minimum of 10 photographs to show existing conditions adjacent to property before starting the Work.

3. Take photographs of existing facilities either on or adjoining property to accurately record physical conditions at start of construction.
- E. Periodic Construction Photographs: Take a minimum of 2 color photographs of each structure or area under construction monthly, coinciding with the cutoff date associated with each Application for Payment. As approved by Resident Project Representative, select vantage points to show status of construction and progress since last photographs were taken.
 - F. Final Construction Photographs. Provide a minimum of 20 color photographs.
 - G. Aerial photographs and videos: Provide a minimum of 2 each color aerial photographs and videos of the Project site at the following times:
 1. Prior to construction.
 2. During key stages of construction.
 3. Following construction completion.
 - H. Additional Photographs: ENGINEER may issue requests for additional photographs, in addition to periodic photographs specified.
 1. Three days' notice will be given, where feasible.
 2. In emergency situations, take additional photographs within 24 hours of request.
 3. Circumstances that could require additional photographs include, but are not limited to, the following:
 - a. Special events planned at Project site.
 - b. Immediate follow-up when on-site events result in construction damage or losses.
 - c. Photographs to be taken at fabrication locations away from Project site. These photographs are not subject to unit prices or unit bid items.
 - d. Substantial Completion of a major phase or component of the Work.
 - e. Extra record photographs at time of final acceptance.
 - f. Owner's request for special publicity photographs.

END OF SECTION

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SECTION 01 33 00
SUBMITTAL PROCEDURES

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes administrative and procedural requirements for submitting Shop Drawings, Product Data, Samples, and other submittals.

1.2 REFERENCES

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 1 Specification Sections, apply to this Section.
- B. Definitions
 - 1. Action Submittals: Written and graphic information that requires ENGINEER'S responsive action.
 - 2. Informational Submittals: Written information that does not require ENGINEER'S responsive action. Submittals may be rejected for not complying with requirements.
- C. Related Sections include the following:
 - 1. Section 01 31 26 Electronic Communication Protocols.
 - 2. Section 01 32 16 Construction Progress Schedule.
 - 3. Section 01 32 33 Photographic Documentation.
 - 4. Section 01 70 00 Execution and Requirements.
 - 5. Section 01 77 00 Closeout Procedures.
 - 6. Section 01 78 23 Operations and Maintenance Data.
 - 7. Section 01 78 36 Warranties.
 - 8. Section 01 78 39 Project Record Documents.
 - 9. Section 01 79 00 Demonstration and Testing.
 - 10. Divisions 2 through 49 Sections for specific requirements for submittals in those Sections.

1.3 SUBMITTAL PROCEDURES

- A. Coordination: Coordinate preparation and processing of submittals with performance of construction activities.
 - 1. Coordinate each submittal with fabrication, purchasing, testing, delivery, other submittals, and related activities that requires sequential activity.
 - 2. Coordinate transmittal of submittals for related parts of the Work so that delays will not occur because of need to review submittals concurrently for coordination.
 - a. ENGINEER reserves the right to withhold action on a submittal requiring coordination with other submittals until all related submittals are received.
- B. Submittals Schedule: Comply with requirements in Division 1 for list of submittals and time requirements for scheduled performance of related construction activities.
- C. Processing Time: Allow enough time for submittal review, including time for resubmittals,

as follows. Time for review shall commence with ENGINEER's receipt of submittal. No extension of the Contract Time will be authorized because of failure to transmit submittals far enough in advance of the Work to permit submittal processing, including resubmittals. Note that submittals complying fully with the respective specifications will be reviewed and approved most easily and promptly.

1. Initial Review: Allow 21 calendar days for initial review of each submittal. Allow additional time if coordination with subsequent submittals is required. ENGINEER will advise CONTRACTOR when a submittal being processed must be delayed for coordination with related submittals.
 2. Intermediate Review: If intermediate submittal is necessary, process it in same manner as initial submittal, allowing 21 calendar days for intermediate review.
 3. Resubmittal Review: Allow 21 calendar days for review of each resubmittal.
- D. Identification: Place a permanent label or title block on each submittal for identification.
1. Indicate name of firm or entity that prepared each submittal on label or title block.
 2. Provide a space approximately on label or beside title block to record CONTRACTOR'S review markings (Green in color).
 3. Include the following information on label for processing and recording action taken:
 - a. Project name.
 - b. Date.
 - c. Name and address of ENGINEER.
 - d. Name and address of CONTRACTOR.
 - e. Name and address of subcontractor.
 - f. Name and address of supplier.
 - g. Name of manufacturer.
 - h. Submittal number shall be by means of a specification number and a chronological order; a letter suffices to indicate number of times submitted.
 - 1) Submittal number shall use Specification Section number followed by a hyponym and then a sequential number (e.g., 33 05 61-01). Resubmittals shall include an alphabetic suffix after another hyponym (e.g., 33 05 61-01-A).
 - 2) Operational and Maintenance Manuals submitted shall be identified with the same number as its corresponding equipment submittal. (e.g., 22 14 29-DRAFT indicates preliminary O&M Manual for equipment submitted under Section 01 78 23.)
 - i. Number and title of appropriate Specification Section.
 - j. Drawing number and detail references, as appropriate.
 - k. Location(s) where product is to be installed, as appropriate.
 - l. Other necessary for unique identification of item.
- E. Deviations from Contract Documents: CONTRACTOR shall highlight, encircle, or otherwise specifically identify deviations (Green in color) from the Contract Documents on submittals. Requests for deviation shall be by Contractor's Modification Request in accordance with the requirements of Division 0 and 1.

- F. Additional Copies: Unless additional copies are required for final submittal, and unless ENGINEER observes noncompliance with provisions in the Contract Documents, initial submittal may serve as final submittal.
- G. Transmittal: Package each submittal individually and appropriately for transmittal and handling. Transmit submittals per Section 01 31 26 ENGINEER will return submittals, without review, received from sources other than CONTRACTOR.
- H. Resubmittals: Make resubmittals in same form as initial submittal.
 - 1. Note date and content of previous submittal.
 - 2. Note date and content of revision in label or title block and clearly indicate extent of revision.
 - 3. Resubmit submittals until they are marked "REVIEWED."
 - 4. For resubmittals, CONTRACTOR shall provide the entire and complete submittal for project documentation. If the CONTRACTOR provides only the portions required by the previous shop drawing review, then the ENGINEER may elect to return the submittal without review.
- I. Distribution: Electronically furnish final submittals to manufacturers, subcontractors, suppliers, fabricators, installers, and authorities having jurisdiction, and others as necessary for performance of construction activities. Show distribution on transmittal forms.
- J. Use for Construction: Use only final submittals with mark indicating "REVIEWED" or "Furnish As Corrected."

PART 2 - PRODUCTS

2.1 ACTION SUBMITTALS

- A. General: Prepare and submit Action Submittals required by individual Specification Sections.
- B. Product Data: Collect information into a single submittal for each element of construction and type of product or equipment.
 - 1. If information must be specially prepared for submittal because standard printed data are not suitable for use, submit as Shop Drawings, not as Product Data.
 - 2. Mark each submittal to show which products and options are applicable.
 - 3. Clearly identify the item to be submitted with arrow or other mark. Information not marked clearly will be returned unreviewed by ENGINEER.
 - 4. Include the following information, as applicable:
 - a. Manufacturer's written recommendations.
 - b. Manufacturer's product specifications.
 - c. Manufacturer's installation instructions.
 - d. Manufacturer's catalog cut sheets.
 - e. Wiring diagrams showing factory-installed wiring.
 - f. Printed performance curves.
 - g. Operational range diagrams.
 - h. Compliance with specified referenced standards.

- i. Testing by recognized testing agency.
- 5. Number of Copies: Submit Product Data electronically in accordance with Section 01 31 26.
- C. Shop Drawings: Prepare Project-specific information, drawn accurately to scale. Do not base Shop Drawings on reproductions of the Contract Documents or standard printed data **unless** submittal of ENGINEER'S CAD Drawings is otherwise permitted.
 - 1. Preparation: Fully illustrate requirements in the Contract Documents. Include the following information, as applicable:
 - a. Dimensions.
 - b. Identification of products.
 - c. Fabrication and installation drawings.
 - d. Roughing-in and setting diagrams.
 - e. Wiring diagrams showing field-installed wiring, including power, signal, and control wiring.
 - f. Shopwork manufacturing instructions.
 - g. Templates and patterns.
 - h. Schedules.
 - i. Notation of coordination requirements.
 - j. Notation of dimensions established by field measurement.
 - k. Relationship to adjoining construction clearly indicated.
 - l. Seal and signature of professional ENGINEER if specified.
 - m. Wiring Diagrams: Differentiate between manufacturer-installed and field-installed wiring.
 - n. Electrical requirements.
 - o. Limits of or range of operation.
 - p. Performance curves.
 - q. When multiple products or materials are allowed, CONTRACTOR shall clearly indicate which product or material is being used at each location throughout the project.
 - 2. Sheet Size: Except for templates, patterns, and similar full-size drawings, submit Shop Drawings suitable for printing on sheets at least 8-1/2 by 11 inches but no larger than 30 by 40 inches.
 - 3. Submit Shop Drawings electronically in accordance with Section 01 31 26.
- D. Samples: Submit required Samples for review of kind, color, pattern, and texture for a check of these characteristics with other elements and for a comparison of these characteristics between submittal and actual component as delivered and installed. Original hard copies must be provided for color selection or items with various finishes. Electronic submittals are not acceptable.
 - 1. Transmit Samples that contain multiple, related components such as accessories together in one submittal package.

2. Identification: Attach label on unexposed side of Samples that includes the following:
 - a. Generic description of Sample.
 - b. Product name and name of manufacturer.
 - c. Sample source.
 - d. Number and title of appropriate Specification Section.
3. Disposition: Maintain sets of approved Samples at Project site, available for quality-control comparisons throughout the course of construction activity. Sample sets may be used to determine final acceptance of construction associated with each set.
4. Samples for Initial Selection: Submit manufacturer's color charts consisting of units or sections of units showing the full range of colors, textures, and patterns available.
 - a. Number of Samples: Submit one full set(s) of available choices where color, pattern, texture, or similar characteristics are required to be selected from manufacturer's product line. ENGINEER will return submittal with options selected.
5. Samples for Verification: Submit full-size units or Samples of size indicated, prepared from same material to be used for the Work, cured and finished in manner specified, and physically identical with material or product proposed for use, and that show full range of color and texture variations expected. Samples include, but are not limited to, the following: partial sections of manufactured or fabricated components; small cuts or containers of materials; complete units of repetitively used materials; swatches showing color, texture, and pattern; color range sets; and components used for independent testing and inspection.
 - a. Number of Samples: Submit two sets of Samples for review. ENGINEER will retain one Sample set; remainder will be returned.
- E. Product Schedule or List: As required in individual Specification Sections, prepare a written summary indicating types of products required for the Work and their intended location.
 1. Submit Product Schedule or List electronically in accordance with Section 01 31 26.
- F. Submittals Schedule: Comply with requirements outlined in Division 1.
- G. Application for Payment: Comply with requirements specified in Section 01 20 00.
- H. Schedule of Values: Comply with requirements specified in Section 01 20 00.
- I. Subcontract List: Prepare a written summary identifying individuals or firms proposed for each portion of the Work, including those who are to furnish products or equipment fabricated to a special design.
 1. Electronically submit subcontractor list electronically in accordance with Section 01 31 26.

2.2 INFORMATIONAL SUBMITTALS

- A. General: Prepare and submit Informational Submittals required by other Specification Sections.
 1. Submit electronically per Section 01 31 26, unless otherwise indicated. ENGINEER will not return copies.
 2. Certificates and Certifications: Electronically provide a notarized statement that

includes signature of entity responsible for preparing certification. An officer or other individual authorized to sign documents on behalf of that entity shall sign certificates and certifications.

3. Test and Inspection Reports: Comply with requirements specified in Section 01 40 00.
- B. Coordination Drawings: As required, comply with requirements specified in Section 01 31 00.
- C. Contractor's Construction Schedule: Comply with requirements specified in Section 01 32 16.
- D. Qualification Data: Prepare written information that demonstrates capabilities and experience of firm or person. Include lists of completed projects with project names and addresses, names, and addresses of architects and OWNERS, and other information specified.
- E. Welding Certificates: Prepare written certification that welding procedures and personnel comply with requirements in the Contract Documents. Submit record of Welding Procedure Specification (WPS) and Procedure Qualification Record (PQR) on AWS forms. Include names of firms and personnel certified.
- F. Installer Certificates: Prepare written statements on manufacturer's letterhead certifying that Installer complies with requirements in the Contract Documents and, where required, is authorized by manufacturer for this specific Project.
- G. Manufacturer Certificates: Prepare written statements on manufacturer's letterhead certifying that manufacturer complies with requirements in the Contract Documents. Include evidence of manufacturing experience where required.
- H. Product Certificates: Prepare written statements on manufacturer's letterhead certifying that product complies with requirements in the Contract Documents.
- I. Material Certificates: Prepare written statements containing manufacturer's letterhead certifying that material complies with requirements in the Contract Documents.
- J. Material Test Reports: Prepare reports written by a qualified testing agency, on testing agency's standard form, indicating and interpreting test results of material for compliance with requirements in the Contract Documents.
- K. Product Test Reports: Prepare written reports indicating current product produced by manufacturer complies with requirements in the Contract Documents. Base reports on evaluation of tests performed by manufacturer and witnessed by a qualified testing agency, or on comprehensive tests performed by a qualified testing agency.
- L. Compatibility Test Reports: Prepare reports written by a qualified testing agency, on testing agency's standard form, indicating and interpreting results of compatibility tests performed before installation of product. Include written recommendations for primers and substrate preparation needed for adhesion.
- M. Field Test Reports: Prepare reports written by a qualified testing agency, on testing agency's standard form, indicating and interpreting results of field tests performed either during installation of product or after product is installed in its final location, for compliance with requirements in the Contract Documents.
- N. Operational and Maintenance Data: Prepare written and graphic instructions and

procedures for operation and normal maintenance of products and equipment. Comply with requirements specified in Section 01 78 23.

- O. Design Data: Prepare written and graphic information, including, but not limited to, performance and design criteria, list of applicable codes and regulations, and calculations. Include list of assumptions and other performance and design criteria and a summary of loads. Include load diagrams if applicable. Provide name and version of software, if any, used for calculations. Include page numbers.
- P. Manufacturer's Instructions: Prepare written or published information that documents manufacturer's recommendations, guidelines, and procedures for installing or operating a product or equipment. Include name of product and name, address, and telephone number of manufacturer.
- Q. Manufacturer's Field Reports: Prepare written information documenting factory-authorized service representative's tests and inspections. Include the following, as applicable:
 - 1. Statement on condition of substrates and their acceptability for installation of product.
 - 2. Summary of installation procedures being followed, whether they comply with requirements and, if not, what corrective action was taken.
 - 3. Results of operational and other tests and a statement of whether observed performance complies with requirements.
- R. Insurance Certificates and Bonds: Prepare written information indicating current status of insurance or bonding coverage. Include name of entity covered by insurance or bond, limits of coverage, amounts of deductibles, if any, and term of the coverage.
- S. Construction Photographs and Videos: Comply with requirements specified in Section 01 32 33.
- T. Safety Data Sheets (SDS): Submit information directly to OWNER; do not submit to ENGINEER.
 - 1. ENGINEER will not review submittals that include SDS and will return them for resubmittal.

2.3 DELEGATED DESIGN

- A. Performance and Design Criteria: Where professional design services or certifications by a design professional are specifically required of CONTRACTOR by the Contract Documents, provide products and systems complying with specific performance and design criteria indicated.
 - 1. If criteria indicated are not sufficient to perform services or certification required, submit a written request for additional information to ENGINEER.
- B. Delegated-Design Submittal: In addition to Shop Drawings, Product Data, and other required submittals, submit per Division 1 Section 01 31 26, signed, and sealed by the responsible design professional, licensed to work in the state, for each product and system specifically assigned to CONTRACTOR to be designed or certified by a design professional.
 - 1. Indicate that products and systems comply with performance and design criteria in the Contract Documents. Include list of codes, loads, and other factors used in performing these services.

PART 3 - EXECUTION

3.1 CONTRACTOR'S REVIEW

- A. CONTRACTOR shall be responsible for the accuracy and completeness of the information contained in each submittal and shall confirm that the values, material, equipment, or method of work shall be as described.
- B. CONTRACTOR shall confirm that there is no conflict with other submittals and shall notify ENGINEER of any case in which a potential conflict may occur.
- C. Review each submittal and check for coordination with other Work of the Contract and for compliance with the Contract Documents. Note corrections and field dimensions. Mark with approval stamp (Green in color) before submitting to ENGINEER.
- D. Approval Stamp: Stamp each submittal with a uniform, approval stamp (Green in color). Include Project name and location, submittal number, Specification Section title and number, name of reviewer, date of CONTRACTOR'S approval, and statement certifying that submittal has been reviewed, checked, and approved for compliance with the Contract Documents.

3.2 ENGINEER ACTION

- A. General: ENGINEER will not review submittals that do not bear CONTRACTOR'S approval stamp and will return them without action.
- B. Action Submittals: ENGINEER will review each submittal, make marks to indicate corrections or modifications required, and return it. ENGINEER will either 1) stamp each submittal with an action stamp and mark stamp appropriately to indicate action taken, or 2) use the Shop Drawing Review Comments form listed in Part 3 to indicate the action taken for each submittal as follows:
 - 1. REVIEWED
 - a. CONTRACTOR may incorporate product(s) or implement Work covered by submittal.
 - 2. FURNISH AS CORRECTED
 - a. CONTRACTOR may incorporate product(s) or implement Work covered by submittal, in accordance with ENGINEER's notations.
 - 3. REVISE AND RESUBMIT
 - a. Make corrections or obtain missing portions and resubmit.
 - 4. REJECTED
 - a. CONTRACTOR may not incorporate product(s) or implement Work covered by submittal.
 - b. Provide a submittal that is compliant with Project specifications for Work covered by the rejected submittal.
- C. Informational Submittals: ENGINEER will review each submittal and will not return it, or will return it if it does not comply with requirements. ENGINEER will forward each submittal to appropriate party.
- D. Partial submittals are not acceptable, will be considered nonresponsive, and will be returned

without review.

- E. Submittals not required by the Contract Documents may not be reviewed and may be discarded.

3.3 SUPPLEMENTS

- A. Forms are provided using an electronic format provided by OWNER in accordance with Section 01 31 26 Electronic Communication Protocols.

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SECTION 01 40 00
QUALITY REQUIREMENTS

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes administrative and procedural requirements for quality assurance and quality control.
- B. Testing and inspecting services are required to verify compliance with requirements specified or indicated. These services do not relieve CONTRACTOR of responsibility for compliance with the Contract Document requirements.
 - 1. Specific quality-assurance and -control requirements for individual construction activities are specified in the Sections that specify those activities. Requirements in those Sections may also cover production of standard products.
 - 2. Specified tests, inspections, and related actions do not limit CONTRACTOR'S other quality-assurance and -control procedures that facilitate compliance with the Contract Document requirements.
 - 3. Provisions of this Section do not limit requirements for CONTRACTOR to provide quality-assurance and -control services required by ENGINEER, OWNER, or authorities having jurisdiction.

1.2 REFERENCES

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 1 Specification Sections, apply to this Section.
- B. Related Sections
 - 1. Section 01 31 26 Electronic Communication Protocols.
 - 2. Section 01 33 00 Submittal Procedures.
 - 3. Section 01 70 00 Execution Requirements.
 - 4. Section 01 77 00 Closeout Procedures.
 - 5. Section 01 79 00 Demonstration and Testing.
 - 6. All other Contract Document sections with specific test and inspection requirements.

1.3 DEFINITIONS

- 1. Quality-Assurance Services: Activities, actions, and procedures performed before and during execution of the Work to guard against defects and deficiencies and substantiate that proposed construction will comply with requirements.
- 2. Quality-Control Services: Tests, inspections, procedures, and related actions during and after execution of the Work to evaluate that actual products incorporated into the Work and completed construction comply with requirements. Services do not include contract enforcement activities performed by ENGINEER or OWNER.
- 3. Mockups: Full-size, physical assemblies that are constructed on-site. Mockups are used to verify selections made under sample submittals, to demonstrate aesthetic effects and, where indicated, qualities of materials and execution, and to review

construction, coordination, testing, or operation; they are not Samples. Approved mockups establish the standard by which the Work will be judged.

4. Laboratory Mockups: Full-size, physical assemblies that are constructed at testing facility to verify performance characteristics.
5. Product Testing: Tests and inspections that are performed by a Nationally Recognized Testing Laboratory (NRTL), a National Voluntary Laboratory Accreditation Program (NVLAP), or a testing agency qualified to conduct product testing and acceptable to authorities having jurisdiction, to establish product performance and compliance with industry standards.
6. Source Quality-Control Testing: Tests and inspections that are performed at the source, i.e., plant, mill, factory, or shop.
7. Field Quality-Control Testing: Tests and inspections that are performed on-site for installation of the Work and for completed Work.
8. Independent Testing Agency: An entity engaged by separate contract with the OWNER to perform specific tests, inspections, or both. The terms Independent Testing Laboratory and Independent Testing Agency shall have equivalent meaning.
9. Testing Agency: An entity engaged by the CONTRACTOR to perform specific tests, inspections, or both identified as the CONTRACTOR'S responsibility by the Contract Documents. Testing Laboratory shall mean the same as Testing Agency. Testing agency shall be approved by ENGINEER.
10. Installer/Applicator/Erector: CONTRACTOR or another entity engaged by CONTRACTOR as an employee, Subcontractor, or Sub-subcontractor, to perform a particular construction operation, including installation, erection, application, and similar operations.
 - a. Using a term such as "carpentry" does not imply that accredited or unionized individuals of a corresponding generic name, such as "carpenter", must perform certain construction activities. It also does not imply that requirements specified apply exclusively to trades people of the corresponding generic name.
11. Experienced: When used with an entity, "experienced" means having successfully completed a minimum of five (5) previous projects similar in size and scope to this Project; being familiar with special requirements indicated; and having complied with requirements of authorities having jurisdiction.

1.4 CONFLICTING REQUIREMENTS

- A. General: If compliance with two or more standards is specified and the standards establish different or conflicting requirements for minimum quantities or quality levels, comply with the most stringent requirement. Refer uncertainties and requirements that are different, but apparently equal, to ENGINEER for a decision before proceeding.
- B. Minimum Quantity or Quality Levels: The quantity or quality level shown or specified shall be the minimum provided or performed. The actual installation may comply exactly with the minimum quantity or quality specified, or it may exceed the minimum within reasonable limits. To comply with these requirements, indicated numeric values are minimum or maximum, as appropriate, for the context of requirements. Refer uncertainties to ENGINEER for a decision before proceeding.

1.5 SUBMITTALS

- A. Qualification Data: For Testing Agencies specified in Paragraph 1.5 "Quality Assurance" to demonstrate their capabilities and experience. Include proof of qualifications in the form of a recent report on the inspection of the testing agency by a recognized authority.

1.6 QUALITY ASSURANCE

- A. General: Qualifications paragraphs in this Article establish the minimum qualification levels required; individual Specification Sections specify additional requirements.
- B. Installer Qualifications: A firm or individual experienced in installing, erecting, or assembling work similar in material, design, and extent to that indicated for this Project, whose work has resulted in construction with a record of successful in-service performance.
- C. Manufacturer Qualifications: A firm experienced in manufacturing products or systems similar to those indicated for this Project and with a record of successful in-service performance, as well as sufficient production capacity to produce required units.
- D. Fabricator Qualifications: A firm experienced in producing products similar to those indicated for this Project and with a record of successful in-service performance, as well as sufficient production capacity to produce required units.
- E. Professional Engineer Qualifications: A professional engineer who is legally qualified and licensed to practice in jurisdiction where Project is located and who is experienced in providing engineering services of the kind indicated. Engineering services are defined as those performed for installations of the system, assembly, or products that are similar to those indicated for this Project in material, design, and extent.
- F. Testing Agency Qualifications:
 - 1. Laboratory facilities, including personnel, and equipment, utilized shall meet the criteria detailed in ASTM E329 "Specification for Agencies Engaged in Construction Inspection and/or Testing", ASTM D3666 "Practice for Minimum Requirements for Agencies Testing and Inspecting Road and Paving Materials," and ASTM D3740 "Practice for Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction."
 - 2. Testing Agency shall be accredited by the American Association of Laboratory Accreditation (AALA), National Institute of Standards and Technology (NIST), National Voluntary Laboratory Accreditation Program (NVLAP), the American Association of State Highway and Transportation Officials (AASHTO)), or other nationally recognized testing laboratory according to §29 CFR 1910.7.
 - 3. Comply with additional qualifications specified in individual Sections; and where required by authorities having jurisdiction, that is acceptable to authorities.
- G. Factory-Authorized Service Representative Qualifications: An authorized representative of manufacturer who is trained and approved by manufacturer to inspect installation of manufacturer's products that are similar in material, design, and extent to those indicated for this Project.
- H. Mockups: If applicable, before installing portions of the Work requiring mockups, build mockups for each form of construction and finish required to comply with the following requirements, using materials indicated for the completed Work:
 - 1. Build mockups in location and of size indicated or, if not indicated, as directed by ENGINEER.

2. Notify ENGINEER 7 calendar days in advance of dates and times when mockups will be constructed and available.
3. Demonstrate the proposed range of aesthetic effects and workmanship.
4. Obtain ENGINEER's approval of mockups before starting work, fabrication, or construction.
 - a. Allow 7 calendar days for initial review and each re-review, if necessary, of each mockup.
5. Maintain mockups during construction in an undisturbed condition as a standard for evaluating the completed Work.
6. Demolish and remove mockups when directed, unless otherwise indicated.

1.7 QUALITY CONTROL

- A. Owner Responsibilities: The OWNER will engage a qualified Independent Testing Agency to perform these services.
 1. Costs for retesting and reinspecting construction that replaces or is necessitated by work that failed to comply with the Contract Documents will be charged to CONTRACTOR. A deductive Change Order will be used to adjust the Contract Sum.
 2. The OWNER shall provide field and laboratory services in connection with verification surveying, geotechnical analysis and construction materials testing required by separate contract with an Independent Testing Agency or other consultant. Such work includes but is not limited to the following:
 - a. Testing of concrete mix designs, design of asphalt mixtures, lime stabilization of subgrade, flowable mix design, and related design parameter determinations.
 - b. Determination of soil test for classifications of on-site and off-site borrow materials, soil densities and moisture determination of subgrade and embankment materials, cement or lime stabilization of subgrade, and other related testing required during construction.
 - c. Weld inspection, coating inspections, torque requirements for steel erection, and other non-destructive testing required by the Contract Documents.
 - d. Vacuum and pressure testing of pipelines, manholes, and related work, including disinfection testing of potable water lines and CCTV of lines directed by the Contract Documents.
 - e. All inspection and testing work not specifically stated to be the CONTRACTOR'S responsibility.
 - f. Verification surveys of final constructed grades, by a Registered Professional Land Surveyor (RPLS) licensed in the State of Colorado, where required by the Contract Documents.
 3. Where quality-control services are indicated as OWNER'S responsibility, the independent testing agency or other consultant shall be required by contract with the OWNER to prepare certified written reports to be submitted in accordance with Section 01 33 00 "Submittal Procedures" for each quality-control service.
- B. Contractor Responsibilities: Only such tests and inspections that are explicitly assigned to the CONTRACTOR shall be the CONTRACTOR'S responsibility. Unless otherwise indicated, the OWNER shall provide both the quality-control services specified and those required by authorities having jurisdiction. Perform the following quality-control services.

1. Where services are specifically indicated as CONTRACTOR'S responsibility, engage a qualified testing agency to perform these quality-control services.
 - a. CONTRACTOR shall not employ same entity engaged by OWNER, unless agreed in writing by OWNER.
 2. Notify Testing Agencies at least 24 hours in advance of time when Work that requires testing or inspecting will be performed.
 3. Where quality-control services are specifically indicated as CONTRACTOR'S responsibility, the selected Testing Agency shall prepare certified written reports to be submitted by the CONTRACTOR in accordance with Section 01 33 00 "Submittal Procedures" for each quality-control service.
 4. Testing and inspecting desired by CONTRACTOR and not required by the Contract Documents are CONTRACTOR'S responsibility and will be performed at CONTRACTOR's cost.
 5. Submit additional copies of each written report directly to authorities having jurisdiction, when they so direct.
 6. The CONTRACTOR shall provide construction surveying, completed by a Registered Professional Land Surveyor (RPLS) licensed in the State of Colorado, required to construct the improvements as depicted on the plans.
- C. Manufacturer's Field Services: Where indicated, engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including service connections. Report results in writing as specified in Section 01 33 00 "Submittal Procedures."
- D. Retesting/Reinspecting: Regardless of whether original tests or inspections were CONTRACTOR'S responsibility, provide quality-control services, including retesting and reinspecting, for construction of replaced Work that failed to comply with the Contract Documents. Should laboratory services provided by the OWNER under Paragraph 1.7 A of this Section indicate the work does not meet Contract Document requirements, the cost of additional testing or surveying shall be paid by the CONTRACTOR by deductive Change Order to the Contract Amount. The testing or surveying services required shall be performed by the Independent Testing Agency or other consultant under separate contract with the OWNER.
- E. Independent Testing Agency Responsibilities: Cooperate with ENGINEER and CONTRACTOR in performance of duties. Provide qualified personnel to perform required tests and inspections. The Independent Testing Agency shall:
1. Notify ENGINEER and CONTRACTOR promptly of irregularities or deficiencies observed in the Work during performance of its services.
 2. Determine the location from which test samples will be taken and in which in-situ tests are conducted.
 3. Conduct and interpret tests and inspections and state in each report whether tested and inspected work complies with or deviates from requirements.
 4. Submit a certified written report, distribution as indicated, of each test, inspection, and similar quality-control service in accordance with Section 01 33 00 "Submittal Procedures" for each quality-control service.
 5. Not release, revoke, alter, or increase the Contract Document requirements or

- approve or accept any portion of the Work.
- 6. Not perform any duties of CONTRACTOR.
- F. Associated Services: CONTRACTOR shall cooperate with all agencies, whether under contract with the OWNER or CONTRACTOR, performing required tests, inspections, and similar quality-control services, and provide reasonable auxiliary services as requested. Notify all agencies, whether under contract with the OWNER or CONTRACTOR, sufficiently in advance of operations to permit assignment of personnel. Provide the following:
 - 1. Access to the Work.
 - 2. Incidental labor and facilities necessary to facilitate tests and inspections.
 - 3. Adequate quantities of representative samples of materials that require testing and inspecting. Assist agency in obtaining samples.
 - 4. Facilities for storage and field curing of test samples if required.
 - 5. Delivery of samples to testing agencies as applicable.
 - 6. Preliminary design mix proposed for use for material mixes that require control by testing agency.
 - 7. Security and protection for samples and for testing and inspecting equipment at Project site.
- G. Coordination: CONTRACTOR shall coordinate sequence of activities to accommodate required quality-assurance and quality-control services with a minimum of delay and to avoid necessity of removing and replacing construction to accommodate testing and inspecting.
 - 1. Schedule times for tests, inspections, obtaining samples, and similar activities.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 TEST AND INSPECTION LOG

- A. Prepare an electronic record of tests and inspections. Include the following:
 - 1. Date test or inspection was conducted.
 - 2. Description of the Work tested or inspected.
 - 3. Detailed locations and elevations where applicable.
 - 4. Date test or inspection results were transmitted to ENGINEER.
 - 5. Identification of testing agency or special inspector conducting test or inspection.
- B. Maintain log at Project site. Post changes and modifications as they occur. Provide access to test and inspection log for ENGINEER's reference during normal working hours.

3.2 REPAIR AND PROTECTION

- A. General: On completion of testing, inspecting, sample taking, and similar services, repair damaged construction and restore substrates and finishes.
 - 1. Provide materials and comply with installation requirements specified in other Specification Sections. Restore patched areas and extend restoration into adjoining areas with durable seams that are as invisible as possible.

- B. Protect construction exposed by or for quality-control service activities.
- C. Repair and protection are CONTRACTOR'S responsibility, regardless of the assignment of responsibility for quality-control services.

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SECTION 01 42 00
REFERENCES

PART 1 - GENERAL

1.1 REFERENCES

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 1 Specification Sections, apply to this Section.
- B. Definitions
 - 1. General: Basic Contract definitions are included in the Conditions of the Contract.
 - 2. "Approved": When used to convey ENGINEER's action on Contractor's submittals, applications, and requests, "approved" is limited to ENGINEER duties and responsibilities as stated in the Conditions of the Contract.
 - 3. "Directed": A command or instruction by ENGINEER. Other terms including "requested," "authorized," "selected," "required," and "permitted" have the same meaning as "directed."
 - 4. "Indicated": Requirements expressed by graphic representations or in written form on Drawings, in Specifications, and in other Contract Documents. Other terms including "shown," "noted," "scheduled," and "specified" have the same meaning as "indicated."
 - 5. "Regulations": Laws, ordinances, statutes, and lawful orders issued by authorities having jurisdiction, and rules, conventions, and agreements within the construction industry that control performance of the Work.
 - 6. "Furnish": Supply and deliver to Project site, ready for unloading, unpacking, assembly, installation, and similar operations.
 - 7. "Install": Operations at Project site including unloading, temporarily storing, unpacking, assembling, erecting, placing, anchoring, applying, working to dimension, finishing, curing, protecting, cleaning, and similar operations.
 - 8. "Provide": Furnish and install, complete and ready for the intended use.
 - 9. "Project Site": Space available for performing construction activities. The extent of Project site is shown on Drawings and may or may not be identical with the description of the land on which Project is to be built.

1.2 INDUSTRY STANDARDS

- A. Applicability of Standards: Unless the Contract Documents include more stringent requirements, applicable construction industry standards have the same force and effect as if bound or copied directly into the Contract Documents to the extent referenced. Such standards are made a part of the Contract Documents by reference.
- B. Publication Dates: Comply with standards in effect as of date of the Contract Documents unless otherwise indicated.
- C. Copies of Standards: Each entity engaged in construction on Project must be familiar with industry standards applicable to its construction activity. Copies of applicable standards are not bound with the Contract Documents.

Where copies of standards are needed to perform a required construction activity, obtain

copies directly from publication source.

- D. Abbreviations and Acronyms for Standards and Regulations: Where abbreviations and acronyms are used in Specifications or other Contract Documents, they shall mean the recognized name of the organizations responsible for the standards and regulations in the following list.

ADAAG	Americans with Disabilities Act (ADA)
	Architectural Barriers Act (ABA)
CFR	Code of Federal Regulations
DOD	Department of Defense Military Specifications and Standards
DSCC	Defense Supply Center Columbus (See FS)
FED-STD	Federal Standard (See FS)
FS	Federal Specification
FTMS	Federal Test Method Standard (See FS)
MIL	(See MILSPEC)
MIL-STD	(See MILSPEC)
MILSPEC	Military Specification and Standards
UFAS	Uniform Federal Accessibility Standards

1.3 ABBREVIATIONS AND ACRONYMS

- A. Industry Organizations: Where abbreviations and acronyms are used in Specifications or other Contract Documents, they shall mean the recognized name of the entities in the following list.

AA	Aluminum Association, Inc. (The)
AAADM	American Association of Automatic Door Manufacturers
AAMA	American Architectural Manufacturers Association
AASHTO	American Association of State Highway and Transportation Officials
ABMA	American Bearing Manufacturers Association
ACI	ACI International (American Concrete Institute)
ACPA	American Concrete Pipe Association
AEIC	Association of Edison Illuminating Companies, Inc. (The)
AGA	American Gas Association
AGC	Associated General Contractors of America (The)
AI	Asphalt Institute
AIA	American Institute of Architects (The)
AISC	American Institute of Steel Construction
AISI	American Iron and Steel Institute
AITC	American Institute of Timber Construction
ALCA	Associated Landscape Contractors of America (Now PLANET - Professional Landcare Network)
ALSC	American Lumber Standard Committee, Incorporated
AMCA	Air Movement & Control Association International, Inc.
ANSI	American National Standards Institute
APA	Architectural Precast Association

API	American Petroleum Institute
ARI	Air-Conditioning & Refrigeration Institute
ARMA	Asphalt Roofing Manufacturers Association
ASCE	American Society of Civil Engineers
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
ASME	ASME International
ASSE	American Society of Sanitary Engineering
ASTM	ASTM International (American Society for Testing and Materials International)
AWI	Architectural Woodwork Institute
AWPA	American Wood-Preservers' Association
AWS	American Welding Society
AWWA	American Water Works Association
BHMA	Builders Hardware Manufacturers Association
BIA	Brick Industry Association (The)
CGA	Compressed Gas Association
CISPI	Cast Iron Soil Pipe Institute
CLFMI	Chain Link Fence Manufacturers Institute
CPA	Composite Panel Association
CPPA	Corrugated Polyethylene Pipe Association
CRSI	Concrete Reinforcing Steel Institute
CSI	Cast Stone Institute
CSI	Construction Specifications Institute (The)
DHI	Door and Hardware Institute
DMS	Departmental Material Specifications, TxDOT
EIA	Electronic Industries Alliance
EJCDC	Engineers Joint Contract Documents Committee
EJMA	Expansion Joint Manufacturers Association, Inc.
FMG	FM Global (Formerly: FM - Factory Mutual System)
FMRC	Factory Mutual Research (Now FMG)
HI	Hydraulic Institute
HMMA	Hollow Metal Manufacturers Association (Part of NAAMM)
HPVA	Hardwood Plywood & Veneer Association
ICEA	Insulated Cable Engineers Association, Inc.
IEEE	Institute of Electrical and Electronics Engineers, Inc. (The)
IESNA	Illuminating Engineering Society of North America
IENT	Institute of Environmental Sciences and Technology
IGCC	Insulating Glass Certification Council
IGMA	Insulating Glass Manufacturers Alliance
ISO	International Organization of Standardization
LPI	Lightning Protection Institute
MBMA	Metal Building Manufacturers Association
MFMA	Metal Framing Manufacturers Association
MHIA	Material Handling Industry of America

MSS	Manufacturers Standardization Society of The Valve and Fittings Industry Inc.
NAAMM	National Association of Architectural Metal Manufacturers
NACE	NACE International (National Association of Corrosion Engineers International)
NRCA	National Roofing Contractors Association
NECA	National Electrical Contractors Association
NEMA	National Electrical Manufacturers Association
NETA	InterNational Electrical Testing Association
NFPA	National Fire Protection Association
NGA	National Glass Association
NHLA	National Hardwood Lumber Association
NSF	NSF International (National Sanitation Foundation International)
NWWDA	National Wood Window and Door Association (Now WDMA)
PCI	Precast/Prestressed Concrete Institute
PDCA	Painting & Decorating Contractors of America
PDI	Plumbing & Drainage Institute
PGI	PVC Geomembrane Institute
PLANET	Professional Landcare Network (Formerly: ACLA - Associated Landscape Contractors of America)
PTI	Post-Tensioning Institute
RCSC	Research Council on Structural Connections
SAE	SAE International (Society of Automotive Engineers)
SDI	Steel Deck Institute
SDI	Steel Door Institute
SIGMA	Sealed Insulating Glass Manufacturers Association (Now IGMA)
SJI	Steel Joist Institute
SMACNA	Sheet Metal and Air Conditioning Contractors' National Association
SSINA	Specialty Steel Industry of North America
SSPC	SSPC: The Society for Protective Coatings
STI	Steel Tank Institute
UL	Underwriters Laboratories Inc.
UNI	Uni-Bell PVC Pipe Association
WASTEC	Waste Equipment Technology Association
WDMA	Window & Door Manufacturers Association (Formerly: NWWDA - National Wood Window and Door Association)

- B. Code Agencies: Where abbreviations and acronyms are used in Specifications or other Contract Documents, they shall mean the recognized name of the entities in the following list.

BOCA	BOCA International, Inc. (See ICC)
IAPMO	International Association of Plumbing and Mechanical Officials

ICBO	International Conference of Building Officials (See ICC)
ICBO ES	ICBO Evaluation Service, Inc. (See ICC-ES)
ICC	International Code Council
ICC-ES	ICC Evaluation Service, Inc.
SBCCI	Southern Building Code Congress International, Inc. (See ICC)

- C. Federal Government Agencies: Where abbreviations and acronyms are used in Specifications or other Contract Documents, they shall mean the recognized name of the entities in the following list.

CE	Army Corps of Engineers
CPSC	Consumer Product Safety Commission
DOC	Department of Commerce
DOD	Department of Defense
DOE	Department of Energy
EPA	Environmental Protection Agency
FAA	Federal Aviation Administration
FCC	Federal Communications Commission
FDA	Food and Drug Administration
GSA	General Services Administration
HUD	Department of Housing and Urban Development
NCHRP	National Cooperative Highway Research Program (See TRB)
NIST	National Institute of Standards and Technology
OSHA	Occupational Safety & Health Administration
PBS	Public Building Service (See GSA)
PHS	Office of Public Health and Science
RUS	Rural Utilities Service (See USDA)
SD	State Department
TRB	Transportation Research Board
USDA	Department of Agriculture
USPS	United States Postal Service

- D. State Government and Regional Agencies: Where abbreviations and acronyms are used in Specifications or other Contract Documents, they shall mean the recognized name of the entities in the applicable state or location. Names, telephone numbers, and websites are subject to change and are believed to be accurate and up-to-date as of the date of the Contract Documents.

CDPHE	Colorado Department of Public Health and Environment
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PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION

SECTION 01 43 33
MANUFACTURERS' FIELD SERVICES

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes the requirements for the qualifications, services, training, installation assistance, and related Work required for manufacturers' services.

1.2 REFERENCES

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 1 Specification Sections, apply to this Section.
- B. Related Sections include the following:
 - 1. Section 01 31 26 Electronic Communication Protocols.
 - 2. Section 01 32 16 Construction Progress Schedule.
 - 3. Section 01 33 00 Submittal Procedures.
 - 4. Section 01 70 00 Execution Requirements.
 - 5. Section 01 75 00 Equipment Testing and Startup.
 - 6. Section 01 77 00 Closeout Requirements.
 - 7. Section 01 78 36 Warranties.
 - 8. Section 01 79 00 Demonstration and Testing.
 - 9. All other Contract Documents for additional requirements.
- C. Definitions
 - 1. Person-Day: One person for 8 hours within regular CONTRACTOR working hours.
 - 2. Manufacturer: Entity which furnishes a single piece of equipment or an equipment system to be installed by the Contractor or a Subcontractor.
 - 3. Supplier: Entity which furnished a complete system comprised of more than one interfacing component, to be installed by the Contractor or a Subcontractor.

1.3 SUBMITTALS

- A. Training Schedule: Submit proposed training schedule not less than 21 days prior to start of equipment installation.
- B. Lesson Plan: Submit proposed lesson plan not less than 21 days prior to scheduled training session.
- C. Representative: Submit the resume of the authorized representative with lesson plan.
- D. Video Session: Submit recorded training sessions for OWNER'S use not more than 30 days after the equipment startup.

1.4 QUALITY ASSURANCE

- A. Authorized representative of the manufacturer, factory trained, and experienced in the technical applications, operation, and maintenance of respective equipment, subsystem, or system, with full authority by the equipment manufacturer will issue the certifications

required of equipment manufacturer. Additional qualifications may be specified in the individual Sections.

- B. Representative will be subject to acceptance by ENGINEER and OWNER. No substitute representative will be allowed unless prior written approval has been given by OWNER and ENGINEER.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 MANUFACTURERS' SERVICES

- A. Furnish minimum manufacturers' services, when required by the Contract Documents, to comply with the requirements of this Section.
 - 1. When required by the Contract Documents, manufacturer's services apply to both the Manufacturer and/or Supplier, depending on the application.
- B. Where time is necessary in excess of that stated in the Section for manufacturers' services, or when a minimum time is not specified, the time required to perform the specified services shall be considered incidental.
- C. Schedule manufacturers' services to avoid conflict with other onsite testing, other manufacturers' onsite services, or OWNER's schedule requirements.
- D. Determine, before scheduling manufacturers' services that all conditions necessary to allow successful completion of the services have been met, in compliance with Specifications and Contract Documents.
- E. Only those days of service approved by ENGINEER will be credited to fulfill the specified minimum service.
- F. When specified by the Contract Documents, manufacturer's onsite services shall include:
 - 1. Assistance during product (system, subsystem, or component) installation to include observation, guidance, and instruction of CONTRACTOR'S personnel during the assembly, erection, installation, or application Work.
 - 2. Inspection, checking, and adjustments as required for product (system, subsystem, or component) to function as warranted by manufacturer and required to provide Manufacturer's Certificate of Installation.
 - 3. Copies of manufacturer's representative field notes and data to ENGINEER, provided daily.
 - 4. Site visits as required to correct problems and until installation and operation are acceptable to ENGINEER.
 - 5. Resolution of assembly or installation problems attributable to, or associated with, respective manufacturer's products and systems.
 - 6. Assistance during functional and performance testing, facility start-up, evaluation, and commissioning.
 - 7. Training of OWNER'S personnel in the operation and maintenance of the product as required for product to function as designed and specified.
 - 8. Additional requirements may be specified in applicable Section(s).

3.2 MANUFACTURER'S CERTIFICATE OF COMPLIANCE

- A. When specified in the Contract Documents, provide a Manufacturer's Certificate of Compliance, completed, and signed by the entity supplying the product, material, or service prior to shipment. A copy of the Certificate template is attached to this Section.
- B. ENGINEER may permit use of certain products, materials, or service prior to sampling and testing if accompanied by an accepted Certificate of Compliance.
- C. The Certificate shall certify the product, material, or service complies with the Contract Documents, including attached supporting documentation as necessary to confirm compliance. This information may reflect previous test results on the product, material, or services.

3.3 MANUFACTURER'S CERTIFICATE OF INSTALLATION

- A. When specified in the Contract Documents, provide a Manufacturer's Certificate of Proper Installation, completed, and signed by the manufacturer's representative. A copy of the Certificate template is attached to this Section.
- B. The Certificate shall certify the signing party is a duly authorized representative of the manufacturer, is empowered by the manufacturer to inspect, approve the installation, operate their equipment, and make recommendations required to ensure the equipment installation is complete and operational.

3.4 EQUIPMENT TESTING AND STARTUP

- A. Provide manufacturers' representative to assist CONTRACTOR for the specified product (system, subsystem, and component) in accordance with Section 01 79 00 Demonstration and Testing.

3.5 TRAINING

- A. Provide manufacturers' representative for detailed classroom and hands-on training to OWNER'S personnel on the operation and maintenance of specified product (system, subsystem, and component). Refer to Section 01 79 00 Demonstration and Testing for additional requirements. All training sessions will be video recorded for the OWNER'S use.
- B. Furnish trained, articulate personnel to coordinate and expedite training, to be present during training coordination meetings with OWNER and familiar with required operation and maintenance information submitted in accordance with Section 01 78 23 Operation and Maintenance Data.
- C. Furnish training materials, which will be retained by the trainee.

3.6 SUPPLEMENTS

- A. The following forms located after "END OF SECTION" are part of this Section:
 - 1. Form: Manufacturer's Certificate of Compliance.
 - 2. Form: Manufacturer's Certificate of Installation.

END OF SECTION

MANUFACTURER'S CERTIFICATE OF COMPLIANCE

OWNER: _____

PRODUCT, MATERIAL OR SERVICE: _____

PROJECT NAME: _____

Comments: _____

I hereby certify that the above-referenced product, material, or service called for by the Contract for the named Project has been furnished in accordance with all applicable requirements. I further certify that the product, material, or service is of the quality specified and conform in all respects with the Contract Documents, and of the quantity shown.

Date of Execution:

Manufacturer:

Manufacturer's Authorized Agent (Print): _____

(Authorized Signature)

Attachments: Add comments on separate sheets as applicable.

MANUFACTURER'S CERTIFICATE OF INSTALLATION

Owner: _____ Serial No.: _____

Tag No.: _____ System: _____

Project No.: _____ Spec. Section: _____

I hereby certify the above referenced equipment/system has been:

(Check Applicable)

- ☐ Installed in accordance with manufacturer's recommendations.
- ☐ Inspected, checked, and adjusted.
- ☐ Serviced with proper lubricants.
- ☐ Electrical and mechanical connections meet quality and safety requirements.
- ☐ All applicable safety equipment has been properly installed.
- ☐ Functional test completed.
- ☐ System has been performance tested, and meets or exceeds specified performance requirements. (When complete system furnished by single manufacturer)

Date of Execution: _____

Manufacturer: _____

Manufacturer's Authorized Agent (Print): _____

(Authorized Signature)

Attachments: Add comments on separate sheets as applicable.

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SECTION 01 50 00
TEMPORARY FACILITIES AND CONTROLS

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes requirements for temporary utilities, support facilities, and security and protection facilities. The Section also includes provisions for the Project sign, plant operation during construction and plant shutdowns, and other Work.

1.2 REFERENCES

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 1 Specification Sections, apply to this Section.
- B. Definitions
 - 1. Permanent Enclosure: as determined by ENGINEER, permanent or temporary roofing is complete, insulated, and weathertight; exterior walls are insulated and weathertight; and all openings are closed with permanent construction or substantial temporary closures.
- C. Related Sections include the following:
 - 1. Section 01 12 16 Sequence of Construction.
 - 2. Section 01 31 26 Electronic Communication Protocols.
 - 3. Section 01 33 00 Submittal Procedures.
 - 4. Section 01 70 00 Execution Requirements.
 - 5. Section 01 77 00 Closeout Procedures.
 - 6. Section 01 79 00 Demonstration and Testing.
 - 7. Divisions 2 through 49 Sections for temporary heat, ventilation, and humidity requirements for products in those Sections.

1.3 USE CHARGES

- A. General: Cost or use charges for temporary facilities shall be included in the Contract Sum. Allow other entities to use temporary services and facilities without cost, including but not limited to Owner's construction forces, ENGINEER, testing agencies, and authorities having jurisdiction.
- B. Electric Power Service: Electric power shall be obtained by CONTRACTOR, with CONTRACTOR responsible for obtaining meter and paying for installation charges. OWNER will pay for usage. CONTRACTOR will provide connections and extensions of services as required for construction operations.
- C. Potable Water Service: CONTRACTOR shall be responsible for obtaining a meter from the OWNER (or the OWNER's designated water service provider if not the same entity as the OWNER) and providing potable water service to construction trailers and other temporary locations. OWNER will pay for potable water usage.

1.4 SUBMITTALS

- A. Site Plan: Show temporary facilities, utility hookups, staging areas, and parking areas for

construction personnel and ENGINEER's representative.

1.5 QUALITY ASSURANCE

- A. Electric Service: Comply with NECA, NEMA, and UL standards and regulations for temporary electric service. Install service to comply with NFPA 70.
- B. Tests and Inspections: Arrange for authorities having jurisdiction to test and inspect each temporary utility before use. Obtain certifications and permits required by applicable federal, state, and local rules and regulations.

1.6 PROJECT CONDITIONS

- A. Temporary Use of Permanent Facilities: Installer of each permanent service shall assume responsibility for operation, maintenance, and protection of each permanent service during its use as a construction facility before OWNER'S acceptance, regardless of previously assigned responsibilities.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Portable Chain-Link Fencing: Minimum 2-inch, 9-gauge, galvanized steel, chain-link fabric fencing; minimum 8 feet high with galvanized steel pipe posts; minimum 2-3/8-inch-Outside Diameter (OD) line posts and 2-7/8-inch- OD corner and pull posts, with 1-5/8-inch- OD top and bottom rails.

2.2 TEMPORARY FACILITIES

- A. Field Offices, General: prefabricated or mobile units with serviceable finishes, temperature controls, foundations adequate for normal loading, having insulated double walls, ceiling, and floors.
- B. Storage and Fabrication Sheds: Provide sheds sized, furnished, and equipped to accommodate materials and equipment for construction operations.
- C. First Aid Facilities: Provide a first aid station in CONTRACTOR'S field office. Provide full complement of first aid supplies in weatherproof container at first aid station.

2.3 EQUIPMENT

- A. Fire Protection:
 - 1. Furnish and maintain onsite adequate firefighting equipment capable of extinguishing incipient fires. UL rated; with class and extinguishing agent as required by locations and classes of fire exposures. Comply with applicable parts of National Fire Protection Standard for Safeguarding Building Construction Operations (NFPA No. 241).
 - 2. Provide portable fire extinguishers, rated 2A minimum, at CONTRACTOR's and ENGINEER's field office, and at storage sheds.
 - 3. Locate internal combustion engine powered equipment a safe distance from combustible materials.
 - 4. Prohibit smoking in locations and operations of potential fire hazard, and clearly post "No Smoking" or "Open Flame" signs to correctly represent hazards.

- B. Flammable Material Storage: Store flammable/combustible liquids in conformance with requirements of federal, state, and local codes and regulations, and prohibit storage of flammable/combustible liquids near exits, stairways or common passageways. Provide approved metal safety containers for storage of flammable/combustible liquids in excess of 1 gallon.

2.4 PROJECT SIGN

- A. Provide and maintain one Project identification sign at location designated by ENGINEER. Sign shall be 8 feet wide by 4 feet high, constructed of ¾ inch exterior, high-density, overlaid plywood. Sign shall bear the name of Project, OWNER, ENGINEER, CONTRACTOR, and other participating agencies. Lettering shall be blue applied on a white background by an experienced sign painter. Paint shall be exterior grade enamel. Information to be included shall be provided by ENGINEER or OWNER. If the project is supported by a funding agency, defer to the agency's sign requirements.

2.5 TEMPORARY FACILITY SERVICES

- A. CONTRACTOR shall provide disposable facility services for treatment plant between substantial completion and final completion and shall budget a minimum of three months for this service. Temporary facility services includes replacement of toilet paper, hand soap, paper towels; emptying trash cans; and cleaning restroom, shower, and operations room.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

- A. Locate facilities where they will serve Project adequately and result in minimum interference with performance of the Work. Relocate and modify facilities as required by progress of the Work.
- B. Provide each facility ready for use when needed to avoid delay. Do not remove until facilities are no longer needed or are replaced by authorized use of completed permanent facilities.

3.2 TEMPORARY UTILITY INSTALLATION

- A. General: Install temporary service.
- B. Sewers and Drainage: Provide temporary utilities to remove effluent lawfully.
- C. Water Service: Install water service and distribution piping in sizes and pressures adequate for construction and in accordance with local rules and regulations.
- D. Sanitary Facilities: Provide temporary toilets, wash facilities, and drinking water for use of construction personnel. Comply with authorities having jurisdiction for type, number, location, operation, and maintenance of fixtures and facilities.
- E. Heating: Provide temporary heating required by construction activities for curing or drying of completed installations or for protecting installed construction from adverse effects of low temperatures or high humidity. Select equipment that will not have a harmful effect on completed installations or elements being installed.
- F. Ventilation and Humidity Control: Provide temporary ventilation required by construction activities for curing or drying of completed installations or for protecting installed

construction from adverse effects of high humidity. Select equipment that will not have a harmful effect on completed installations or elements being installed. Coordinate ventilation requirements to produce ambient condition required and minimize energy consumption.

- G. Electric Power Service: Provide electric power service and distribution system of sufficient size, capacity, and power characteristics required for construction operations.
- H. Lighting: Provide temporary lighting with local switching that provides adequate illumination for construction operations, observations, inspections, and traffic conditions.
- I. Telephone Service: Provide temporary telephone service in common-use facilities for use by all construction personnel. Provide a directory at each telephone, listing the name and business telephone number of:
 - 1. CONTRACTOR and all subcontractors employed at work site.
 - 2. ENGINEER's Representatives.
 - 3. Medical Services; physicians, hospitals, and ambulance service companies.
 - 4. Emergency numbers of all utilities.
 - 5. Local police and/or sheriff.
 - 6. Fire Departments.
- J. Electronic Communication Service: Provide temporary electronic communication service, including electronic mail in field offices.

3.3 FACILITY OPERATIONS DURING CONSTRUCTION AND FACILITY SHUTDOWNS

- A. The following stipulations shall apply to the construction on this Project.
 - 1. The ability of the facility to meet treatment requirements is critical and will take priority over shutdown of facilities. All shutdowns of any facilities must be coordinated with the ENGINEER or the OWNER. The CONTRACTOR shall request permission from the ENGINEER or OWNER to take existing equipment, structures, roadways, pipelines and electrical and instrumentation facilities out of service at least twenty one (21) days prior to the requested date. A pre-shutdown meeting shall be conducted at least 14 days prior to shutdown and should include the OWNER, ENGINEER, and CONTRACTOR. Meetings shall be in accordance with Section 01 31 00 "Project Management and Coordination."
 - 2. The shutdown request must include the proposed date; the proposed time for initiating the shutdown; the proposed time for returning the item back to service; a description of the item to be taken out of service; the purpose of the shutdown; and any other information which may be needed by the ENGINEER and OWNER to evaluate the request.
 - 3. The shutdown request must be repeated three (3) days prior to the requested date. The CONTRACTOR shall not initiate the shutdown until approval is granted. The OWNER reserves the right to choose a range of times during the day or night for the shutdown.
 - 4. Under no circumstances will the CONTRACTOR be permitted to by-pass processes necessary for treatment to achieve potable water
 - 5. Contaminated water from basin draining, dewatering operations and excavations

must be recycled into the facility at locations designated by the OWNER or ENGINEER and at a flow rate acceptable to the OWNER or ENGINEER.

6. Contaminated or turbid water cannot be pumped into the streets, storm drainage system, or any stream. The CONTRACTOR must obtain the OWNER'S approval for his proposed method to discharge into the facility's system. Process facilities must be accessible to operations personnel at all times once operation begins. For these reasons, although approval for a shutdown may be granted, operating conditions of the facility may require that the shutdown be canceled at short notice, or that the time allowed for the shutdown be reduced. No additional compensation will be made to the CONTRACTOR for these unavoidable changes in the schedule.
7. It may be necessary, during the course of construction, to make several temporary connections to the existing facilities such as pipelines, structures or process equipment. All Work involved in making connections, which will require that existing facilities be taken out of service, shall be carefully planned and coordinated with both the ENGINEER and the OWNER to permit "down time" of the existing facilities be held to a minimum. On occasions when more than one parallel existing facility (basin, pump, pipeline, etc.) must be taken out of service, Work shall proceed on a 24-hour schedule approved by the OWNER until the additional facilities are back in operation.

3.4 FIELD OFFICES AND SUPPORT FACILITIES

- A. General Requirements: Provide incombustible construction for offices, shops, and sheds located within construction area or within 30 feet of building lines. Comply with NFPA 241.
- B. ENGINEER's Representative Field Office: **NOT USED**
- C. Contractor Field Office: furnish, equip, and maintain a field office at the plant site for CONTRACTOR's use. The CONTRACTOR's field office shall have weather-tight construction, doors with locks and convenience outlets, air conditioning, ventilation and heating, electric lighting, and telephones.
- D. Storage Sheds: provide storage sheds for products in conformance with the General Conditions. The storage sheds shall have weather-tight construction, sufficient space to provide for inspection, electric lighting, heating, ventilation and air conditioning as required to comply with the General Conditions, and.
- E. Equipment and Material Storage: properly store and protect Project equipment delivered to the job site until installation in accordance with manufacturer's recommendations. Motor space heaters shall be connected, shafts rotated, and otherwise installed as required to meet Project specifications. All equipment shall be stored on skids or blocking, off the ground.
- F. Temporary Roads and Paved Areas: Construct and maintain temporary roads and paved areas adequate for construction operations and access to field offices. When possible, locate temporary roads and paved areas in the same location as permanent roads and paved areas. Extend temporary roads and paved areas, within construction limits indicated, as necessary for construction operations and approved by OWNER.
 1. Coordinate elevations of temporary roads and paved areas with permanent roads and paved areas.
 2. Prepare subgrade and install subbase and base for temporary roads and paved areas

according to Section 31 20 00 "Earthwork."

3. Recondition base after temporary use, including removing contaminated material, regrading, proof-rolling, compacting, and testing.
 4. Provide dust-control treatment that is nonpolluting and nontracking. Reapply treatment as required to minimize dust.
- G. Traffic Controls: Comply with requirements of authorities having jurisdiction.
1. Protect existing site improvements to remain including curbs, pavement, and utilities.
 2. Maintain access for fire-fighting equipment and to fire hydrants.
 3. Control construction traffic to minimize impact of normal plant traffic.
 4. Repair damage to plant and public roadways resulting from construction.
 5. Provide signs warning of a construction site entrance.
 6. Provide flagman when excessive construction traffic is expected.
- H. Parking: provide temporary parking areas for construction personnel in accordance with contract documents. Place sign to clearly label construction personnel parking areas.
- I. Dewatering Facilities and Drains: comply with requirements of authorities having jurisdiction. Maintain Project site, excavations, and construction free of water.
1. Dispose of rainwater in a lawful manner that will not result in flooding Project or adjoining properties nor endanger permanent Work or temporary facilities.
 2. Remove snow and ice as required to minimize accumulations and maintain safe work conditions.
- J. Project Identification and Temporary Signs: Provide Project identification and other signs. Obtain OWNER's approval of signs, and install where indicated to inform public and individuals seeking entrance to Project. Unauthorized signs are not permitted.
1. Provide temporary, directional signs for construction personnel and visitors.
 2. Maintain and touch up signs so that they are legible at all times.
- K. Waste Disposal Facilities: provide waste-collection containers in sizes adequate to handle waste from construction operations. Comply with requirements of authorities having jurisdiction. Comply with Section 01 70 00 "Execution Requirements" for progress cleaning requirements.

3.5 SECURITY AND PROTECTION FACILITIES INSTALLATION

- A. Environmental Protection: Provide protection, operate temporary facilities, and conduct construction in ways and by methods that comply with environmental regulations and that minimize possible air, waterway, and subsoil contamination or pollution or other undesirable effects.
- B. Temporary Erosion and Sedimentation Control: Provide measures to prevent soil erosion and discharge of soil-bearing water runoff and airborne dust to adjacent properties and walkways, according to requirements of authorities having jurisdiction.
- C. Stormwater Control: Comply with authorities having jurisdiction, including application for and posting of required permits. Provide barriers in and around excavations and subgrade construction to prevent flooding by runoff of stormwater from heavy rains. Perform regular inspections as required by federal, state, and local permits and regulations.

- D. Tree and Plant Protection: Install temporary fencing located as indicated or outside the drip line of trees to protect vegetation from damage from construction operations. Protect tree root systems from damage, flooding, and erosion.
- E. Pest Control: Engage pest-control service to recommend practices to minimize attraction and proliferation of rodents, roaches, and other pests and to perform extermination and control procedures at regular intervals so Project will be free of pests and their residues at Substantial Completion. Obtain extended warranty for OWNER. Perform control operations lawfully, using environmentally safe materials.
- F. Site Enclosure Fence: Before construction operations begin, furnish and install site enclosure fence to prevent people and animals from easily entering site except as authorized by entrance gates.
 - 1. Extent of Fence: as required to enclose entire Project site or portion determined sufficient to accommodate construction operations.
 - 2. Fence shall be a temporary chain link fence 8 feet tall.
 - 3. Maintain security by limiting number of keys, restricting distribution to authorized personnel and maintaining up-to-date log of key recipients. Provide Resident Project Representative with one set of keys.
- G. Security Enclosure and Lockup: Install substantial temporary enclosure around partially completed areas of construction. Provide lockable entrances to prevent unauthorized entrance, vandalism, theft, and similar violations of security.
- H. Barricades, Warning Signs, and Lights: Comply with requirements of authorities having jurisdiction for erecting structurally adequate barricades, including warning signs and lighting.
- I. Temporary Enclosures: Provide temporary enclosures for protection of construction, in progress and completed, from exposure, foul weather, other construction operations, and similar activities.

3.6 PROTECTION OF EXISTING STRUCTURES AND UTILITIES

- A. Where excavation or demolition endangers adjacent structures (including fences) and utilities, the CONTRACTOR shall at his own expense carefully support and protect all such structures and/or utilities to prevent failure or settlement. Where it is necessary to move services, poles, guy wires, pipelines or other obstructions, the CONTRACTOR shall notify and cooperate with the utility owner.
- B. In case damage to an existing structure or utility occurs, whether failure or settlement, the CONTRACTOR shall restore the structure or utility to its original condition and position without compensation from the OWNER. The CONTRACTOR shall protect any plant equipment in construction areas, which remain in service during construction.
- C. CONTRACTOR shall repair or replace all damaged street surfaces, driveways, sidewalks, curb and gutter, fences, drainage structures, or other structures, to the satisfaction of the ENGINEER and the OWNER. Structures shall be restored to a condition equal to or better than the original condition and of a similar material and design. The costs of such repair or replacement shall be borne by the CONTRACTOR and shall be included in the Proposal.
- D. The Plans show the locations of all known surface and subsurface structures and utilities.

However, the OWNER and the ENGINEER assume no responsibility for failure to show any or all of these structures or utilities on the Plans, or to show them in their exact locations. It is mutually agreed that such failure shall not be considered sufficient basis for claims for additional compensation for extra Work or for increasing the pay quantities in any manner whatsoever, unless the obstruction encountered is such as to necessitate changes in the lines or grades, or require the building of special Work, provisions for which are not made in the Plans and Proposal, in which case the provisions in these Specifications for extra Work shall apply.

- E. It is anticipated that some utilities exist which are not shown on the Plans. The CONTRACTOR, prior to ordering material and beginning Work, shall make an independent survey to locate and identify the type and size of all existing piping and valves in the construction area, using hand excavation if necessary.
- F. The CONTRACTOR shall keep an accurate record of the location, depth, size, type of material, and type of service of all underground utilities encountered during construction. All piping, valves, electrical and other conduits in the construction area shall be protected as necessary, in a manner acceptable to the ENGINEER or CONSTRUCTION MANAGER. No additional compensation will be considered for the protection of any of these items whether shown on the Plans or not.
- G. No claims for delays will be considered as a result of encountering obstructions or conflicts not shown on the Plans. It is the sole responsibility of the CONTRACTOR to confirm the location of all subsurface piping, electrical conduits, and all utilities which affect the safe execution of Work prior to ordering materials or beginning Work.

3.7 OPERATION, TERMINATION, AND REMOVAL

- A. Supervision: Enforce strict discipline in use of temporary facilities. To minimize waste and abuse, limit availability of temporary facilities to essential and intended uses only.
- B. Maintenance: Maintain temporary facilities in good operating condition until removal.
- C. Temporary Facility Changeover: Do not change from using temporary security and protection facilities to permanent facilities until Substantial Completion is approved by OWNER.
- D. Termination and Removal: Remove each temporary facility when need for its service has ended, when it has been replaced by authorized use of a permanent facility, or no later than Substantial Completion. Complete or, if necessary, restore permanent construction that may have been interrupted because of interference from temporary facility. Repair damaged Work, clean exposed surfaces, and replace construction that cannot be satisfactorily repaired.
 - 1. Materials and facilities that constitute temporary facilities are property of CONTRACTOR, except as noted elsewhere. OWNER reserves right to take possession of Project identification signs.
 - 2. At Substantial Completion, clean and renovate permanent facilities used during construction period. Comply with final cleaning requirements specified in Section 01 77 00 "Closeout Procedures."

3.8 DUST CONTROL

- A. The CONTRACTOR shall be responsible for eliminating and/or alleviating dust resulting from his construction operations. This is particularly applicable to dust which results from vehicular traffic traveling along or through areas where construction has resulted in dirt or dust being left on roadways. The CONTRACTOR shall sprinkle water or use other dust control methods which will reduce dust to a minimum. The OWNER may request additional dust control sprinkling at any time as deemed necessary. Dust control will be considered subsidiary to construction and no separate measurement and payment will be made.

3.9 DEWATERING AND WASH DOWN OF EXISTING TREATMENT UNITS

- A. Where the CONTRACTOR is required to modify existing treatment units the OWNER will be responsible for dewatering and washing down existing treatment units prior to the CONTRACTOR beginning Work. Washing down basins and tanks is not the same as cleaning and or disinfecting. CONTRACTOR shall take appropriate precautions to protect his staff and the subcontractors staff from exposure to materials or surfaces that may include hazardous materials and/or pathogens. CONTRACTOR shall provide 30 days written notice prior to needing access to basins that must be dewatered and washed down.

END OF SECTION

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SECTION 01 60 00
PRODUCT REQUIREMENTS

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes administrative and procedural requirements for selection of products for use in Project; product delivery, storage, and handling; product substitutions; and comparable products.

1.2 REFERENCES

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 1 Specification Sections, apply to this Section.
- B. Related Sections include the following:
 - 1. Section 01 33 00 Submittal Procedures.
 - 2. Section 01 43 33 Manufacturers' Field Services.
 - 3. Section 01 70 00 Execution Requirements.
 - 4. Section 01 75 00 Equipment Testing and Startup.
 - 5. Section 01 77 00 Closeout Requirements.
 - 6. Section 01 78 36 Warranties.
 - 7. All other Contract Documents for specific requirements for warranties on products and installations specified to be warranted.
- C. Definitions
 - 1. Products: Items purchased for incorporating into the Work, whether purchased for Project or taken from previously purchased stock. The term "product" includes the terms "material," "equipment," "system," and terms of similar intent.
 - a. Named Products: Items identified by manufacturer's product name, including make or model number or other designation shown or listed in manufacturer's published product literature, which is current as of date of the Contract Documents.
 - b. New Products: Items that have not previously been incorporated into another project or facility, except that products consisting of recycled-content materials and otherwise meeting specifications are allowed, unless explicitly stated otherwise. Products salvaged or recycled from other projects without refurbishment are not considered new products and are not allowed.
 - c. Comparable Product: Product that is demonstrated and approved through submittal process, or where indicated as a product substitution, to have the indicated qualities related to type, function, dimension, in-service performance, physical properties, appearance, and other characteristics that equal or exceed those of specified product.
 - 2. Substitutions: Changes in products, materials, equipment, and methods of construction from those required by the Contract Documents and proposed by Contractor.
 - 3. Basis-of-Design Product Specification: Where a specific manufacturer's product is

named and accompanied by the words "basis of design," including make or model number or other designation, to establish the significant qualities related to type, function, dimension, in-service performance, physical properties, appearance, and other characteristics for purposes of evaluating comparable products of other named manufacturers.

1.3 ADMINISTRATIVE REQUIREMENTS – NOT USED

1.4 SUBMITTALS

- A. Material and Equipment List. Within 30 days after Notice to Proceed, submit a complete list of major products proposed for the Project, with the name of the manufacturer and the installing entity.
- B. Substitution Requests: Submit electronic copy of each request for consideration. Identify product or fabrication or installation method to be replaced. Include Specification Section number and title; Drawing numbers and titles; sufficient information for review by ENGINEER; CONTRACTOR'S certification that proposed substitution complies with requirements in the Contract Documents and is appropriate for applications indicated; and CONTRACTOR'S waiver of rights to additional payment or time that may subsequently become necessary because of failure of proposed substitution to produce indicated results.
 - 1. Substitution Request Form: Use form provided at end of Section.
 - 2. Documentation: Show compliance with requirements for substitutions and the following, as applicable:
 - a. Statement indicating why specified material or product cannot be provided.
 - b. Coordination information, including a list of changes or modifications needed to other parts of the Work and to construction performed by OWNER and separate contractors, which will be necessary to accommodate proposed substitution.
 - c. Detailed comparison of significant qualities of proposed substitution with those of the Work specified. Significant qualities may include attributes such as performance, weight, size, durability, visual effect, and specific features and requirements indicated.
 - d. Product Data, including drawings and descriptions of products and fabrication and installation procedures.
 - e. Samples, where applicable or requested.
 - f. List of at least three similar installations for completed projects with project names and addresses and names and addresses of architects, engineers, and owners.
 - g. Material test reports from a qualified testing agency indicating and interpreting test results for compliance with requirements indicated.
 - h. Research/evaluation reports evidencing compliance with building code in effect for Project, from a model code organization acceptable to authorities having jurisdiction.
 - i. Cost information, including a proposal of change, if any, in the Contract Sum.
 - j. CONTRACTOR'S certification that proposed substitution complies with requirements in the Contract Documents and is appropriate for applications indicated.

- k. CONTRACTOR'S waiver of rights to additional payment or time that may subsequently become necessary because of failure of proposed substitution to produce indicated results.
 - 3. ENGINEER Action: If necessary, ENGINEER will request additional information or documentation for evaluation within 7 days of receipt of a request for substitution. ENGINEER will notify CONTRACTOR of acceptance or rejection of proposed substitution within 15 days of receipt of request, or 7 days of receipt of additional information or documentation, whichever is later.
 - a. Form of Acceptance: Change Order or Field Order.
 - b. Use product specified if ENGINEER cannot make a decision on use of a proposed substitution within time allocated.
- C. Comparable Product Requests: Submit electronic copy of each request for consideration. Identify product or fabrication or installation method to be replaced. Include Specification Section number and title and Drawing numbers and titles.
 - 1. ENGINEER Action: If necessary, ENGINEER will request additional information or documentation for evaluation within one week of receipt of a comparable product request. ENGINEER will notify CONTRACTOR of approval or rejection of proposed comparable product request within 15 days of receipt of request, or 7 days of receipt of additional information or documentation, whichever is later.
 - a. Form of Approval: As specified in Section 01 33 00 "Submittal Procedure."
 - b. Use product specified if ENGINEER cannot make a decision on use of a comparable product request within time allocated.
- D. Basis-of-Design Product Specification Submittal: Comply with requirements in Section 01 33 00 " Submittal Procedures." Show compliance with requirements.

1.5 QUALITY ASSURANCE

- A. Compatibility of Options: If CONTRACTOR is given option of selecting between two or more products for use on Project, product selected shall be compatible with products previously selected, even if previously selected products were also options.
- B. Design Requirements: Where CONTRACTOR design is specified; design of installation, systems, equipment, and components, including supports and anchorage, shall be in keeping with provisions of International Building Code by International Code Council. Refer to the drawings for required design load criteria.
- C. Environmental Requirements: Provide products suitable for installation and operation under rated conditions at 650 feet above sea level. Products installed outdoors or in unheated enclosures shall be capable of continuous operation within an ambient temperature range of 10°F to 110°F and air moisture up to 95% relative humidity.
- D. Product installations are defined as equipment furnished for an individual facility installed as part of a single project. Multiple equipment items installed as part of the same project shall not be considered multiple installations. Multiple equipment items installed at the same facility at different times as part of different projects can be considered multiple installations.

1.6 PRODUCT DELIVERY, STORAGE, AND HANDLING

- A. Deliver, store, and handle products using means and methods that will prevent damage, deterioration, and loss, including theft. Comply with manufacturers' written instructions.
- B. Delivery and Handling:
 - 1. Schedule delivery to minimize long-term storage at Project site and to prevent overcrowding or unsafe conditions of construction spaces.
 - 2. Coordinate delivery with installation time to accommodate minimum holding time for items that are flammable, hazardous, easily damaged, or sensitive to deterioration, theft, and other losses.
 - 3. Deliver products to Project site in an undamaged condition in manufacturers' original sealed containers or other packaging systems, complete with labels and instructions for handling, storing, unpacking, protecting, and installing.
 - 4. Inspect products on delivery for compliance with the Contract Documents and confirmation that products are undamaged and properly protected.
- C. Storage:
 - 1. Store products to allow for inspection and measurement of quantity or counting of units.
 - 2. Store materials in a manner that will not endanger Project structure.
 - 3. Store products that are subject to damage by the elements under cover in a weathertight enclosure above ground, with ventilation adequate to prevent condensation.
 - 4. Store cementitious products and materials on elevated platforms.
 - 5. Store foam plastic from exposure to sunlight, except to extent necessary for period of installation and concealment.
 - 6. Comply with product manufacturers' written instructions for temperature, humidity, ventilation, and weather-protection requirements for storage.
 - 7. Protect stored products from damage and liquids from freezing.
 - 8. Off-site storage of materials and equipment when necessary shall be the sole responsibility of the CONTRACTOR.

1.7 SITE CONDITIONS

- A. The equipment, sizes, materials, and arrangements described in this section are based on recommendations by equipment suppliers and shall be considered minimum limits of acceptability. The EQUIPMENT SUPPLIER shall be responsible for design, arrangement, and performance of all equipment supplied under this section.
- B. Environmental Conditions:
 - 1. All equipment including controls and drives specified herein shall be specifically designed to be installed for this service and the environment encountered in this installation, unless noted otherwise.
 - 2. The environment will be moist and corrosive, exhibiting corrosive gases encountered in municipal water treatment plants.
 - 3. All equipment shall be designed and capable of operation outdoors at ambient

temperatures of 10°F to 110°F and air moisture up to 95% relative humidity.

4. Equipment shall be compatible with heat tracing and insulation, which will be furnished and installed by the CONTRACTOR. Equipment SUPPLIERS shall design piping systems with ample clearances and material compatibility to accept required heat tracing and insulation. If additional freeze protection beyond heat tracing and insulation is required, it shall be furnished by the Equipment SUPPLIER. Equipment SUPPLIERS and PRESELECTIONED EQUIPMENT SUPPLIERS shall coordinate with the CONTRACTOR to provide direction on where heat tracing is required and shall verify that the CONTRACTOR has provided adequate heat tracing and insulation during startup activities.

1.8 PRODUCT WARRANTIES

- A. Warranties specified in other Sections shall be in addition to, and run concurrent with, other warranties required by the Contract Documents. Manufacturer's disclaimers and limitations on product warranties do not relieve Contractor of obligations under requirements of the Contract Documents.
 1. Manufacturer's Warranty: Preprinted written warranty published by individual manufacturer for a particular product and specifically endorsed by manufacturer to OWNER.
 2. Special Warranty: Written warranty required by or incorporated into the Contract Documents, either to extend time limit provided by manufacturer's warranty or to provide more rights for OWNER.
 3. Refer to Section 01 78 36 Warranties for additional requirements.

PART 2 - PRODUCTS

2.1 PRODUCT SELECTION PROCEDURES

- A. General Product Requirements: Provide products that comply with the Contract Documents, that are undamaged and, unless otherwise indicated, that are new at time of installation.
 1. Provide products complete with accessories, trim, finish, fasteners, and other items needed for a complete installation and indicated use and effect.
 2. Standard Products: If available, and unless custom products or nonstandard options are specified, provide standard products of types that have been produced and used successfully in similar situations on other water treatment projects.
 3. Like items of products furnished and installed shall be end products of one manufacturer and of the same series or family of models to achieve standardization for appearance, operation and maintenance, spare parts and replacement, manufacturer's services, and implement same or similar process instrumentation and control functions.
 4. Provide interchangeable components of the same manufacturer, for similar components, unless otherwise specified.
 5. OWNER reserves the right to limit selection to products with warranties not in conflict with requirements of the Contract Documents.
 6. Where products are accompanied by the term "as selected," ENGINEER will make

selection.

7. Where products are accompanied by the term "match sample," sample to be matched is evaluated by ENGINEER.
 8. Descriptive, performance, and reference standard requirements in the Specifications establish "salient characteristics" of products.
 9. Regulatory Requirements: Coating materials shall meet federal, state, and local requirements limiting the emission of volatile organic compounds, for worker exposure and environmental emissions.
 10. Safety Guards:
 - a. Provide for all belt or chain drives, fan blades, couplings, or other moving or rotary parts. Cover rotating part on all sides. Design for easy installation and removal.
 - b. Use 16-gauge or heavier: galvanized steel, aluminum, coated steel and ½-inch mesh expanded steel.
 - c. For outdoor installations, prevent entrance of rain or dripping water.
 11. Electrical Components: Provide Work in accordance with NFPA 70, National Electrical code, and be labeled by a nationally recognized testing laboratory or other agency acceptable to the authority having jurisdiction.
 12. Equipment Finish:
 - a. Provide manufacturer's standard finish and color, except where specific color is indicted.
 - b. If manufacturer does not have a standard color, provide color as approved by ENGINEER.
 13. Special Tools and Accessories: Provide the OWNER all special tools and accessories required for placing equipment in operation. These include, but are not limited to, adequate oil and grease (as required for first servicing of equipment after field testing), light bulbs, fuses, hydrant wrenches, valve keys, handwheels, chain operators, special tools, and other spare parts required for maintenance.
 14. Lubricant: Provide initial lubricant recommended by manufacturer in sufficient quantity to fill lubricant reservoirs and to replace consumption during testing, start-up, and operation until final acceptance by OWNER.
- B. Fabrication and Manufacture:
1. General Requirements:
 - a. Manufacture parts to U.S.A. standard sizes and gauges.
 - b. Two or more items of the same type shall be identical, by the same manufacturer, and interchangeable.
 - c. Design structural members for anticipated shock and vibratory loads.
 - d. Use 1/4-inch minimum thickness for steel that will be submerged, wholly or partially, during normal operation.
 - e. Modify standard products as necessary to meet performance specifications.
 2. Lubrication System Requirements:
 - a. Require no more than weekly attention during continuous operation.

- b. Convenient and accessible. Oil drains, with bronze or stainless steel valves, and fill-plugs easily accessible from normal operating area or platform. Locate drains to allow convenient collection of oil during changes without removing equipment from its installed position.
- c. Provide constant-level oilers or oil level indicators for oil lubrication systems.
- d. For grease type bearings, which are not easily accessible, provide and install stainless steel tubing; protect and extend tubing to convenient location with suitable grease fitting.

C. Product Selection Procedures:

- 1. Product: Where Specifications name a single product and manufacturer, provide the named product that complies with requirements.
- 2. Manufacturer/Source: Where Specifications name a single manufacturer or source, provide a product by the named manufacturer or source that complies with requirements.
- 3. Products: Where Specifications include a list of names of both products and manufacturers, provide one of the products listed that complies with requirements.
- 4. Manufacturers: Where Specifications include a list of manufacturers' names, provide a product by one of the manufacturers listed that complies with requirements.
- 5. Available Products: Where Specifications include a list of names of both products and manufacturers, provide one of the products listed, or an unnamed product, that complies with requirements. Comply with provisions in Part 2 "Comparable Products" Article for consideration of an unnamed product.
- 6. Available Manufacturers: Where Specifications include a list of manufacturers, provide a product by one of the manufacturers listed, or an unnamed manufacturer, that complies with requirements. Comply with provisions in Part 2 "Comparable Products" Article for consideration of an unnamed product.
- 7. Product Options: Where Specifications indicate that sizes, profiles, and dimensional requirements on Drawings are based on a specific product or system, provide the specified product or system. Comply with provisions in Part 2 "Product Substitutions" Article for consideration of an unnamed product or system.
- 8. Basis-of-Design Product: Where Specifications name a product and include a list of manufacturers, provide the specified product or a comparable product by one of the other named manufacturers. Drawings and Specifications indicate sizes, profiles, dimensions, and other characteristics that are based on the product named. Comply with provisions in Part 2 "Comparable Products" Article for consideration of an unnamed product by the other named manufacturers.
- 9. Visual Matching Specification: Where Specifications require matching an established Sample, select a product that complies with requirements and matches ENGINEER'S sample. ENGINEER'S decision will be final on whether a proposed product matches.
 - a. If no product available within specified category matches and complies with other specified requirements, comply with provisions in Part 2 "Product Substitutions" Article for proposal of product.
- 10. Visual Selection Specification: Where Specifications include the phrase "as selected from manufacturer's colors, patterns, and textures" or a similar phrase, select a

product that complies with other specified requirements.

- a. Standard Range: Where Specifications include the phrase "standard range of colors, patterns, textures" or similar phrase, ENGINEER will select color, pattern, density, or texture from manufacturer's product line that does not include premium items.
- b. Full Range: Where Specifications include the phrase "full range of colors, patterns, textures" or similar phrase, ENGINEER will select color, pattern, density, or texture from manufacturer's product line that includes both standard and premium items.

2.2 PRODUCT SUBSTITUTIONS

- A. Timing: ENGINEER will consider requests for substitution if received within 30 days after the Notice to Proceed. Requests received after that time may be considered or rejected at discretion of ENGINEER.
- B. Conditions: ENGINEER will consider CONTRACTOR'S request for substitution when the following conditions are satisfied. If the following conditions are not satisfied, ENGINEER will return requests without action, except to record noncompliance with these requirements:
 1. Requested substitution offers OWNER a substantial advantage in cost, time, energy conservation, or other considerations, after deducting additional responsibilities OWNER must assume. OWNER'S additional responsibilities may include compensation to ENGINEER for redesign and evaluation services, increased cost of other construction by OWNER, and similar considerations.
 2. Requested substitution does not require extensive revisions to the Contract Documents.
 3. Requested substitution is consistent with the Contract Documents and will produce indicated results.
 4. Substitution request is fully documented and properly submitted.
 5. Requested substitution will not adversely affect CONTRACTOR'S Construction Schedule.
 6. Requested substitution has received necessary approvals of authorities having jurisdiction.
 7. Requested substitution is compatible with other portions of the Work.
 8. Requested substitution has been coordinated with other portions of the Work.
 9. Requested substitution provides specified warranty.

2.3 COMPARABLE PRODUCTS

- A. Conditions: ENGINEER will consider CONTRACTOR'S request for comparable product when the following conditions are satisfied. If the following conditions are not satisfied, ENGINEER will return requests without action, except to record noncompliance with these requirements:
 1. Evidence that the proposed product does not require extensive revisions to the Contract Documents, which it is consistent with the Contract Documents and will produce the indicated results, and that it is compatible with other portions of the

Work.

2. Detailed comparison of significant qualities of proposed product with those named in the Specifications. Significant qualities include attributes such as performance, weight, size, durability, visual effect, and specific features and requirements indicated.
3. Evidence that proposed product provides specified warranty.
4. List of at least three similar installations for completed projects with project names and addresses and names and addresses of architects and owners, if requested.
5. Samples, if requested.

2.4 REUSE OF EXISTING MATERIAL

- A. Except as specifically indicated or specified, materials and equipment removed from existing facilities shall not be used in the completed Work.
- B. For materials and equipment designated for reuse in the Work:
 1. Use special care in removal, handling, storage, and installation to facilitate proper function in the completed Work.
 2. Arrange for transportation, storage and handling of the products when offsite storage, restoration, or renovation. All costs associated with this work are the CONTRACTOR'S responsibility.

2.5 TOOLS, SPARE PARTS AND MAINTENANCE MATERIALS

- A. See applicable sections for specific requirements.
- B. Schedule:
 1. Shipment and delivery occurs timely and safely, consistent with shipment of product.
 2. Transfer to OWNER upon acceptance by CONTRACTOR of shipment.
- C. Packaging and Shipment:
 1. Package and ship items to avoid damage during long term storage in original cartons or in appropriately sized, hinged-cover; wood, plastic or metal boxes.
 2. Prominently display on each package: Part number, consistent with Operation and Maintenance Manual identification system; equipment description, quantity of parts; and equipment manufacturer.
- D. Deliver to designation location as directed by OWNER's Representative.

PART 3 - EXECUTION

3.1 WORK IN ACCORDANCE WITH MANUFACTURER'S INSTRUCTIONS

- A. When the specification Section requires the Work to be accomplished in accordance with "manufacturer's instructions", obtain and distribute copies of such instructions to parties involved in the installation. Provide two copies to the Resident Project Representative and maintain one set at the Project site.
- B. Handle, install, connect, clean, condition and adjust products in strict accordance with the manufacturer's instructions and in conformity with the Contract Documents. Do not omit any preparatory step or installation procedures. In case of conflict between job conditions or Contract Documents with manufacturer's instructions notify ENGINEER.

- C. Upon completion of installation, obtain Certificate of Installation from manufacturer's representative.

3.2 INSPECTION

- A. Inspect products for signs of pitting, rust decay, or other deleterious effects of storage. Do not install products showing such effects. Remove damaged product from Project site and expedite delivery of identical new product. Delays to Work resulting from product damage, which necessitates procurement of new product, will be considered delays within CONTRACTOR'S control.

3.3 INSTALLATION

- A. Drawings show general locations for product installation, unless specially dimensioned.
- B. No shimming between machined surfaces is allowed.
- C. Install Work in accordance with NECA Standard of Installation, unless otherwise specified.
- D. Recoat finish surfaces that are damaged prior to final acceptance of Work.
- E. Do not cut or notch any structural member or building surface without specific approval of ENGINEER.
- F. Handle, install, connect, clean, condition, and adjust product in accordance with Contract Documents and manufacturer's instructions.
- G. Apply field coating in accordance with Contract Documents.
- H. Perform required adjustments, tests, operation checks, and other start-up activities.
- I. Fill lubricant reservoirs and replace consumption during testing, start-up, and operation prior to final acceptance of Work by OWNER.

3.4 SUPPLEMENTS

- A. Sample forms included after "End Of Section" are considered part of this Section:
 - 1. Substitution Request.

END OF SECTION



SUBSTITUTION REQUEST (After the Bidding Phase)

Project: _____ Substitution Request Number: _____

From: _____
To: _____ Date: _____

A/E Project Number: _____
Re: _____ Contract For: _____

Specification Title: _____ Description: _____
Section: _____ Page: _____ Article/Paragraph: _____

Proposed Substitution: _____
Manufacturer: _____ Address: _____ Phone: _____
Trade Name: _____ Model No.: _____
Installer: _____ Address: _____ Phone: _____

History: ☐ New product ☐ 2-5 years old ☐ 5-10 yrs old ☐ More than 10 years old

Differences between proposed substitution and specified product: _____

☐ Point-by-point comparative data attached - REQUIRED BY ENGINEER

Reason for not providing specified item: _____

Similar Installation:

Project: _____ Engineer: _____
Address: _____ Owner: _____
_____ Date Installed: _____

Proposed substitution affects other parts of Work: ☐ No ☐ Yes; explain _____

Savings to Owner for accepting substitution: _____ (\$ _____).

Proposed substitution changes Contract Time: ☐ No ☐ Yes [Add] [Deduct] _____ days.

Supporting Data Attached: ☐ Drawings ☐ Product Data ☐ Samples ☐ Tests ☐ Reports ☐

(Continued)

The Undersigned certifies:

- Proposed substitution has been fully investigated and determined to be equal or superior in all respects to specified product.
 - Same warranty will be furnished for proposed substitution as for specified product.
 - Same maintenance service and source of replacement parts, as applicable, is available.
 - Proposed substitution will have no adverse effect on other trades and will not affect or delay progress schedule.
 - Cost data as stated above is complete. Claims for additional costs related to accepted substitution which may subsequently become apparent are to be waived.
 - Proposed substitution does not affect dimensions and functional clearances.
 - Payment will be made for changes to building design, including A/E design, detailing, and construction costs caused by the substitution.
 - Coordination, installation, and changes in the Work as necessary for accepted substitution will be complete in all respects.
-

Submitted by: _____

Signed by: _____

Firm: _____

Address: _____

Telephone: _____

Attachments: _____

A/E's REVIEW AND ACTION

- ☐ Substitution approved - Make submittals in accordance with Specification Section 01 33 10.
- ☐ Substitution approved as noted - Make submittals in accordance with Specification Section 01 33 10.
- ☐ Substitution rejected - Use specified materials.
- ☐ Substitution Request received too late - Use specified materials.

Signed by: _____

Date: _____

Additional Comments: ☐ Contractor ☐ Subcontractor ☐ Supplier ☐ Manufacturer ☐ A/E ☐ _____

SECTION 01 70 00
EXECUTION REQUIREMENTS

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes general procedural requirements governing execution of the Work including, but not limited to, the following:
 - 1. Construction layout.
 - 2. Field engineering and surveying.
 - 3. General installation of products.
 - 4. Progress cleaning.
 - 5. Starting and adjusting.
 - 6. Protection of installed construction.
 - 7. Correction of the Work.
 - 8. Basin dewatering and cleaning.
 - 9. Workmanship.
 - 10. Firearms.
 - 11. Handling materials not approved.
 - 12. Salvaged material.
 - 13. Archeological discoveries.
 - 14. Endangered species.
 - 15. Blasting and burning.
 - 16. Pipe closure and buoyancy of structures.
 - 17. OSHA Standards

1.2 REFERENCES

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 1 Specification Sections, apply to this Section.
- B. Related Sections include the following:
 - 1. Section 01 12 16 Sequence of Construction.
 - 2. Section 01 32 16 Construction Progress Schedule.
 - 3. Section 01 33 00 Submittal Procedures.
 - 4. Section 01 75 00 Equipment Testing and Startup.
 - 5. Section 01 77 00 Closeout Procedures.
 - 6. Section 01 79 00 Demonstration and Testing.

1.3 SUBMITTALS

- A. Certificates: Submit certificate signed by land surveyor certifying that location and elevation of improvements comply with requirements.
- B. Landfill Receipts: Submit copy of receipts issued by a landfill facility, licensed to accept

hazardous materials, for hazardous waste disposal.

- C. Certified Surveys: Submit two copies signed by land surveyor.
- D. Final Property Survey: Submit two copies showing the Work performed and record survey data.

1.4 QUALITY ASSURANCE

- A. Land Surveyor Qualifications: A licensed professional land surveyor who is legally qualified to practice in state where Project is located and who is experienced in providing land-surveying services of the kind indicated in the region.

PART 2 - PRODUCTS – NOT USED

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Existing Conditions and Utilities: When appropriate, the existence and location of site improvements, underground and other utilities, and other construction indicated as existing are not guaranteed. Before beginning Work, investigate and verify the existence and location of mechanical and electrical systems and other construction affecting the Work.
 - 1. Before construction, verify the location and points of connection of utility services.
 - 2. Before construction, verify the location and invert elevation at points of connection of sanitary sewer, storm sewer, and water-service piping; and underground electrical services.
 - 3. Furnish location data for Work related to Project that must be performed by public utilities serving Project site.
 - 4. Proceed with Work only after existing conditions and utilities have been located and properly protected according to federal, state, and local rules and regulations and requirements of this Section.
- B. Acceptance of Conditions: Examine substrates, areas, and conditions, with Installer or Applicator present where indicated, for compliance with requirements for installation tolerances and other conditions affecting performance. Record observations.
 - 1. Verify compatibility with and suitability of substrates, including compatibility with existing finishes or primers.
 - 2. Examine rough-in for mechanical and electrical systems to verify actual locations of connections before equipment and fixture installation.
 - 3. Examine walls, floors, and roofs for suitable conditions where products and systems are to be installed.
 - 4. Proceed with installation only after unsatisfactory conditions have been corrected. Proceeding with the Work indicates acceptance of surfaces and conditions.

3.2 PREPARATION

- A. Existing Utility Information: Furnish information to local utility that is necessary to adjust, move, or relocate existing utility structures, utility poles, lines, services, or other utility appurtenances located in or affected by construction. Coordinate with authorities having jurisdiction.

- B. Field Measurements: Take field measurements as required to fit the Work properly. Recheck measurements before installing each product. Where portions of the Work are indicated to fit to other construction, verify dimensions of other construction by field measurements before fabrication. Coordinate fabrication schedule with construction progress to avoid delaying the Work.
- C. Space Requirements: Verify space requirements and dimensions of items shown diagrammatically on Drawings.
- D. Review of Contract Documents and Field Conditions: Immediately on discovery of the need for clarification of the Contract Documents, submit a request for information to ENGINEER. Include a detailed description of problem encountered, together with recommendations for changing the Contract Documents.

3.3 CONSTRUCTION LAYOUT

- A. Verification: Before proceeding to lay out the Work, verify layout information shown on Drawings, in relation to the property survey and existing benchmarks. If discrepancies are discovered, notify ENGINEER promptly.
- B. General: Engage a licensed professional land surveyor to lay out the Work using accepted surveying practices of the state.
 - 1. Establish benchmarks and control points to set lines and levels at each story of construction and elsewhere as needed to locate each element of Project.
 - 2. Establish dimensions within tolerances indicated. Do not scale Drawings to obtain required dimensions.
 - 3. Inform installers of lines and levels to which they must comply.
 - 4. Check the location, level and plumb, of every major element as the Work progresses.
 - 5. Notify ENGINEER when deviations from required lines and levels exceed allowable tolerances.
 - 6. Close site surveys with an error of closure equal to or less than the standard established by authorities having jurisdiction.
- C. Site Improvements: Locate and lay out site improvements, including pavements, grading, fill and topsoil placement, utility slopes, and invert elevations.
- D. Building Lines and Levels: Locate and lay out control lines and levels for structures, building foundations, column grids, and floor levels, including those required for mechanical and electrical work. Transfer survey markings and elevations for use with control lines and levels. Level foundations and piers from two or more locations.
- E. Record Log: Maintain a log of layout control work. Record deviations from required lines and levels. Include beginning and ending dates and times of surveys, weather conditions, name and duty of each survey party member, and types of instruments and tapes used. Make the log available for reference by ENGINEER.

3.4 FIELD ENGINEERING

- A. Reference Points: Locate existing permanent benchmarks, control points, and similar reference points before beginning the Work. Preserve and protect permanent benchmarks and control points during construction operations.

- B. Benchmarks: Establish and maintain a minimum of two permanent benchmarks on Project site, referenced to data established by survey control points. Comply with authorities having jurisdiction for type and size of benchmark.
 - 1. Record benchmark locations, with horizontal and vertical data, on Project Record Documents.
- C. Final Property Survey: Prepare a final property survey showing significant features (real property) for Project. Include on the survey a certification, signed by licensed professional land surveyor, that principal metes, bounds, lines, and levels of Project are accurately positioned as shown on the survey.

3.5 INSTALLATION

- A. General: Locate the Work and components of the Work accurately, in correct alignment and elevation, as indicated.
 - 1. Make vertical work plumb and make horizontal work level.
 - 2. Where space is limited, install components to maximize space available for maintenance and ease of removal for replacement.
 - 3. Conceal pipes, ducts, and wiring in finished areas, unless otherwise indicated.
- B. Comply with manufacturer's written instructions and recommendations for installing products in applications indicated.
- C. Install products at the time and under conditions for the best possible results. Maintain conditions required for product performance through Substantial Completion.
- D. Conduct construction operations so that no part of the Work is subjected to damaging operations or loading in excess of that expected during normal conditions of occupancy.
- E. Tools and Equipment: Do not use tools or equipment that produce harmful noise levels.
- F. Templates: Obtain and distribute to the parties involved templates for work specified to be factory prepared and field installed. Check Shop Drawings of other work to confirm that adequate provisions are made for locating and installing products to comply with indicated requirements.
- G. Anchors and Fasteners: Provide anchors and fasteners as required to anchor each component securely in place, accurately located and aligned with other portions of the Work.
 - 1. Mounting Heights: Where mounting heights are not indicated, mount components at heights directed by ENGINEER.
 - 2. Allow for building movement, including thermal expansion and contraction.
 - 3. Coordinate installation of anchorages. Furnish setting drawings, templates, and directions for installing anchorages, including sleeves, concrete inserts, anchor bolts, and items with integral anchors, that are to be embedded in concrete or masonry. Deliver such items to Project site within at least one week of installation.
- H. Joints: Make joints of uniform width. Where joint locations in exposed work are not indicated, arrange joints for the best visual effect. Fit exposed connections together to form hairline joints.
- I. Hazardous Materials: Use products, cleaners, and installation materials that are not

considered hazardous.

3.6 PROGRESS CLEANING

- A. General: Clean Project site and work areas daily, including common areas. Coordinate progress cleaning for joint-use areas where more than one installer has worked. Enforce requirements strictly. Dispose of materials lawfully.
 - 1. Comply with requirements in NFPA 241 for removal of combustible waste materials and debris.
 - 2. Do not hold materials more than 7 days of temperatures less than 80°F or 3 days if the temperature is expected to rise above 80°F.
 - 3. Containerize hazardous and unsanitary waste materials separately from other waste. Mark containers using clear labels and hazard diamonds, and dispose of legally, according to federal, state, and local regulations.
- B. Site: Maintain Project site free of waste materials and debris.
- C. Work Areas: Clean areas where work is in progress to the level of cleanliness necessary for proper execution of the Work.
 - 1. Remove liquid spills promptly and in compliance with federal, state, and local regulations.
 - 2. Where dust would impair proper execution of the Work, broom-clean or vacuum the entire work area, as appropriate.
- D. Installed Work: Keep installed work clean. Clean installed surfaces according to written instructions of manufacturer or fabricator of product installed, using only cleaning materials specifically recommended. If specific cleaning materials are not recommended, use cleaning materials that are not hazardous to health or property and that will not damage exposed surfaces.
- E. Concealed Spaces: Remove debris from concealed spaces before enclosing the space.
- F. Exposed Surfaces in Finished Areas: Clean exposed surfaces and protect as necessary for freedom from damage and deterioration at time of Substantial Completion.
- G. During handling and installation, clean and protect construction in progress and adjoining materials already in place. Apply protective covering where required for protection from damage or deterioration at Substantial Completion.
- H. Clean and provide maintenance on completed construction as frequently as necessary through the remainder of the construction period. Adjust and lubricate operable components for optimal operability without damaging effects.
- I. Limiting Exposures: Supervise construction operations so that no part of the construction completed or in progress is subject to harmful, dangerous, damaging, or otherwise deleterious human or environmental exposure during the construction period.

3.7 STARTING AND ADJUSTING

- A. Start equipment and operating components to confirm proper operation in accordance with Section 01 75 00 Starting and Adjusting and the following:
 - 1. Remove malfunctioning components, replace with new components, and retest.

2. Adjust operating components for proper operation without binding. Adjust equipment for proper operation.
 3. Test each piece of equipment to verify proper operation. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- B. Manufacturer's Services: If a factory-authorized service representative is required to inspect field-assembled components and equipment installation, comply with qualification requirements in Section 01 43 33 "Manufacturers' Field Services."

3.8 PROTECTION OF INSTALLED CONSTRUCTION

- A. Provide final protection and maintain conditions so that installed Work is without damage or deterioration at time of Substantial Completion.
- B. Comply with manufacturers' written instructions for temperature and relative humidity.

3.9 CORRECTION OF THE WORK

- A. Repair or remove and replace defective construction. Restore damaged substrates and finishes.
1. Repairing includes replacing defective parts, refinishing damaged surfaces, touching up with matching materials, and properly adjusting operating equipment.
- B. Restore permanent facilities used during construction to their specified condition, as approved by OWNER or ENGINEER.
- C. Remove and replace damaged surfaces that are exposed to view if surfaces cannot be repaired without visible evidence of repair.
- D. Repair components that do not operate properly. Remove and replace operating components that cannot be repaired.
- E. Remove and replace chipped, scratched, and broken glass or reflective surfaces.

3.10 HAZARDOUS ENVIRONMENT/CONFINED SPACE ENTRY PLANS

- A. CONTRACTOR shall develop and implement Hazardous Environment/Confined Space Entry Plans for this Project. Plans shall be submitted to the ENGINEER for record purposes prior to the pre-construction conference. Plans shall include all local, state and federal requirements for entrance to and work in hazardous environments and confined spaces and shall include a written safety plan for the Project.
- B. CONTRACTOR shall have a safety officer present at the jobsite whenever the CONTRACTOR'S activities require entering or working in a hazardous environment or confined space.

3.11 PLAN OF ACTION

- A. CONTRACTOR shall prepare a detailed, written plan of action covering all shutdowns, material deliveries, confined space/hazardous environment entries, plant protection system, construction sequence for major facilities and modifications to existing facilities, trench/excavation protection, for review and coordination with the OWNER and ENGINEER at the pre-construction conference. The pre-construction conference will be held prior to beginning construction activities.

3.12 BASIN DEWATERING AND CLEANING

- A. The CONTRACTOR shall clean basins, pipelines and equipment as specified and in sufficient advance to complete the work. No additional payment will be made for such work. Washdown water shall be contained and disposed properly according to applicable federal, state, and local regulations.

3.13 WORKMANSHIP

- A. Specifications contain detailed instructions and descriptions of the major items of construction and workmanship necessary for building and completing the various elements of the Project. The Specifications are intended to be written so that only first-class workmanship and finish of the best grade and quality will result. The fact that these Specifications may fail to be so complete as to cover all details will not relieve the CONTRACTOR of full responsibility for providing a completed project of high quality, first class finish and appearance and satisfactory for operation, all within the apparent intent of the Plans and Specifications.

3.14 FIREARMS

- A. Neither the Contractor nor any of his employees shall be allowed to carry firearms on the Project, either on their persons or within their automobiles. Any violation of this requirement will result in the permanent removal from the Project of the employee committing the violation.

3.15 HANDLING MATERIALS NOT APPROVED

- A. The CONTRACTOR shall remove from the site any materials found to be damaged, and any materials not meeting the specifications. These materials shall be removed promptly, unless the ENGINEER will accept the materials after repairing. Materials found to be damaged, or not acceptable to the ENGINEER, shall be removed. Examination before installation shall not relieve the CONTRACTOR from any responsibility to furnish good quality materials.

3.16 SURPLUS AND SALVAGED MATERIAL

- A. Surplus equipment or material, which is removed by the CONTRACTOR as specified in the Drawings and Specifications, shall become the property of the CONTRACTOR. The CONTRACTOR shall be responsible for the disposal of salvage material offsite.
- B. Equipment and material designated to be salvage shall be transported by the CONTRACTOR to a location as directed by the Resident Project Representative.

3.17 ARCHEOLOGICAL DISCOVERIES

- A. No activity, which may affect a State Archeological Landmark, is authorized until the OWNER has complied with provisions of the Historical, Prehistorical, and Archaeological Resources Act. The OWNER has previously coordinated with the appropriate agencies and impacts to known cultural or archeological deposits have been avoided or mitigated. However, the CONTRACTOR may encounter unanticipated cultural or archeological deposits during construction.
- B. In the event the Contractor discovers any artifacts, cultural materials, or suspected cultural remains during construction, the Contractor shall halt Work and contact the OWNER and ENGINEER and American Archaeology Group LLC (512-843-0135) immediately. Any construction in the immediate vicinity of the suspected cultural deposits shall cease until

they can be examined. Contractor shall in no instance make contact with any parties other than those referenced above. Contractor shall restart construction activities in the vicinity of the suspected cultural deposit only upon receipt of written notice from ENGINEER or OWNER after the issues have been resolved.

3.18 ENDANGERED SPECIES

- A. No activity is authorized that is likely to jeopardize the continued existence, or a threatened, or endangered species as listed, or proposed for listing, under the Federal Endangered Species Act (ESA), and/or the State of Colorado Parks and Wildlife Code on Endangered Species, or to destroy or adversely modify the habitat of such species.
- B. If a threatened or endangered species is encountered during construction, the CONTRACTOR shall immediately cease work in the area of the encounter and notify the OWNER and ENGINEER, who will immediately implement actions in accordance with the ESA and applicable State statutes. These actions shall include reporting the encounter to the U.S. Fish and Wildlife Service and the Colorado Parks and Wildlife Department, obtaining any necessary approvals or permits to enable the continuation of work, or implement other mitigate actions.
- C. The CONTRACTOR shall not resume construction in the area of the encounter until authorized to do so by the Resident Project Representative in accordance with ESA and applicable state statutes.

3.19 BLASTING AND BURNING

- A. Explosives: Do not use explosives.
- B. Burning and Waste Disposal: Burying or burning waste materials on-site will not be permitted. Washing waste materials down sewers or into waterways will not be permitted. Trees and brush removed shall be shredded onsite with disposal off-site according to applicable federal, state, and local regulations.

3.20 PIPE CLOSURE AND BUOYANCY OF STRUCTURES

- A. At the end of each working day, the CONTRACTOR shall plug the ends of all exposed pipeline to prevent any material or objects from entering the pipeline.
- B. The CONTRACTOR shall anchor all pipelines and structures to prevent their flotation should rain occur prior to the completion of backfilling to proposed final grade.

3.21 OSHA STANDARDS

- A. All work performed under this Contract shall meet the applicable requirements of the Occupational Safety and Health Administration (OSHA). It is the responsibility of the CONTRACTOR to become familiar with the provisions of regulations published by OSHA in the Federal Register and to perform all of the responsibilities thereunder. It is the CONTRACTOR's responsibility to see that the Project is constructed in accordance with OSHA regulations and to indemnify and save harmless the OWNER from any penalties resulting from the CONTRACTOR's failure to so perform.

END OF SECTION

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SECTION 01 73 29
CUTTING AND PATCHING

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes procedural requirements for cutting and patching.

1.2 REFERENCES

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 1 Specification Sections, apply to this Section.
- B. Related Sections include the following:
1. Section 01 12 16 Sequence of Construction.
 2. Section 01 32 33 Photographic Documentation.
 3. Section 01 33 00 Submittal Procedures.
 4. Section 01 70 00 Execution and Requirements.
 5. Section 01 77 00 Closeout Procedures.
 6. Section 02 41 13 Selective Demolition.
 7. Divisions 2 through 19 Sections for specific requirements and limitations applicable to cutting and patching individual parts of the Work.

1.3 SUBMITTALS

- A. Cutting and Patching Proposal: Submit to the ENGINEER a proposal describing procedures at least 10 days before the time cutting and patching is scheduled to be performed, requesting approval to proceed. Include the following information:
1. Extent: Describe cutting and patching, show how they will be performed, and indicate why they cannot be avoided.
 2. Changes to In-Place Construction: Describe anticipated results. Include changes to structural elements and operating components as well as changes in building's appearance and other significant visual elements.
 3. Products: List products to be used and firms or entities that will perform the Work.
 4. Dates: Indicate when cutting and patching will be performed.
 5. Utility Services and Mechanical/Electrical Systems: As applicable, list services/systems that cutting and patching procedures will disturb or affect. List services/systems that will be relocated and those that will be temporarily out of service. Indicate how long services/systems will be disrupted.
 6. Structural Elements: Where cutting and patching involve adding reinforcement to structural elements, submit details and engineering calculations showing integration of reinforcement with original structure.
 7. ENGINEER'S Approval: Obtain approval of cutting and patching proposal before cutting and patching. Approval does not waive right to later require removal and replacement of unsatisfactory work.

1.4 QUALITY ASSURANCE

- A. Structural Elements: Do not cut and patch structural elements in a manner that could change their load-carrying capacity or load-deflection ratio.
- B. Operational Elements: Do not cut and patch operating elements and related components in a manner that results in reducing their capacity to perform as intended or that result in increased maintenance or decreased operational life or safety.
- C. Miscellaneous Elements: Do not cut and patch miscellaneous elements or related components in a manner that could change their load-carrying capacity, which results in reducing their capacity to perform as intended, or that result in increased maintenance or decreased operational life or safety.
- D. Visual Requirements: Do not cut and patch construction in a manner that results in visual evidence of cutting and patching. Do not cut and patch construction exposed on the exterior or in occupied spaces in a manner that would, in Architect's opinion, reduce the building's aesthetic qualities. Remove and replace construction that has been cut and patched in a visually unsatisfactory manner.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. General: Comply with requirements specified in other Sections.
- B. In-Place Materials: Use materials identical to in-place materials. For exposed surfaces, use materials that visually match in-place adjacent surfaces to the fullest extent possible.
 - 1. If identical materials are unavailable or cannot be used, use materials that, when installed, will match the visual and functional performance of in-place materials. The material selected must be approved by the ENGINEER prior to use.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. The CONTRACTOR shall make his own investigations and determine the nature of work involved in making the connections and modifications to existing facilities in the manner intended by the Plans.
- B. Sequencing and coordination requirements are described elsewhere.
- C. Examine surfaces to be cut and patched and conditions under which cutting and patching are to be performed.
 - 1. Compatibility: Before patching, verify compatibility with and suitability of substrates, including compatibility with in-place finishes or primers.
 - 2. Proceed with installation only after unsafe or unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Temporary Support: Provide temporary support of Work to be cut.
- B. Protection: Protect in-place construction during cutting and patching to prevent damage. Provide protection from adverse weather conditions for portions of Project that might be exposed during cutting and patching operations.

- C. Adjoining Areas: Avoid interference with use of adjoining areas or interruption of free passage to adjoining areas.
- D. Existing Utility Services and Mechanical/Electrical Systems: Where existing services/systems are required to be removed, relocated, or abandoned, bypass such services/systems before cutting to prevent interruption to occupied areas, if applicable. Obtain approval of ENGINEER for acceptable bypass.

3.3 PERFORMANCE

- A. General: Employ skilled workers to perform cutting and patching. Proceed with cutting and patching at the earliest feasible time, and complete without delay.
 - 1. Cut in-place construction to provide for installation of other components or performance of other construction, and subsequently patch as required to restore surfaces to their original condition.
- B. Cutting: Cut in-place construction by sawing, drilling, breaking, chipping, grinding, and similar operations, including excavation, using methods least likely to damage elements retained or adjoining construction. If possible, review proposed procedures with original Installer; comply with original Installer's written recommendations.
 - 1. In general, use hand or small power tools designed for sawing and grinding, not hammering and chopping. Cut holes and slots as small as possible, neatly to size required, and with minimum disturbance of adjacent surfaces. Temporarily cover openings when not in use. Limit sound from tools to level and schedule acceptable to OWNER.
 - 2. Finished Surfaces: Cut or drill from the exposed or finished side into concealed surfaces.
 - 3. Concrete and Masonry: Cut using a cutting machine, such as an abrasive saw or a diamond-core drill.
 - 4. Excavating and Backfilling: Comply with requirements in applicable Division 31 Sections where required by cutting and patching operations.
 - 5. Mechanical and Electrical Services: Cut off pipe or conduit in walls or partitions to be removed. Cap, valve, or plug and seal remaining portion of pipe or conduit to prevent entrance of moisture or other foreign matter after cutting.
 - 6. Proceed with patching after construction operations requiring cutting are complete.
- C. Patching: Patch construction by filling, repairing, refinishing, closing up, and similar operations following performance of other Work. Patch with durable seams that are as invisible as possible. Provide materials and comply with installation requirements specified in other Sections.
 - 1. Inspection: Where feasible, test and inspect patched areas after completion to demonstrate integrity of installation.
 - 2. Exposed Finishes: Restore exposed finishes of patched areas and extend finish restoration into retained adjoining construction in a manner that will eliminate evidence of patching and refinishing.
 - 3. Floors and Walls: Where walls or partitions that are removed extend one finished area into another, patch and repair floor and wall surfaces in the new space. Provide an even surface of uniform finish, color, texture, and appearance. Remove in-place

floor and wall coverings and replace with new materials, if necessary, to achieve uniform color and appearance.

4. Ceilings: Patch, repair, or rehang in-place ceilings as necessary to provide an even-plane surface of uniform appearance.
 5. Exterior Building Enclosure: Patch components in a manner that restores enclosure to a weathertight condition.
- D. The CONTRACTOR shall dewater and clean existing basins, pipelines and equipment as specified and, when necessary to complete the work, shall be the responsibility of the CONTRACTOR. No additional payment will be made for such work.
- E. Cleaning: Clean areas and spaces where cutting and patching are performed. Completely remove paint, mortar, oils, putty, and similar materials.

END OF SECTION

**SECTION 01 75 00
STARTING AND ADJUSTING**

PART 1 - GENERAL

1.1 SUMMARY

- A. SUPPLIER's scope of work to be performed under this specification shall be to support installation, testing and startup of all supplied equipment systems.

1.2 REFERENCES

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 1 Specification Sections, apply to this Section.
 - 1. Section 01 12 16 Sequence of Construction.
 - 2. Section 01 32 16 Construction Progress Schedule.
 - 3. Section 01 33 00 Submittal Procedures.
 - 4. Section 01 70 00 Execution and Requirements.
 - 5. Section 01 77 00 Closeout Procedures.
 - 6. Section 01 79 00 Demonstration and Testing.

1.3 ADMINISTRATIVE REQUIREMENTS

- A. Service of MANUFACTURER's Representative
 - 1. MANUFACTURER's contracted cost for the equipment shall include the cost of furnishing competent and experienced personnel who shall represent the manufacturers and shall assist the CONTRACTOR, when required, to renovate or install, adjust, and test the equipment in conformity with the Contract Documents.
 - 2. After the equipment is placed in permanent operation by the CONTRACTOR, MANUFACTURER's personnel shall make all adjustments and tests required to prove that such equipment is in proper and satisfactory operating condition and shall instruct the OWNER's representatives in the proper operation and maintenance of such equipment or system. Training must be adequate and acceptable to OWNER's representative. The preliminary Equipment O&M must be approved prior to start of training.

1.4 SUBMITTALS

- A. Submit to ENGINEER, for review, start-up and test schedule a minimum of 60 days prior to commencing Work specified in this section.
- B. Submit to ENGINEER an electronic copy and a minimum of two (2) hard copies of field test data and test records for all equipment and systems within 14 days of completion of installation, testing and startup.

PART 2 - PRODUCTS

2.1 FURNISH INITIAL LUBRICANTS AND OTHER CONSUMABLES

- A. CONTRACTOR shall furnish and install the initial supply of oil, grease or other consumable

required per SUPPLIER's/MANUFACTURER's instructions to startup, test and place into service the supplied equipment.

2.2 TOOLS, SPARE PARTS, AND MAINTENANCE MATERIALS

A. Extra Materials

1. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
2. Provide one set of spare parts for all components exposed to operational wear during normal equipment service as recommended by the manufacturer as typically needed in the first two years of operation. Refer to individual specifications for each piece of equipment.

PART 3 - EXECUTION

3.1 TESTING AND STARTUP PLAN

- A. Submit a plan that includes a schedule for testing and startup of all equipment and systems provided as part of the Work. Specific Tests for each piece of equipment are detailed in the respective Equipment Specification Sections.
- B. Contractor is responsible for the startup of the GAC pressure vessels; the startup will require temporary backwash storage tanks provided by the Owner. Contractor to coordinate with Owner in a timely manner to execute the vessel startup.
- C. Include in the startup plan:
 1. Sequences.
 2. Lock-out procedures and safety precautions.
 3. Utility requirements.
 4. Related items and piping which must be complete and the required schedule for completion.
 5. Instrumentation settings.
 6. Operational Support.
- D. SUPPLIER/MANUFACTURER shall provide a schedule and outline for training of OWNER's personnel. Equipment shall not be turned over to OWNER prior to training of OWNER's personnel. Specifically identify adjustment and maintenance items that must be completed in initial 30-day period.

3.2 PREPARATION

- A. SUPPLIER/MANUFACTURER shall verify that the CONTRACTOR has performed the following work prior to testing and startup:
 1. Complete equipment installation with controls, safety devices and auxiliary support systems necessary to start the equipment and verify that the equipment functions correctly under no load conditions.
 2. Remove temporary bracing supports and other construction debris that may damage equipment once equipment is structurally stable.
 3. Remove protective coatings and oils from new equipment used for protection during shipment and installation.

4. Flush and fill lubricated systems in equipment in accordance with Manufacturer's instructions.
5. On new equipment, install temporary connections and devices required to fill, operate, evaluate, and drain the system.
6. Check equipment for correct direction of rotation and freedom of moving parts.
7. Align equipment to Manufacturers' tolerances.
8. Check installation prior to start-up for conformance to Manufacturers' instructions.
9. Adjust or modify equipment to make equipment properly operational according to Project Specifications and Manufacturers' instructions.
10. Correct any deficiencies or problems noted in Manufacturers' representatives' installation reports.
11. Complete testing of related piping systems and furnish test reports to ENGINEER.

3.3 TESTING AND STARTUP

A. MANUFACTURER shall perform the following:

1. MANUFACTURER with CONTRACTOR assistance as required shall begin checkout, testing, and startup procedures as approved by ENGINEER of testing and startup plan. MANUFACTURER's installation report shall be submitted within 48 hours of startup.
2. Make final connections to equipment and complete the system installation necessary to apply the system loads to the equipment and verify the equipment functions correctly.
3. Perform all tests as required by the specifications prior to startup.
4. Start equipment according to manufacturer's instructions.
5. Place each piece of equipment in the system in operation until the entire system is functioning.
6. Operate the system through the design performance range consistent with anticipated flows. Adjust, balance, calibrate, and, in general, check out the equipment, safety devices, controls, and process system to operate within the design conditions.

END OF SECTION

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**SECTION 01 77 00
CLOSEOUT PROCEDURES**

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes administrative and procedural requirements for contract closeout, including, but not limited to, the following:
 - 1. Inspection procedures.
 - 2. Final cleaning.

1.2 REFERENCES

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 1 Specification Sections, apply to this Section.
- B. Related Sections include the following:
 - 1. Section 01 12 16 Sequence of Construction.
 - 2. Section 01 31 26 Electronic Communication Protocols.
 - 3. Section 01 32 16 Construction Progress Schedule.
 - 4. Section 01 33 00 Submittal Procedures.
 - 5. Section 01 70 00 Execution and Requirements.
 - 6. Section 01 78 23 Operation and Maintenance Data.
 - 7. Section 01 78 39 Project Record Documents.
 - 8. Section 01 79 00 Demonstration and Testing.
 - 9. All other Contract Document sections for specific closeout and special cleaning requirements for the Work in those Sections.

1.3 SUBSTANTIAL COMPLETION

- A. Preliminary Procedures: Substantial completion is defined as: the project is operational for the owner's use. Before requesting inspection for determining date of Substantial Completion, complete the items numbered below, and list in request any items below that are incomplete and the schedule for their completion of the incomplete items.
 - 1. Prepare a punch list or list of items to be completed and corrected, the value of items on the list, and reasons why the Work is not complete.
 - 2. Advise OWNER of pending insurance changeover requirements.
 - 3. Submit specific warranties, workmanship bonds, maintenance service agreements, final certifications, and similar documents.
 - 4. Obtain and submit releases permitting OWNER unrestricted use of the Work and access to services and utilities. Include occupancy permits, operating certificates, and similar releases.
 - 5. Prepare and submit Project Record Documents, comprehensive field notes for ENGINEER's preparation of as-built drawings, operation and maintenance manuals, Final Completion construction photographs, damage or settlement surveys, property surveys, and similar final record information.
 - 6. Deliver tools, spare parts, extra materials, and similar items to location designated by OWNER. Label with manufacturer's name and model number where applicable.
 - 7. Make final changeover of permanent locks and deliver keys to OWNER. Advise OWNER'S personnel of changeover in security provisions, including electronic

documentation.

8. Complete startup testing of systems.
 9. Submit test/adjust/balance records.
 10. Terminate and remove temporary facilities from Project site, along with mockups, construction tools, and similar elements.
 11. Advise OWNER of changeover in heat and all utilities, including electronic documentation.
 12. Submit changeover information related to OWNER'S occupancy, use, operation, and maintenance, including electronic documentation.
 13. Complete final cleaning requirements, including touchup painting.
 14. Touch up and otherwise repair and restore marred exposed finishes to eliminate visual defects.
- B. Inspection: Submit an electronic request for inspection for Substantial Completion. On receipt of request, ENGINEER will either proceed with inspection or notify CONTRACTOR of unfulfilled requirements. ENGINEER will prepare the Certificate of Substantial Completion after inspection or will notify CONTRACTOR of items, either on CONTRACTOR'S list or additional items identified by ENGINEER, which must be completed or corrected before certificate will be issued.
1. Reinspection: Request reinspection when the Work identified in previous inspections as incomplete is completed or corrected.
 2. Results of completed inspection will form the basis of requirements for Final Completion.

1.4 FINAL COMPLETION

- A. Preliminary Procedures: Before requesting final inspection for determining date of Final Completion, complete the following:
1. Submit a final Application for Payment and invoice for the release of retainage, according to the provisions in the Agreement Form.
 2. Submit certified copy of ENGINEER'S Substantial Completion inspection list of items to be completed or corrected (punch list), endorsed and dated by ENGINEER. The certified copy of the punch list shall state that each item has been completed or otherwise resolved for acceptance.
 3. Submit evidence of final, continuing insurance coverage complying with insurance requirements.
 4. Submit pest-control final inspection report and warranty, as applicable.
 5. Instruct Owner's personnel in operation, adjustment, and maintenance of products, equipment, and systems. Submit demonstration and training videotapes.
 6. Submit final release of lien documents signed by bonding company.
- B. Inspection: Submit a written request for final inspection for acceptance. On receipt of request, ENGINEER will either proceed with inspection or notify CONTRACTOR of unfulfilled requirements. ENGINEER will prepare a final Certificate for Payment after inspection or will notify Contractor of construction that must be completed or corrected before certificate will be issued.
1. Reinspection: Request reinspection when the Work identified in previous inspections as incomplete is completed or corrected.
- C. The retainage and its interest earnings, if any, shall not be paid to the Contractor until the OWNER and/or TWDB or other funding agency has authorized a reduction in, or release of,

retainage on the contract work.

1.5 LIST OF INCOMPLETE ITEMS (PUNCH LIST)

- A. Preparation: Submit electronic and three (3) hard copies of list. Include name and identification of each space and area affected by construction operations for incomplete items and items needing correction including, if necessary, areas disturbed by Contractor that are outside the limits of construction.
 - 1. Organize list in sequential order for completion.
 - 2. Organize items applying to each space by major element.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Cleaning Agents: Use cleaning materials and agents recommended by manufacturer or fabricator of the surface to be cleaned. Do not use cleaning agents that are potentially hazardous to health, property, environment, or that might damage finished surfaces.

PART 3 - EXECUTION

3.1 FINAL CLEANING

- A. General: Provide final cleaning. Conduct cleaning and waste-removal operations to comply with local laws and ordinances and federal, state, and local environmental and antipollution regulations.
- B. Cleaning: Employ experienced workers or professional cleaners for final cleaning. Clean each Project site, equipment, structures, buildings and related facilities. Comply with manufacturer's written instructions.
 - 1. Complete the following cleaning operations before requesting inspection for certification of Substantial Completion for entire Project or for a portion of Project:
 - a. Clean Project site, yard, and grounds, in areas disturbed by construction activities, including landscape development areas, of rubbish, waste material, litter, and other foreign substances.
 - b. Sweep paved areas broom clean. Remove petrochemical spills, stains, and other foreign deposits.
 - c. Rake grounds that are neither planted nor paved to a smooth, even-textured surface.
 - d. Remove tools, construction equipment, machinery, and surplus material from Project site.
 - e. Clean exposed exterior and interior hard-surfaced finishes to a dirt-free condition, free of stains, films, and similar foreign substances. Avoid disturbing natural weathering of exterior surfaces. Restore reflective surfaces to their original condition.
 - f. Remove debris and surface dust from limited access spaces, including roofs, plenums, shafts, trenches, equipment vaults, manholes, attics, and similar spaces.
 - g. Sweep concrete floors broom clean in unoccupied spaces.
 - h. Vacuum carpet and similar soft surfaces, removing debris and excess nap; shampoo if visible soil or stains remain.
 - i. Clean transparent materials, including mirrors and glass in doors and windows. Remove glazing compounds and other noticeable, vision-obscuring materials.

- Replace chipped or broken glass and other damaged transparent materials. Polish mirrors and glass, taking care not to scratch surfaces.
- j. Remove labels that are not permanent.
 - k. Touch up and otherwise repair and restore marred, exposed finishes and surfaces. Replace finishes and surfaces that cannot be satisfactorily repaired or restored or that already show evidence of repair or restoration.
 - 1) Do not paint over "UL" and similar labels, including mechanical and electrical nameplates.
 - l. Wipe surfaces of mechanical and electrical equipment and similar equipment. Remove excess lubrication, paint and mortar droppings, and other foreign substances.
 - m. Replace parts subject to unusual operating conditions.
 - n. Clean plumbing fixtures to a sanitary condition, free of stains, including stains resulting from water exposure.
 - o. Replace disposable air filters, and clean permanent air filters. Clean exposed surfaces of diffusers, registers, and grills.
 - p. Clean light fixtures, lamps, globes, and reflectors to function with full efficiency. Replace burned-out bulbs, and those noticeably dimmed by hours of use, and defective and noisy starters in fluorescent and mercury vapor fixtures to comply with requirements for new fixtures.
 - q. Leave Project clean and ready for occupancy.
- C. Pest Control: Engage an experienced, licensed exterminator to make a final inspection and rid Project of rodents, insects, and other pests. Prepare a report.
- D. Comply with safety standards for cleaning. Do not burn waste materials. Do not bury debris or excess materials on Owner's property. Do not discharge volatile, harmful, or dangerous materials into drainage systems. Remove waste materials from Project site and dispose lawfully.

END OF SECTION

SECTION 01 78 23
OPERATION AND MAINTENANCE DATA

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes administrative and procedural requirements for preparing operation and maintenance manuals, including the following:
 - 1. Operation and maintenance documentation directory.
 - 2. Emergency manuals.
 - 3. Operation manuals for systems, subsystems, and equipment.
 - 4. Maintenance manuals for the care and maintenance of systems and equipment.

1.2 REFERENCES

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 1 Specification Sections, apply to this Section.
- B. Related Sections include the following:
 - 1. Section 01 31 26 Electronic Communication Protocols.
 - 2. Section 01 33 00 Submittal Procedures.
 - 3. Section 01 43 33 Manufacturers' Field Services.
 - 4. Section 01 70 00 Execution Requirements.
 - 5. Section 01 75 00 Equipment Testing and Startup.
 - 6. Section 01 77 00 Closeout Requirements.
 - 7. Section 01 78 36 Warranties.
 - 8. Section 01 78 39 Project Record Documents.
 - 9. All other Contract Documents for specific requirements for warranties on products and installations specified to be warranted.
- C. Definitions
 - 1. Preliminary Data: Initial and subsequent submissions for ENGINEER'S review.
 - 2. Final Data: ENGINEER accepted data, submitted as specified herein.
 - 3. Maintenance Operation: As used on Maintenance Summary Form is defined to mean any routine operation required to ensure satisfactory performance and longevity of equipment. Examples of typical maintenance operations are lubrication, belt tensioning, adjustment of pump packing glands, and routine adjustments.
 - 4. System: An organized collection of parts, equipment, or subsystems united by regular interaction.
 - 5. Subsystem: A portion of a system with characteristics similar to a system.
 - 6. Instructional Manual: Equipment and Operating Data submitted prior to the testing and startup of the equipment, subsystem, or system.
 - 7. Operation and Maintenance Data: The operation and maintenance data submitted to be included in the Operation and Maintenance Manual for the Project.

1.3 ADMINISTRATIVE REQUIREMENTS

A. Sequencing and Scheduling

1. Equipment and System Data (Instructional Manual):
 - a. Preliminary Data:
 - 1) Do not submit until ENGINEER has approved Shop Drawings.
 - b. Final Data: Submit Instructional Manual Formatted data not less than 30 days prior to equipment or system field functional testing. Submit Compilation Formatted and Electronic Media Formatted data prior to Substantial Completion of Project.

B. Coordination

1. Where operation and maintenance documentation includes information on installations by more than one factory-authorized service representative, assemble and coordinate information furnished by representatives, and prepare Manuals.

1.4 SUBMITTALS

- A. Initial Submittal: Submit electronic draft copy of each Operation and Maintenance Data (Manual) at least 60 days before requesting inspection for Substantial Completion in accordance with Division 1 Section 01 31 00 "Project Management and Coordination." Include a complete operation and maintenance directory. ENGINEER will return one copy of draft and mark whether general scope and content of Manual is acceptable.
- B. Final Submittal: Submit electronic and one (1) hard copy of each Manual in final form at least 30 days before requesting inspection for start-up and testing or Substantial Completion, whichever comes first. ENGINEER will return copy with comments within 21 days of receipt or notify CONTRACTOR that the Manual is accepted.
 1. Correct or modify each Manual to comply with ENGINEER'S comments. Submit electronic and four (4) hard copies of each corrected manual within 21 days of receipt of ENGINEER'S comments.

PART 2 - PRODUCTS

2.1 OPERATION AND MAINTENANCE DOCUMENTATION DIRECTORY

- A. Organization: Include a section in the directory for each of the following:
 1. List of documents.
 2. List of systems.
 3. List of equipment.
 4. Table of contents.
- B. List of Systems and Subsystems: List systems alphabetically or by treatment area as directed by ENGINEER. Include references to operation and maintenance Manuals that contain information about each system.
- C. List of Equipment: List equipment for each system, organized alphabetically by system or by treatment area as directed by ENGINEER. For pieces of equipment not part of system, list alphabetically in separate list.
- D. Tables of Contents: Include a table of contents for each emergency, operation, and

maintenance Manual.

- E. Identification: In the documentation directory and in each operation and maintenance Manual, identify each system, subsystem, and piece of equipment with same designation used in the Contract Documents.

2.2 MANUALS, GENERAL

- A. Organization: Unless otherwise indicated, organize each Manual into a separate section for each system and subsystem, and a separate section for each piece of equipment not part of a system. Each Manual shall contain the following sections, in the order listed:
 - 1. Title page.
 - 2. Table of contents.
 - 3. Manual contents.
- B. Title Page: Enclose each hard copy title page in transparent plastic sleeve. Include the following information:
 - 1. Subject matter included in Manual.
 - 2. Name and address of Project.
 - 3. Name and address of OWNER.
 - 4. Name, address, and telephone number of CONTRACTOR.
 - 5. Name and address of ENGINEER.
 - 6. Subcontractor, Supplier, Manufacturer, Installer, or Maintenance Contractor's name, address, and telephone number, as appropriate.
 - a. Identify area of responsibility of each.
 - b. Provide name and telephone number of local source of supply for parts, replacement, and service.
 - 7. Cross-reference to related systems in other operation and maintenance Manuals.
- C. Table of Contents: List each product included in Manual, identified by product name, indexed to the content of the volume, and cross-referenced to Specification Section number in Project Manual.
 - 1. If operation or maintenance documentation requires more than one volume to accommodate data, include comprehensive table of contents for all volumes in each volume of the set.
- D. Manual Contents: Organize into sets of manageable size. Arrange contents alphabetically by system, subsystem, and equipment. If possible, assemble hard copy instructions for subsystems, equipment, and components of one system into a single binder.
 - 1. Hard copy binders: Heavy-duty, 3-ring, vinyl-covered, loose-leaf binders, in thickness necessary to accommodate contents, sized to hold 8-1/2-by-11-inch paper; with clear plastic sleeve on spine to hold label describing contents and with pockets inside covers to hold folded oversize sheets.
 - a. If two or more binders are necessary to accommodate data of a system, organize data in each binder into groupings by subsystem and related components. Cross-reference other binders if necessary to provide essential information for proper operation or maintenance of equipment or system.

- b. Identify each binder on front and spine, with printed title "OPERATION AND MAINTENANCE MANUAL, VOLUME NO. ____ OF ____", Project title or name, and subject matter of contents. Indicate volume number for multiple-volume sets.
 - c. Text: Manufacturer's printed data, or neatly typed.
 - d. Three-hole punch data for binding and composition; arrange printing so that punched holes do not obliterate data.
- 2. Dividers: Heavy-paper dividers with plastic-covered tabs for each section. Mark each tab to indicate contents. Include typed list of products and major components of equipment included in the section on each divider, cross-referenced to Specification Section number and title of Manual.
- 3. Protective Plastic Sleeves: Transparent plastic sleeves designed to enclose diagnostic software diskettes for computerized electronic equipment.
- 4. Supplementary Text: Prepared on 8-1/2-by-11-inch 20-POUND MINIMUM, white bond paper.
- 5. Drawings: Attach reinforced, punched binder tabs on drawings and bind with text.
 - a. If oversize drawings are necessary, fold drawings to same size as text pages and use as foldouts.
 - b. If drawings are too large to be used as foldouts, fold and place drawings in labeled envelopes and bind envelopes in rear of manual. At appropriate locations in manual, insert typewritten pages indicating drawing titles, descriptions of contents, and drawing locations.
- 6. Electronic Media Format:
 - a. Portable Document format (PDF)
 - 1) After all preliminary data has been found to be acceptable, submit operational and maintenance data in PDF format on CD-ROM, USB drive, or stable link.
 - 2) Files to be exact duplicates of accepted preliminary data. Arrange by specification Section number. Bookmark sections.
 - 3) Files to be fully functional and viewable in most recent versions of Adobe Acrobat and Bluebeam/Revu.
 - b. Manufacturer's Standard Electronic Format:

2.3 OPERATION MANUALS

- A. Content: In addition to requirements in this Section, include operation data required in individual Specification Sections and the following information:
 - 1. System, subsystem, and equipment descriptions.
 - 2. Performance and design criteria.
 - 3. Operating standards.
 - 4. Operating procedures.
 - 5. Operating logs.
 - 6. Wiring diagrams.
 - 7. Control diagrams.
 - 8. Piped system diagrams.

9. Precautions against improper use.
 10. License requirements including inspection and renewal dates.
- B. Descriptions: Include the following:
1. Product name and model number.
 2. Manufacturer's name.
 3. Equipment identification with serial number of each component.
 4. Equipment function.
 5. Operating characteristics.
 6. Limiting conditions.
 7. Performance curves.
 8. Engineering data and tests.
 9. Complete nomenclature and number of replacement parts.
- C. Operating Procedures: Include the following, as applicable:
1. Startup procedures.
 2. Equipment or system break-in procedures.
 3. Routine and normal operating instructions.
 4. Regulation and control procedures.
 5. Instructions on stopping.
 6. Normal shutdown instructions.
 7. Seasonal, holiday, and weekend operating instructions.
 8. Required sequences for electric or electronic systems.
 9. Special operating instructions and procedures.
- D. Systems and Equipment Controls: Describe the sequence of operation, and diagram controls as installed.
- E. Piped Systems: Diagram piping as installed, and identify color-coding where required for identification.

2.4 PRODUCT MAINTENANCE MANUAL

- A. Content: Organize Manual into a separate section for each product, material, and finish. Include source information, product information, maintenance procedures, repair materials and sources, and warranties and bonds, as described below.
- B. Source Information: List each product included in Manual identified by product name and arranged to match Manual's table of contents. For each product, list name, address, and telephone number of Installer or supplier and maintenance service agent, and cross-reference Specification Section number and title in Project Manual.
- C. Product Information: Include the following, as applicable:
1. Product name and model number.
 2. Manufacturer's name.
 3. Color, pattern, and texture.
 4. Material and chemical composition.

5. Reordering information for specially manufactured products.
- D. Maintenance Procedures: Include manufacturer's written recommendations and the following:
 1. Inspection procedures.
 2. Types of cleaning agents to be used and methods of cleaning.
 3. List of cleaning agents and methods of cleaning detrimental to product.
 4. Schedule for routine cleaning and maintenance.
 5. Repair instructions.
- E. Repair Materials and Sources: Include lists of materials and local sources of materials and related services.
- F. Warranties and Bonds: Include copies of warranties and bonds and lists of circumstances and conditions that would affect validity of warranties or bonds.
 1. Include procedures to follow and required notifications for warranty claims.

2.5 SYSTEMS AND EQUIPMENT MAINTENANCE MANUAL

- A. Content: For each system, subsystem, and piece of equipment not part of a system, include source information, manufacturers' maintenance documentation, maintenance procedures, maintenance and service schedules, spare parts list and source information, maintenance service contracts, and warranty and bond information, as described below.
- B. Source Information: List each system, subsystem, and piece of equipment included in manual identified by product name and arranged to match manual's table of contents. For each product, list name, address, and telephone number of Installer or supplier and maintenance service agent, and cross-reference Specification Section number and title in Project Manual.
- C. Manufacturers' Maintenance Documentation: Manufacturers' maintenance documentation including the following information for each component part or piece of equipment:
 1. Standard printed maintenance instructions and bulletins.
 2. Drawings, diagrams, and instructions required for maintenance, including disassembly and component removal, replacement, and assembly.
 3. Identification and nomenclature of parts and components.
 4. List of items recommended to be stocked as spare parts.
- D. Maintenance Procedures: Include the following information and items that detail essential maintenance procedures:
 1. Test and inspection instructions.
 2. Troubleshooting guide.
 3. Precautions against improper maintenance.
 4. Disassembly; component removal, repair, and replacement; and reassembly instructions.
 5. Aligning, adjusting, and checking instructions.
 6. Demonstration and training videotape, if available.
- E. Maintenance and Service Schedules: Include service and lubrication requirements, list of

required lubricants for equipment, and separate schedules for preventive and routine maintenance and service with standard time allotment.

1. Scheduled Maintenance and Service: Tabulate actions for daily, weekly, monthly, quarterly, semiannual, and annual frequencies.
 2. Maintenance and Service Record: Include manufacturers' forms for recording maintenance.
- F. Spare Parts List and Source Information: Include lists of replacement and repair parts, with parts identified and cross-referenced to manufacturers' maintenance documentation and local sources of maintenance materials and related services.
- G. Maintenance Service Contracts: If applicable, include copies of maintenance agreements with name and telephone number of service agent.
- H. Warranties and Bonds: Include copies of warranties and bonds and lists of circumstances and conditions that would affect validity of warranties or bonds.
1. Include procedures to follow and required notifications for warranty claims.

PART 3 - EXECUTION

3.1 MANUAL PREPARATION

- A. Operation and Maintenance Documentation Directory: Prepare a separate Manual that provides an organized reference to emergency, operation, and maintenance Manuals.
- B. Emergency Manual: Assemble a complete set of emergency information indicating procedures for use by emergency personnel and by Owner's operating personnel for types of emergencies indicated.
- C. Product Maintenance Manual: Assemble a complete set of maintenance data indicating care and maintenance of each product, material, and finish incorporated into the Work.
- D. Operation and Maintenance Manuals: Assemble a complete set of operation and maintenance data indicating operation and maintenance of each system, subsystem, and piece of equipment not part of a system.
1. Engage a factory-authorized service representative to assemble and prepare information for each system, subsystem, and piece of equipment not part of a system.
 2. Prepare a separate Manual for each system and subsystem, in the form of an instructional Manual for use by Owner's operating personnel.
- E. Manufacturers' Data: Where Manuals contain manufacturers' standard printed data, include only sheets pertinent to product or component installed. Mark each sheet to identify associated product or component incorporated into the Work. If data include more than one item in a tabular format, identify each item using appropriate references from the Contract Documents. Identify data applicable to the Work and delete references to information not applicable.
1. Prepare supplementary text if manufacturers' standard printed data are not available and where the information is necessary for proper operation and maintenance of equipment or systems.
- F. Drawings: Prepare drawings supplementing manufacturers' printed data to illustrate the relationship of component parts of equipment and systems and to illustrate control

sequence and flow diagrams. Coordinate these drawings with information contained in Record Drawings to ensure correct illustration of completed installation.

1. Do not use original Project Record Documents as part of operation and maintenance Manuals.
 2. Comply with requirements of newly prepared Record Drawings in Section 01 78 39.
- G. Comply with Section 01 77 00 for schedule of submitting operation and maintenance documentation.
- H. Maintenance Summary:
1. Compile individual Maintenance Summary Form for each applicable equipment item, respective unit or system and for components or sub-units.
 2. Format:
 - a. Use Maintenance Summary Form included with this Section as a guide.
 - b. Use only 8-1/2 by 11-inch size paper for hard copies.
 3. Include detailed lubrication instructions and diagrams showing parts to be greased or oiled, recommended type, grade, and temperature range of lubricants and frequency of lubrication.
 4. Recommended Spare Parts:
 - a. Data to be consistent with manufacturer's Bill of Materials/Parts List furnished with the Operation and Maintenance Data.
 - b. "Unit" is the unit of measure for ordering part.
 - c. "Quantity" is the number of units recommended.
 - d. "Unit Cost" is the current purchase price.

3.2 DATA FOR MATERIALS AND FINISHES

- A. Content for Architectural Products, Applied Materials, and Finishes:
1. Manufacturer's data, giving full information on products:
 - a. Catalog number, size, and composition.
 - b. Color and texture designations.
 - c. Information required for reordering special-manufactured products.
 2. Instructions for Care and Maintenance:
 - a. Manufacturer's recommendation for types of cleaning agents and methods.
 - b. Cautions against cleaning agents and methods that are detrimental to product.
 - c. Recommended schedule for cleaning and maintenance.
- B. Content for Moisture Protection and Weather Exposed Products:
1. Manufacturer's data, giving full information on products:
 - a. Applicable standards.
 - b. Chemical composition.
 - c. Details of installation.
 2. Instructions for inspection, maintenance, and repair.

3.3 SUPPLEMENTS

- A. Sample forms included after “End of Section” are considered part of this Section.
 - 1. Maintenance Summary Form.

END OF SECTION

PROJECT: _____ CONTRACT NO: _____

MANUFACTURER: _____

WEIGHT OF INDIVIDUAL COMPONENTS (Over 100 Pounds)

Manufacturer's Local Representative:

Address: _____

[illegible]

MAINTENANCE SUMMARY FORM (Continued)**LUBRICANT LIST**

Reference Symbol	Mfgr _____	Mfgr _____	Mfgr _____
List symbols used in maintenance requirements	List equivalent lubricants of several manufacturers'		

RECOMMENDED SPARE PARTS FOR OWNER'S INVENTORY

Part No.	Description	Unit	Quantity	Unit Price

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SECTION 01 78 36
WARRANTIES

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes:
 - 1. Information on Product Warranty Certificates.
- B. Contract Drawings.
- C. Related Sections include the following:
 - 1. Section 0700 General Conditions.
 - 2. Section 0800 Supplementary Conditions.
 - 3. Section 01 31 26 Electronic Communication Protocols.
 - 4. Section 01 33 00 Submittal Procedures.
 - 5. Section 01 70 00 Execution Requirements.
 - 6. Section 01 77 00 Closeout Procedures.
 - 7. Section 01 79 00 Demonstration and Training.
 - 8. Warranties required for specific products or work included in individual technical specification Sections.

1.2 SUBMITTALS

- A. Submittals shall be submitted by the CONTRACTOR in accordance with Section 01 33 00.

PART 2 - PRODUCTS

2.1 WARRANTY CERTIFICATES

- A. The CONTRACTOR shall provide all warranty certificates and register the product with the manufacturer.
- B. No warranty shall start prior to Substantial Completion.
- C. Provide the responsible subcontractors, suppliers, and manufacturers' warranties in duplicate, within ten days after completion of the applicable item of work.
- D. List the product model, product serial number, and any additional information required by the manufacturer on each certificate.
- E. Provide a separate letter for each maintenance responsibility transference to include the mutually agreed time and date of the transfer of responsibility.
- F. Provide a copy of the original certificate in lieu of the original certificate in the warranty manual if the manufacturer requires the original copy in lieu of a copy.

2.2 SPECIAL EXTENDED EQUIPMENT WARRANTY

- A. Special Extended Equipment Warranty
 - 1. The SUPPLIER shall jointly warrant to the Owner and Contractor that all equipment, including all components of the complete assembly furnished by it hereunder, complies in all material respects with the design and specifications of these

documents and contains no defects of material or workmanship. In the event of failure of any part or parts of the equipment during the warranty period, due to defects of design, materials, or workmanship, the affected part or parts shall be replaced or repaired at SUPPLIER's option promptly upon notice by the Owner. All replacement parts shall be furnished, delivered, and installed at the expense of the SUPPLIER.

2. Unless specifically stated otherwise, the warranty period shall be interpreted as the 24-month period of beneficial use following substantial completion which includes the 30-day startup period and successful completion of the performance testing of the SUPPLIER-furnished equipment by the Owner as provided below, and shall be exclusive of the time of use of the equipment in installation, testing, adjusting, etc., during the construction period, or of the time in storage, after delivery and prior to installation. All equipment shall be operated for a minimum 30-day startup period and shall successfully complete the performance testing before final acceptance and before the start of the 24-month warranty period. SUPPLIER's warranty, should Contractor be delayed, will not extend beyond five (5) years (for equipment with a 2-year warranty, extend period for equipment with longer warranties) after receipt of purchase order from the Contractor, without adjustment in contract price.
3. If the equipment does not meet the requirements of the Specifications, the SUPPLIER shall correct or service the equipment at no additional cost to Owner, as necessary to meet the specified requirements. In the event the equipment is unable to meet the specified requirements within the warranty period, the equipment SUPPLIER shall refund an amount equal to the original purchase price of the equipment.
4. The Contractor shall be responsible for insuring that the SUPPLIER's special equipment warranty is not voided by acceptance of the terms of purchase agreements between the Contractor and the SUPPLIER. In all events, the Contractor will be held ultimately responsible for enforcement of the requirements of this warranty at his expense.
5. Payment for equipment as "MATERIALS-On-Hand" will not be made until the Owner receives an approved Special Equipment Warranty.

PART 3 - EXECUTION

3.1 PRODUCT WARRANTY

- A. The CONTRACTOR shall fill out all product warranty forms during the manufacturer's required time limit.
 1. Failure to do so may result in the OWNER's loss of standard product coverage in which the CONTRACTOR shall become liable for the same coverage and time limit forfeited due to their omission.
 2. The CONTRACTOR shall notify the OWNER, prior to installation, of all optional extended warranties provided by the manufacturer and make available to the OWNER the opportunity to purchase the extended warranty.
 3. The CONTRACTOR shall insure that all warranty documents, including copies of completed registration forms, are included in the closeout documents into their closeout documents as required by Section 01 70 00.
- B. Warranty pre-expiration equipment review
 1. The CONTRACTOR, OWNER, and ENGINEER shall conduct an on-site review of

equipment and systems covered by warranties.

- a. Refer to the General and Supplementary Conditions.

END OF SECTION

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SECTION 01 78 39
PROJECT RECORD DOCUMENTS

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes administrative and procedural requirements for Project Record Documents, including the following:
 - 1. Record Drawings.
 - 2. Record Specifications.
 - 3. Record Product Data.

1.2 REFERENCES

- A. Preselection Drawings and general provisions of the Contract, including Preselection Special Conditions and Division 01 Specification Sections, apply to this Section.
- B. Related Sections include the following:
 - 1. Section 01 31 26 Electronic Communication Protocols.
 - 2. Section 01 32 16 Construction Progress Schedule.
 - 3. Section 01 32 33 Photographic Documentation.
 - 4. Section 01 33 00 Submittal Procedures.
 - 5. Section 01 70 00 Execution Requirements.
 - 6. Section 01 77 00 Closeout Procedures.
 - 7. Section 01 79 00 Demonstration and Testing.
 - 8. Remaining Sections for specific requirements for Project Record Documents of the Work in those Sections.

1.3 ADMINISTRATIVE REQUIREMENTS – NOT USED

1.4 SUBMITTALS

- A. Record Drawings: Submit one set of marked-up Record Prints.
- B. Record Product Data: Submit one copy of each Product Data submittal.
- C. Submit one copy of marked-up Project Specifications, including addenda and contract modifications.

PART 2 - PRODUCTS

2.1 RECORD DRAWINGS

- A. Record Prints: CONTRACTOR shall maintain one set of blue- or black-line white prints of the Contract Drawings and Shop Drawings.
 - 1. Preparation: Mark Record Prints to show the actual installation where installation varies from that shown originally. Require individual or entity who obtained record data, whether individual or entity is Installer, subcontractor, or similar entity, to prepare the marked-up Record Prints.

- a. Give particular attention to information on concealed elements that would be difficult to identify or measure and record later.
 - b. Record data as soon as possible after obtaining it. Record and check the markup before enclosing concealed installations.
 2. Mark the Contract Drawings or Shop Drawings, whichever is most capable of showing actual physical conditions, completely and accurately. If Shop Drawings are marked, show cross-reference on the Contract Drawings.
 3. Mark record sets with erasable, red-colored pencil. Use other colors to distinguish between changes for different categories of the Work at same location.
 4. Note Construction Change Directive numbers, alternate numbers, Change Order numbers, and similar identification, where applicable.
- B. Format: Identify and date each Record Drawing; include the designation "PROJECT RECORD DRAWING" in a prominent location.
1. Include identification on cover sheets.
 2. Identification: As follows:
 - a. Date.
 - b. Designation "PROJECT RECORD DRAWINGS."
 - c. Name of ENGINEER.
 - d. Name of CONTRACTOR.

2.2 MISCELLANEOUS RECORD SUBMITTALS

- A. Assemble miscellaneous records required by other Specification Sections for miscellaneous record keeping and submittal in connection with actual performance of the Work. Prior to Substantial Completion, complete miscellaneous records and place in good order, properly identified and found or filed, ready for use and reference. Miscellaneous records include, but are not limited to, the following:
1. Field records on excavations and foundations.
 2. Field records on underground construction and similar work.
 3. Surveys showing locations and elevations of underground lines.
 4. Invert elevations of drainage pipes.
 5. Surveys establishing building lines and levels.
 6. Records of equipment testing, start-up, and operation.
 7. Certifications received in lieu of labels on bulk products.
 8. Batch mixing and bulk delivery tickets.
 9. Documented qualifications of installation firms.
 10. Inspections and certification of governing agencies.
 11. Load and performance testing.
 12. Results of pressure testing of lines.
 13. Final inspection and correction procedures.

PART 3 - EXECUTION

3.1 RECORDING AND MAINTENANCE

- A. Recording: Maintain one copy of each submittal during the construction period for Project Record Document purposes. Post changes and modifications to Project Record Documents as they occur; do not wait until the end of Project.

- B. Maintenance of Record Documents and Samples: Store Record Documents and Samples in the field office apart from the Contract Documents used for construction. Do not use Project Record Documents for construction purposes. Maintain Record Documents in good order and in a clean, dry, legible condition, protected from deterioration and loss. Provide access to Project Record Documents for ENGINEER'S reference during normal working hours.

END OF SECTION

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SECTION 01 79 00
DEMONSTRATION AND TRAINING

PART 1 - GENERAL

1.1 SUMMARY

- A. General:
 - 1. Pre-demonstration and demonstration testing, and commissioning of facility, systems, or equipment.
 - 2. Related systems and facility pre-demonstration, demonstration, commissioning period requirements.
 - 3. CONTRACTOR shall pay all costs associated with system or facility pre-demonstration and demonstration work.

1.2 REFERENCES

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 1 Specification Sections, apply to this Section.
- B. Related Sections include the following:
 - 1. Section 01 12 16 Sequence of Construction.
 - 2. Section 01 31 26 Electronic Communication Protocols.
 - 3. Section 01 32 16 Construction Progress Schedule.
 - 4. Section 01 33 00 Submittal Procedures.
 - 5. Section 01 70 00 Execution Requirements.
 - 6. Section 01 77 00 Closeout Procedures.

1.3 DEFINITIONS

- A. Project System: Specific system, consisting of an independent arrangement of equipment, structures, components, piping, wiring, materials, instrumentation, controls, or incidentals that performs an identifiable function which is both operational and safe.
- B. Pre-Demonstration Period: Period of time, prior to and separate from the Demonstration Period of specified duration after initial construction and installation which CONTRACTOR, with assistance from manufacturer's authorized representative(s), completes all work necessary, to make the system ready for the Demonstration Period.
 - 1. Perform the following activities in sequence:
 - a. Initial equipment checkout and start-up.
 - b. Instrument check and final calibration.
 - c. Equipment performance and functional testing in accordance with Division 1 and related technical sections.
 - d. Correction of all discrepancies or functions prior to Demonstration Period.
 - e. Personnel training.
- C. Demonstration Period: Period of time, of specified duration, following the Pre-Demonstration Period, during which CONTRACTOR, with assistance from manufacturer's authorized representative(s), completes all work necessary to complete the Demonstration

Period. The Demonstration period proves the functional integrity and performance-based requirements of the facility or entire project system.

- D. Commissioning Period: Period of time, of specified duration, following the Demonstration Period, during which the OWNER will operate and maintain the Project System with support from the CONTRACTOR.
- E. Related System: Equipment or subsystem whose function is necessary for the pre-demonstration, demonstration, and commissioning of the Project System as a whole.
- F. Project Milestones: Reference Division 1.
- G. Substantial Completion: Reference General Conditions, Supplementary Conditions, and Division 1.

1.4 SUBMITTAL

A. General:

1. Submit in chronological order listed below prior to completion of Pre-Demonstration Period:
 - a. Master pre-demonstration, demonstration, and commissioning schedule:
 - 1) Submit 60 days (minimum) prior to checkout, testing, start-up, and first training session for OWNER's personnel.
 - 2) Schedule to include:
 - a) Target date(s) and time for OWNER witnessing initial start-up of each system.
 - b) Target initiation date and time for Operation and Maintenance training for each system, both field and classroom.
 - c) Target initiation dates for Pre-demonstration and Demonstration Periods.
 - 3) Submit for review and approval by OWNER.
 - 4) Include holidays observed by OWNER.
 - 5) Attend a schedule planning and coordination meeting 45 calendar days prior to first anticipated training session:
 - a) Provide a status report and schedule-to-complete for requirements prerequisite to manufacturer's training.
 - b) Identify initial target dates for individual manufacturer's training sessions.
 - 6) OWNER reserves the right to insist on a minimum 7 days' notice of rescheduled training session not conducted on master schedule target date for any reason.
 - 7) Resubmit schedule until approved.
2. Preliminary O&M Manual Submittal with all revisions incorporated:
 - a. Submit 30 days (minimum) prior to testing of equipment or system.
 - b. In accordance with Section 01 33 00 submit detailed testing procedures for shop tests, field performance tests, and final acceptance tests as specified in the various equipment sections. Submittals shall at a minimum include the

following:

- 1) Test procedures.
 - 2) Copies of test reports.
 - 3) Copies of Supplier's field service technician's reports.
- c. Confirm preliminary O&M manuals with all required revisions and updates are available and in OWNER's possession prior to commencing start-up, testing, and training activities.
3. Substantial Completion Submittal:
- a. File CONTRACTOR 's Notice of Substantial Completion, Request for Inspection, and documentation under provisions of Section 01 70 00.
 - b. Approved Operation and Maintenance manuals received by ENGINEER and OWNER minimum 14 days prior to scheduled training.
 - c. Written request for ENGINEER /OWNER to witness each system pre-demonstration start-up. Request to be received by the ENGINEER a minimum of two weeks before scheduled start-up. A longer lead time may be required to coordinate with OWNER's personnel.
 - d. Equipment installation and pre-demonstration start-up certifications.
 - e. Letter from CONTRACTOR verifying successful completion of all pre-demonstration start-up activities including receipt of all specified items from manufacturers or suppliers as final item prior to initiation of Demonstration Period.
 - f. Letter from CONTRACTOR verifying successful completion of Demonstration Period start-up activities, systems, and equipment start-up.

1.5 SEQUENCING AND SCHEDULING

- A. CONTRACTOR shall submit a sequencing and scheduling plan in accordance with Section 01 33 00 for the starting, demonstration and testing of the project related systems.

1.6 SYSTEM TESTING, START-UP, AND ADJUSTING

- A. Testing Checkout Procedures:
1. Satisfactorily complete and confirm all pipe, equipment, wire, and instrumentation tests as specified in the individual specification sections prior to starting equipment, including checkout by manufacturer's representative.
 2. Coordinate schedule for start-up of various equipment and systems.
 3. Notify the OWNER and ENGINEER 14 days prior to start-up of each item.
 4. Verify that each piece of equipment or system has been checked by manufacturer's representative for proper lubrication, drive rotation, belt tension, control sequence, or other conditions that may cause damage.
 5. Verify that tests, meter readings, and specified electrical characteristics agree with those required by the equipment or system manufacturer.
 6. Verify wiring and support components for equipment are complete and tested.
 7. Execute start-up under supervision of responsible manufacturer's authorized representative in accordance with manufacturers' instructions.

8. When specified in individual specification Sections, require manufacturer to authorize and provide factory trained representative with field experience with the specific piece of equipment to be present at site to inspect, check and approve equipment and system installation prior to start-up, and to supervise placing equipment and system in operation.
 9. Submit a written report in accordance with Section 01 33 00 that equipment or system has been properly installed and is functioning correctly.
- B. Start-up Procedures:
1. Start-up divided into two periods:
 - a. Pre-Demonstration Period including performance of the following activities in sequence:
 - 1) Completion of Work to prepare facility, systems, and equipment for Demonstration Period including installation and testing checkout of all equipment by manufacturer's representative.
 - 2) Submission, resubmission as may be required and filing of all required submittals including but not limited to:
 - a) Preliminary O&M Manuals.
 - b) Equipment checklists.
 - c) Loop checks.
 - d) Calibration records.
 - 3) Training of personnel.
 - 4) Start-up of equipment and project systems.
 - 5) Start-up of entire project system or facility.
 - b. Demonstration Period including:
 - 1) Demonstration of functional integrity and performance-based requirements of facility or entire project system.
 - 2) Review of approved preliminary O&M Manuals with OWNER.
 - 3) Training of personnel.
 - 4) Filing of CONTRACTOR's Notice of Substantial Completion and Request for Inspection.
 2. Operation and Maintenance Manuals for equipment and system scheduled for start-up and training.
 - a. Prepare and submit manuals prior to delivery of equipment and systems as specified.
 - b. Confirm O&M manuals with all required revisions and updates are available and in OWNER's possession prior to commencing training activities.
 - c. Pre-demonstration and demonstration period operations are not considered complete, nor will pre-demonstration and demonstration period payments be made, until the manufacturer's authorized representative completely and thoroughly reviews the approved O&M manual with OWNER during the equipment training session.
 - d. Requirements for individual components may vary with construction staging,

time, performance testing stipulations, construction schedule, etc. Individual equipment start-up and performance testing requirements may exceed the Related System Demonstration Period requirement.

PART 2 - PRODUCTS – NOT APPLICABLE

PART 3 - EXECUTION

3.1 MANUFACTURER'S FIELD SERVICES

A. Services Required:

1. Services with Equipment and Materials Furnished Under this Contract:

- a. Furnish the services of qualified field personnel from the Suppliers or manufacturers of Equipment furnished and installed under this Contract, as required to perform all manufacturer's Field Services called for in the Specifications. Field personnel shall be certified by the Supplier or manufacturer of the specific product or system as having the necessary knowledge and experience to perform the required functions.
- b. Where such service is specified, CONTRACTOR shall not perform any Work related to the installation or operation of Equipment furnished and installed under this Contract without direct observation and guidance of the Supplier's or manufacturer's field personnel unless ENGINEER concurs otherwise.
- c. CONTRACTOR shall arrange for the Supplier's or manufacturer's field personnel to perform the following:
 - 1) Observe the erection, installation, start-up and testing of Equipment.
 - 2) Instruct and guide OWNER in proper procedures.
 - 3) Supervise the initial start-up, operational checkout, and any required adjustments of Equipment.
 - 4) Train OWNER's designated personnel in proper operation and maintenance of all Equipment.
 - 5) Furnish a written report to ENGINEER covering all Work done at least once each week and when Work on each item of Equipment or system is completed.
- d. Advise OWNER and ENGINEER of arrival at the Site of all Supplier's and manufacturer's field personnel.

B. Operation and Testing:

1. Place all Equipment in Operation:

- a. Place all Equipment installed under this Contract into successful operation according to instructions of the Supplier, manufacturer, or field representative, including making all required adjustments, tests, operation checks, and the following:
 - 1) Cleaning, sounding, blowing out, and flushing of lubricating oil and water systems, and other pipelines.
 - 2) Lubrication.
 - 3) Tests of lubrication system safety interlocks and system performance.

- 4) Final alignment checks and measurements made under observation of OWNER. Alignment checks shall include opening connections, if required, to ensure there are no abnormal stresses on Equipment from pipes, ducts, or other attachments. Alignment shall be within tolerances specified by the manufacturer, and measurements shall be recorded and furnished to ENGINEER and OWNER.
 - 5) Motor rotation checks before connecting couplings.
 - 6) Inspection of sleeve bearings for adequate contact.
 - 7) Checking of anchor-bolt tensions, trout, and shims. Tighten anchor bolts with calibrated torque wrenches using care not to over stress bolts.
 - b. After “run-in” and acceptance of alignment, affix major Equipment in place using standard tapered dowels with jack-out nuts at head end to facilitate removal.
 - c. Record all above operations on forms furnished by ENGINEER.
 - d. Furnish all necessary attendants and personnel as part of the work to accomplish the above operations until such time as individual items, systems, Equipment, or sections of the plant are acceptable for operation by OWNER.
 - e. Provide attendants on a continuous basis as required to complete events without interruption once they have been started.
 - f. CONTRACTOR shall provide fuel, electricity, water, and lubricants for placing Equipment in operation. OWNER’s operating personnel will assist.
2. Performance Tests:
- a. Equipment Furnished Under this Contract:
 - 1) OWNER may conduct pre-demonstration tests after installation to determine if the Equipment installed as part of the work perform in accordance with Contract Documents. Substantial Completion will be based on acceptable results of such tests.
 - 2) No tests will be conducted on Equipment for which Supplier’s or manufacturer’s Field Service is specified unless Supplier’s or manufacturer’s field representative is present and declares in writing that the Equipment is ready for such test.
 - 3) CONTRACTOR will be notified by OWNER so that CONTRACTOR can have a representative or manufacturer’s representative present during any tests of Equipment for which Supplier’s or manufacturer’s Field Service is not specified.
 - b. The tests will be made as set forth in the Contract Documents unless the interested parties mutually agree upon some other manner of testing.

3.2 TESTING, ADJUSTING, AND BALANCING

- A. Perform testing, adjusting, and balancing in accordance with the requirements of the individual equipment Sections.
- B. Reports will be submitted by an independent firm to the ENGINEER indicating observations and results of tests and indicating compliance or non-compliance with specified requirements and with the requirements of the Contract Documents.

C. SCADA / Controls Testing:

1. General requirements:

- a. Test and inspect equipment and partially completed or fully completed portions of the work to prove compliance with Contract requirements.
- b. Unless otherwise noted, CONTRACTOR to pay all costs of testing, including temporary facilities and connections.
- c. Test the following:
 - 1) Equipment with one or more moving parts or devices requiring an electrical, pneumatic, or hydraulic connection.
 - 2) Testing and balance for heating, ventilation, and air conditioning Systems as specified in the Contract Documents.
 - 3) Electrical devices and Systems as specified in accordance with the Contract Documents.
 - 4) Instrumentation devices and Systems as specified in the Contract Documents.
- d. Receive Project Representative Approval for the application of all tests only after Project Representative Inspection of equipment for conformance with the Specifications.
- e. Tests and inspections, unless otherwise specified or accepted, shall be in accordance with the recognized standards of the industry.
- f. Provide the ENGINEER unrestricted access to attend and witness Component Testing.
- g. Allow the ENGINEER unrestricted access to undertake System and Operational Testing and to support Commissioning.

2. Procedures:

- a. Design testing procedures to duplicate, as nearly as possible, conditions of operation to insure that the equipment is not damaged. Once the testing procedures have been reviewed and approved by the Project Representative, organize by System into test packages and include the proper checkout, alignment, adjustment, and calibration signoff forms for each item of equipment and System.
- b. Jointly use forms with the Project Representative to ensure that documentation for each electrical, mechanical, and instrumentation equipment item has been properly recorded for installation and testing. Failure to follow the Project Representative approved procedure will result in non-acceptance of the equipment.
- c. Fulfillment of the test and inspection requirements are by either of the following:
 - 1) Tests and inspections carried out in Project Representative's presence, or
 - 2) Certificates or reports of tests and inspections carried out by Project Representative approved persons or organizations.
- d. Maintain the test packages, which contain tests and sign-off forms including, but not limited to, piping, equipment, electrical, and instrumentation. Submit

test packages to the OWNER for inspection upon request.

3. Phases:

a. Pre-demonstration period Test Phase:

- 1) Test items at the place of manufacture during or on completion of manufacture. Tests are comprised of hydraulic pressure tests, electric and instrumentation subsystem tests, performance and operating tests and inspections.
- 2) Perform in accordance with the relevant standards of the industry if not specified in the Contract Documents. Tests other than those specified are in accordance with General Conditions.
- 3) When items are delivered to the site, remove all coverings, containers, or crates to permit the Project Representative to conduct the inspection to determine if the items are of the specified quality and workmanship, and are visually in good order and condition at the time of delivery. Should the Project Representative find, in his/her opinion, indication of damage or deficient quality of workmanship, provide the necessary documentation or conduct such tests to demonstrate compliance.
- 4) Leakage tests and other piping tests as specified in the Contract Documents.

b. Component Test Phase:

- 1) Vendor and Installation CONTRACTOR shall perform component testing as described in this Section.
- 2) Test equipment to the specified requirements before it is placed into operation.
- 3) Incorporate requirements of the Specifications into the installed tests and inspection procedures and proceed in a logical, stepwise sequence to ensure that the installed equipment has been properly assembled, serviced, aligned, adjusted, connected, and calibrated prior to operation.
- 4) Perform all changes, adjustments, or replacements required to make the equipment operate.
- 5) Piping system pressure testing and cleaning as specified in the Contract Documents.
- 6) Electrical system testing as specified in the Contract Documents.
- 7) Instrumentation system testing as specified in the Contract Documents.
- 8) Preparing and completing a checklist to verify PLC discrete and analog outputs are connected to field devices.
- 9) Preparing and completing a checklist to verify discrete and analog inputs from field devices update PLC memory registers.
- 10) Testing, checking and correcting deficiencies of:
 - a) Power, control, and monitoring circuits for continuity prior to connection to power source.
 - b) Voltage of all circuits.

- c) Phase sequence.
- d) Cleanliness of connecting piping systems.
- e) Alignment of connected machinery.
- f) Vacuum and pressure of all closed systems.
- g) Lubrication.
- h) Valve orientation and position status for manual operating mode.
- i) Tankage integrity using clean water.
- j) Instrumentation and control signal generation, transmission, reception, and response.
- k) Tagging and identification systems.
- l) Proper connections, alignment, calibration, and adjustment.
- m) Calibrate all safety equipment.
- n) Manually rotate or move moving parts to assure freedom of movement.
- o) Bump electric motors to verify power and direction of rotation.
- p) Demonstrate that limit switches have been calibrated.
- 11) Perform other tests, checks, and activities required to make component ready for System Test Phase.
- c. System Test Phase:
 - 1) CONTRACTOR will provide System Testing schedule.
 - 2) CONTRACTOR to provide all utilities, testing media, waste disposal, potable water, fuel, power, and chemicals required to complete System Testing.
 - 3) CONTRACTOR to repair all defects discovered on installed Equipment during testing.
 - 4) CONTRACTOR to be available to provide immediate assistance 24 hours per day, seven days per week, in case of failure of a portion of the System being tested.
- d. Demonstration Period Test Phase:
 - 1) Project Representative will provide Test Schedule. The duration is defined in 3.4.A.
 - 2) Provide all utilities, testing media, waste disposal, potable water, fuel, power, and chemicals required to complete Operation Testing.
 - 3) Repair all defects on CONTRACTOR installed Equipment discovered during the Operation Testing.
 - 4) Be available to provide immediate assistance 24 hours per day, seven days per week, in case of failure of a portion of the Facility.
 - 5) See Section 01 70 00.

3.3 PRE-DEMONSTRATION PERIOD

- A. As required to meet the project requirements, perform Pre-Demonstration as defined below:

1. Equipment Start-up:
 - a. Requirements for individual items of equipment are included in the Contract Documents.
 - b. Prepare equipment to operate properly and safely and be ready to demonstrate functional integrity during Demonstration Period.
 - c. Perform equipment start-up to extent possible without introducing product flow.
 - d. Test tanks, pumps, filters, and similar equipment requiring fluid, using clean water supplied at CONTRACTOR's expense.
 - e. Dispose of water used for equipment start-up.
 - f. Prior to equipment startup:
 - 1) Conduct leak and pressure testing of all tanks and piping. Remove or flush debris, and clean systems.
 - 2) Check and confirm that all instrument and control loops are operational.
 - 3) Complete all electrical system checks.
 - 4) Make all submissions and resubmissions of manufacturer field reports, check lists, loop checks, calibration records and equipment installation certifications.
 - 5) Make all submissions and resubmissions of preliminary O&M manuals.
 - g. Procedures include, but are not necessarily limited to the following:
 - 1) Test, check and correct deficiencies of:
 - a) Power, control, and monitoring circuits for continuity prior to connection to power source.
 - b) Voltage of all circuits.
 - c) Phase sequence.
 - d) Cleanliness of connecting piping systems.
 - e) Alignment of connected machinery.
 - f) Vacuum and pressure of all closed systems.
 - g) Lubrication.
 - h) Valve orientation and position status for manual operating mode.
 - i) Tankage for integrity using clean water Pumping equipment using clean water.
 - j) Equipment operates within ranges specified and within manufacturers' acceptable limits.
 - k) Instrumentation and control signal generation, transmission, reception, and response under provisions of Section 01 33 00.
 - l) Tagging and identification systems.
 - m) All equipment: Proper connections, alignment, calibration, and adjustment.
 - 2) Calibrate all safety equipment.
 - 3) Manually rotate movable parts to assure freedom of movement.

- 4) "Bump" start electric motors to verify proper rotation.
 - 5) Perform other tests, checks, calibration, and activities required to make equipment ready for Demonstration Period.
 - 6) Provide all labor, supervision, calibrated instruments, calibrated measuring devices, utilities, chemicals, maintenance, equipment, vehicles, or any other item necessary to start-up and operate all equipment and systems.
 - 7) Perform other tests, checks, and activities required to make equipment ready for Demonstration Period.
 - 8) Documentation:
 - a) Prepare log showing each equipment item subject to this paragraph and listing what is to be accomplished during equipment start-up.
 - i. Make all submissions and resubmissions required of preliminary log to ENGINEER prior to scheduling and performing start-up activities.
 - b) Provide place for CONTRACTOR to record date and person accomplishing required work. Submit completed document before requesting inspection for Substantial Completion certification.
- h. Clean Water Testing:
- 1) Individual pieces of equipment.
 - a) Perform testing for all individual pieces of equipment.
 - b) Provide minimum 1 hour testing duration demonstrating successful continuous operation of each piece of equipment as instructed by and coordinated with ENGINEER.
 - c) Cycle equipment through its full specified range of operation a minimum of five times during testing duration.
 - d) Cycle equipment through its full capable range of operation a minimum of five times during testing duration.
 - e) Contractor will be responsible for any temporary equipment, piping or wiring required to perform these tests.
 - 2) Equipment Systems:
 - a) Testing shall be performed for all systems of equipment. Testing shall include the supporting systems, electrical, controls and instrumentation for the equipment defined below even if they are not specifically identified.
 - b) System testing to commence only following successful clean water testing of individual pieces of equipment.
 - c) Provide minimum 1 hour testing duration demonstrating successful continuous operation of each system as determined by and coordinated with ENGINEER.
 - d) Cycle equipment through its full specified range of operation a minimum of five times during testing duration.

- e) Cycle equipment through its full capable range of operation a minimum of five times during testing duration.
- f) Operate and cycle all pieces of equipment comprising system at same time during the test, or as instructed by and coordinated with the ENGINEER.
- g) Increase and decrease equipment speeds at the same time and rate, or as instructed by and coordinated with ENGINEER.
- i. Obtain certifications, without restrictions or qualifications, and deliver to ENGINEER:
 - 1) Manufacturer's equipment installation and start-up checkout letters.
 - 2) Instrumentation supplier's instrumentation installation and start-up certificate(s).

3.4 DEMONSTRATION PERIOD

- A. Demonstrate operation and maintenance of Products to OWNER 's personnel and ENGINEER within 14 days prior to date of Substantial Completion unless specified otherwise by requirements of construction sequencing per Section 01 10 00.
- B. Utilize operation and maintenance manuals as basis for instruction. Review contents of manual with OWNER s' personnel in detail to explain all aspects of operation and maintenance.
- C. Demonstrate start-up, operation, control, adjustment, troubleshooting, servicing, maintenance, and shutdown of each item of equipment at scheduled times, at equipment location.
- D. Demonstrate the functional integrity of the mechanical, electrical, and control interfaces of the respective equipment and components comprising the facility or system as evidence of an element of Substantial Completion.
- E. During the Demonstration Period, if the aggregate amount of time used for repair, alteration, or unscheduled adjustments to any equipment or systems renders the affected equipment or system inoperative exceeding specification requirements or 10 percent of the Demonstration Period, the demonstration of functional integrity will be deemed to have failed. In the event of failure, a new Demonstration Period will recommence after correction of the cause of failure. The new Demonstration Period shall have the same requirements and duration as the Demonstration Period previously conducted.
- F. Conduct the demonstration of functional integrity under full operational conditions.
- G. OWNER will provide operational personnel to process decisions affecting plant performance. OWNER's, ENGINEER's, and OWNER consultants' assistance will be available only for process decisions. CONTRACTOR will perform all other functions including but not limited to equipment operation and maintenance until successful completion of the Demonstration Period.
- H. OWNER reserves the right to simulate operational variables, equipment failures, routine maintenance scenarios, etc., to verify the functional integrity of automatic and manual backup systems and alternate operating modes.
- I. Provide knowledgeable personnel to answer OWNER's questions throughout the

Demonstration Period.

- J. Provide final field instruction on select systems and respond to any system problems or failures which may occur.
- K. Provide all labor, supervision, utilities, chemicals, maintenance, equipment, vehicles, or any other item necessary to operate and demonstrate all systems being demonstrated.
- L. One successful demonstration period as defined above is required for each system defined herein, in accordance with Section 01 10 00 and individual technical sections.
- M. Demonstration periods and other start-up requirements for individual system components may or may not be concurrent with Related Systems Demonstration Period.
- N. Duration of Demonstration Period:
 - 1. Time of beginning and ending of any Demonstration Period will be agreed upon by CONTRACTOR, OWNER, and ENGINEER in advance of initiating Demonstration Period.
 - 2. Related Systems Demonstration Period to adhere to requirements of technical specifications. Project System Demonstration Period to be 3 consecutive days, unless stated otherwise in the technical specifications.
 - 3. Time requirements for Manufacturer's authorized field representative to be onsite are in addition to the durations listed in respective equipment specification sections of the Contract Documents.
 - 4. Demonstration period may be shortened at the discretion of the ENGINEER and OWNER if the whole Project System is demonstrated to be fully functional and operational in automatic mode to the satisfaction of the OWNER.
 - 5. In the event of an interruption during Demonstration Period due to any of the following event's period shall be extended by the duration of the interruption plus the time required to re-attain operating conditions in effect at the time of the interruption and data recorded during that period shall not be included:
 - a. Power interruption in excess of 60 minutes per day.
 - b. Mechanical or electrical failure of the systems for more than 2 hours.
 - c. Any influent or operating parameter outside the accepted operating ranges defined in this specification.
 - 6. Shortening of the Related Systems Demonstration Period does not reduce, nor relieve the CONTRACTOR of demonstrating, start-up, and testing requirements of individual pieces of equipment.
- O. Failure of Demonstration:
 - 1. If the aggregate amount of time to repair, alter or adjust individual equipment or systems result in equipment or systems being inoperable for 60 percent or greater of the Related Systems Demonstration Period, the demonstration of functional integrity will be deemed to have failed.
 - 2. In the event of failure, the Related Systems Demonstration Period will recommence after correction of the cause(s) of failure.
 - 3. Upon recommencing the Related Systems Demonstration Period, requirements and duration of start-up shall be the same as the initial attempt to demonstrate

functionality.

4. Coordination and completion of a subsequent Related Systems Demonstration Period due to equipment failure or absence of required key personnel shall be conducted at no additional expense to the OWNER.
5. Successful completion of Related Systems Demonstration Period is required per Section 01 10 00 for continuation of construction schedule. No additional contract time will be granted for time lost due to failure of Related Systems Demonstration Period.

3.5 PERSONNEL TRAINING

- A. Reference individual equipment specification sections.
- B. Conduct all personnel training after completion of equipment start-up for the equipment for which training is being conducted:
 1. Personnel training on individual equipment or systems will not be considered completed unless:
 - a. All pre-training deliverables are received and approved before commencement of training on the individual equipment or system.
 - b. No system malfunctions occur during training.
 - c. All provisions of field and classroom training specifications are met.
 2. Training not in compliance with the above will be performed again in its entirety by the manufacturer at no additional cost to OWNER.
- C. Field and Classroom Training Requirements:
 1. Digitally record each training session using video media in accordance with the Contract Documents and submit per the requirements of the Contract Documents and classroom training requirements:
 - a. Hold classroom training on-site.
 - b. Notify each manufacturer specified for on-site training that OWNER reserves the right to video record any or all training sessions. Organize each training session in a format compatible with video recording.
 - c. Training instructor: Factory trained and familiar with giving both classroom and "hands-on" instructions.
 - d. Training instructors: Be at classes on time. Session beginning and ending times to be coordinated with the OWNER and indicated on the master schedule. Normal time lengths for class periods can vary; schedule and take brief rest breaks.
 - e. Organize and separate training sessions by maintenance and operation topics and identify on schedule.
 - f. Plan for minimum class attendance of 10 people at each session and provide sufficient classroom materials, samples, and handouts for those in attendance.
 - g. Instructors to have a typed agenda and well-prepared instructional material. The use of visual aids, e.g., films, pictures, and slides is recommended for use during the classroom training programs. Deliver agendas to the ENGINEER a minimum of 7 days prior to the classroom training. Provide equipment

- required for presentation of films, slides, and other visual aids.
- h. Cover information required in Operation and Maintenance manuals submitted according to Section 01 33 00 and following areas as applicable to project systems:
 - 1) Operation of equipment.
 - 2) Lubrication of equipment.
 - 3) Maintenance and repair of equipment.
 - 4) Troubleshooting of equipment.
 - 5) Preventive maintenance procedures.
 - 6) Adjustments to equipment.
 - 7) Inventory of spare parts.
 - 8) Optimizing equipment performance.
 - 9) Capabilities.
 - 10) Operational safety.
 - 11) Emergency situation response.
 - 12) Takedown procedures (disassembly and assembly).
 - i. Address above paragraphs a), b), h), i), j) and k) in the operation sessions.
 - j. Address above paragraphs c), d), e), f), g), and l) in the maintenance sessions.
 - k. Maintain a log of classroom training provided including Instructors, topics, dates, time, and attendance.
 - l. Complete filing of all required submittals:
 - 1) Shop Drawings.
 - 2) Operation and Maintenance Manuals.
 - 3) Training material.

3.6 CONTRACTOR'S SUBSTANTIAL COMPLETION NOTICE AND REQUEST FOR INSPECTION OF PROJECT OR PRS

- A. File the notice when the following have been completed:
 - 1. Construction work (brought to state of Substantial Completion).
 - 2. Equipment Start-up (pre-demonstration and demonstration periods).
 - 3. Personnel Training.
 - 4. Submittal and approval of required documents.
- B. ENGINEER will review required submittals for completeness within 5 calendar days of CONTRACTOR's notice. If complete, ENGINEER will complete inspection of the Work, within 10 calendar days of CONTRACTOR's notice.
- C. ENGINEER will inform CONTRACTOR in writing of the status of the Work reviewed, within 14 calendar days of CONTRACTOR's notice.
 - 1. Work determined not meeting state of Substantial Completion:
 - a. CONTRACTOR: Correct deficiencies noted or submit plan of action for correction within 5 days of ENGINEER's determination.
 - b. ENGINEER: Reinspect work within 5 days of CONTRACTOR's notice of

- correction of deficiencies.
- c. Reinspection costs incurred by ENGINEER will be billed to OWNER who will deduct them from final payment due CONTRACTOR.
- 2. Work determined to be in state of tentative Substantial Completion: ENGINEER to prepare tentative "ENGINEER 's Certificate of Substantial Completion."
- 3. ENGINEER 's Certificate of Substantial Completion:
 - a. Certificate issued subject to successful Demonstration of functional integrity.
 - b. Issued for Project as a whole or for one or more PRS.
 - c. Issued subject to completion or correction of items cited in the certificate (punch list).
 - d. Issued with responsibilities of OWNER and CONTRACTOR cited.
 - e. Executed by ENGINEER.
 - f. Accepted by OWNER.
 - g. Accepted by CONTRACTOR.
- D. Upon successful completion of Demonstration Period, ENGINEER will endorse certificate attesting to the successful demonstration, and citing the hour and date of ending the successful Demonstration Period of functional integrity as the effective date of Substantial Completion pending the completion of the personnel training and the submittal of required documents.
- E. Prepare and insert additional data in operations and maintenance manuals when the need for additional data becomes apparent during instruction.
- F. The amount of time required for instruction on each item of equipment and system is that specified in individual sections.

3.7 COMMISSIONING

- A. Upon OWNER acceptance of the ENGINEER's Certificate of Substantial Completion, the OWNER will begin operating the Facility during the Commissioning period.
- B. Prior to start of Commissioning, CONTRACTOR shall remove temporary piping that may have been in use during the demonstration period.
- C. CONTRACTOR to provide required labor to support OWNER in order that the Facility attains its fully operational mode.
- D. The OWNER's operations and maintenance personnel will be responsible for operation of the Facility or portion thereof. The Facility shall be fully operational, capable of accepting design parameters, and performing functions as designed.
- E. The OWNER is responsible for normal operational and routine maintenance cost including, but not limited to, electricity, lubricants, and screenings disposal fees.
- F. CONTRACTOR shall be responsible for all costs for necessary repairs or replacements required to keep the Facility operational.
- G. CONTRACTOR shall be available to provide immediate assistance 24 hours per day, seven days per week, in case of failure of a portion of the System being operated.
- H. Upon OWNER acceptance of the ENGINEER's Certificate of Substantial Completion, the

Commissioning period is 30 continuous days for all Related Systems for the Facility.

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SECTION 02 41 19
SELECTIVE DEMOLITION

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes the following selective demolition work when shown on the Drawings:
 - 1. Demolition and removal of selected portions of building or structure.
 - 2. Demolition and removal of selected site elements.
 - 3. Salvage of existing items to be reused or recycled by CONTRACTOR or OWNER.

1.2 REFERENCES

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 1 Specification Sections, apply to this Section.
- B. Definitions
 - 1. Remove: Detach items from existing construction and legally dispose of them off-site, unless indicated to be removed and salvaged or removed and reinstalled.
 - 2. Remove and Salvage: Detach items from existing construction and deliver them to OWNER.
 - 3. Remove and Reinstall: Detach items from existing construction, prepare them for reuse, and reinstall them where indicated.
 - 4. Existing to Remain: Existing items of construction that are not to be removed and that are not otherwise indicated to be removed, removed, and salvaged, or removed and reinstalled.
- C. Related Sections
 - 1. Section 31 10 00 - Site Clearing: site clearing and removal of above- and below-grade improvements.

1.3 SUBMITTALS

- A. Schedule of Selective Demolition Activities: Indicate detailed sequence of selective demolition and removal work, with starting and ending dates for each activity, interruption of utility services, existing building access, and locations of temporary partitions and means of egress.
- B. Pre-demolition Photographs: Show existing conditions of adjoining construction and site improvements, including finish surfaces, which might be misconstrued as damage caused by selective demolition operations. Comply with Section 01 32 00. Submit before Work begins.
- C. Landfill Records: Indicate receipt and acceptance of hazardous wastes by a landfill facility licensed to accept hazardous wastes.

1.4 QUALITY ASSURANCE

- A. Demolition Firm Qualifications: An experienced firm that has specialized in demolition work similar in material and extent to that indicated for this Project.
- B. Regulatory Requirements: Comply with governing EPA notification regulations before beginning selective demolition. Comply with hauling and disposal regulations of authorities having jurisdiction.

- C. Standards: Comply with ANSI A10.6 and NFPA 241.
- D. Pre-demolition Conference: Conduct conference at Project site.

1.5 SITE CONDITIONS

- A. OWNER may occupy portions of structures or treatment units immediately adjacent to selective demolition area. Conduct selective demolition so OWNER'S operations will not be disrupted.
- B. OWNER will maintain conditions existing at time of inspection for bidding purpose as far as practical.
- C. Before selective demolition, CONTRACTOR shall coordinate with OWNER for OWNER to effectively remove the portion to be demolished from service and to remove any materials or supplies located in these areas.
- D. Notify ENGINEER of discrepancies between existing conditions and Drawings before proceeding with selective demolition.
- E. Hazardous Materials: It is unknown whether hazardous materials will be encountered in the Work.
 - 1. If materials suspected of containing hazardous materials are encountered, do not disturb; immediately notify ENGINEER and OWNER. OWNER will remove hazardous materials under a separate contract.
- F. Storage or sale of removed items or materials on-site is not permitted.
- G. Salvageable material such as metal staircases may be retained by OWNER, if desired. OWNER has first right of refusal.
- H. Utility Service: Maintain existing utilities indicated to remain in service and protect them against damage during selective demolition operations.
 - 1. Maintain fire-protection facilities in service during selective demolition operations.

1.6 WARRANTY

- A. Existing Warranties: Remove, replace, patch, and repair materials and surfaces cut or damaged during selective demolition, by methods and with materials so as not to void existing warranties.

PART 2 - EXECUTION

2.1 EXAMINATION

- A. Verify that utilities have been disconnected and capped.
- B. Survey existing conditions and correlate with requirements indicated to determine extent of selective demolition required.
- C. Inventory and record the condition of items to be removed and reinstalled and items to be removed and salvaged.
- D. When unanticipated mechanical, electrical, or structural elements that conflict with intended function or design are encountered, investigate and measure the nature and extent of conflict. Promptly submit a written report to ENGINEER.
- E. Survey of Existing Conditions: Record existing conditions by use of preconstruction

photographs.

1. Comply with requirements specified in Section 01 32 00.

- F. Perform surveys as the Work progresses to detect hazards resulting from selective demolition activities.

2.2 UTILITY SERVICES AND MECHANICAL/ELECTRICAL SYSTEMS

- A. Existing Services/Systems: Maintain services/systems indicated to remain and protect them against damage during selective demolition operations.
- B. Service/System Requirements: Locate, identify, disconnect, and seal or cap off indicated utility services and mechanical/electrical systems serving areas to be selectively demolished.
 1. Arrange to shut off indicated utilities with utility companies.
 2. If services/systems are required to be removed, relocated, or abandoned, before proceeding with selective demolition provide temporary services/systems that bypass area of selective demolition and that maintain continuity of services/systems to other parts of building.
 3. Cut off pipe or conduit in walls or partitions to be removed. Cap, valve, or plug and seal remaining portion of pipe or conduit after bypassing.

2.3 PREPARATION

- A. Site Access and Temporary Controls: Conduct selective demolition and debris-removal operations to ensure minimum interference with roads, streets, walks, walkways, and other adjacent occupied and used facilities.
 1. Comply with requirements for access and protection specified in Section 01 50 00.
- B. Temporary Facilities: Provide temporary barricades and other protection required to prevent injury to people and damage to adjacent buildings and facilities to remain.
- C. Temporary Shoring: Provide and maintain shoring, bracing, and structural supports as required to preserve stability and prevent movement, settlement, or collapse of construction and finishes to remain, and to prevent unexpected or uncontrolled movement or collapse of construction being demolished. Refer to Section 31 23 16.

2.4 SELECTIVE DEMOLITION

- A. General: Demolish and remove existing construction only to the extent required by new construction and as indicated. Use methods required to complete the Work within limitations of governing regulations and as follows:
 1. Neatly cut openings and holes plumb, square, and true to dimensions required. Use cutting methods least likely to damage construction to remain or adjoining construction. Use hand tools or small power tools designed for sawing or grinding, not hammering, and chopping, to minimize disturbance of adjacent surfaces. Temporarily cover openings to remain.
 2. Cut or drill from the exposed or finished side into concealed surfaces to avoid marring existing finished surfaces.
 3. Do not use cutting torches until work area is cleared of flammable materials. At concealed spaces, such as duct and pipe interiors, verify condition and contents of hidden space before starting flame-cutting operations. Maintain portable fire-suppression devices during flame-cutting operations.

4. Locate selective demolition equipment and remove debris and materials so as not to impose excessive loads on supporting walls, floors, or framing.
 5. Dispose of demolished items and materials promptly.
- B. Removed and Salvaged Items:
1. Clean salvaged items.
 2. Pack or crate items after cleaning. Identify contents of containers.
 3. Store items in a secure area until delivery to OWNER.
 4. Transport items to OWNER'S storage area designated by OWNER.
 5. Protect items from damage during transport and storage.
- C. Removed and Reinstalled Items:
1. Clean and repair items to functional condition adequate for intended reuse. Paint equipment to match new equipment.
 2. Pack or crate items after cleaning and repairing. Identify contents of containers.
 3. Protect items from damage during transport and storage.
 4. Reinstall items in locations indicated. Comply with installation requirements for new materials and equipment. Provide connections, supports, and miscellaneous materials necessary to make item functional for use indicated.
- D. Existing Items to Remain: Protect construction indicated to remain against damage and soiling during selective demolition. When permitted by ENGINEER, items may be removed to a suitable, protected storage location during selective demolition and cleaned and reinstalled in their original locations after selective demolition operations are complete.
- E. Damage outside selective demolition: CONTRACTOR damage to existing structures, utilities or facilities outside of the selective demolition areas shall be replaced in-kind at the expense of the CONTRACTOR.

2.5 HAZARDOUS MATERIALS

- A. This Section does not address removal of hazardous materials or substances such as asbestos or polychlorinated biphenyls (PCBs). If these materials or substances are or could be found on-site, stop work in the area and notify the OWNER and ENGINEER.
- B. OWNER will contract with a licensed remediation or abatement firm to determine if dangerous materials exist in the demolition area. If they exist, the firm will proceed with the removal.
- C. PCBs are heavy, oil-like liquids or solids, clear to yellow in color, produced in the U.S. from 1929 to 1977; their manufacturer banned in 1979. PCBs were used as dielectric fluids in electrical transformers, capacitors, and fluorescent light ballasts, also in adhesives and caulking compounds.
- D. Asbestos used in many construction products was banned in 1978. In construction completed before 1978, asbestos is typically found in four forms; as sprayed- or troweled-on surfaces for ceilings or walls; as the thermal insulation around pipes or ducts; as fire proofing on structural members; and in various materials, such as shingles, roofing tiles, and gypsum board patching compounds.

2.6 DISPOSAL OF DEMOLISHED MATERIALS

- A. General: Except for items or materials indicated to be reused, salvaged, reinstalled, or otherwise indicated to remain OWNER'S property, remove demolished materials from Project site and legally dispose of them in an approved landfill.
- B. Burning: Do not burn demolished materials.
- C. Disposal: Transport demolished materials off OWNER'S property and legally dispose them.

2.7 CLEANING

- A. Clean adjacent structures and improvements of dust, dirt, and debris caused by selective demolition operations. Return adjacent areas to condition existing before selective demolition operations began.

END OF SECTION

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**SECTION 03 11 00
CONCRETE FORMING**

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Forming for cast-in-place concrete.
- B. Related Sections:
 - 1. Section 03 15 13 – Waterstops.
 - 2. Section 03 60 00 – Grouting.

1.2 REFERENCES

- A. American Concrete Institute (ACI):
 - 1. 347 – Recommended Practice for Concrete Formwork.

1.3 DEFINITIONS

- A. In accordance with ACI 116R.

1.4 SUBMITTALS

- A. Product Data:
 - 1. Submit manufacturer's descriptive literature and product specifications for each product.

1.5 QUALITY ASSURANCE

- A. Reference Section 03 30 00.

1.6 DELIVERY, STORAGE AND HANDLING

- A. Acceptance at Site:
 - 1. Inspect for damage upon delivery. Reject damaged materials.
- B. Storage and Protection:
 - 1. Follow manufacturer's instructions.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Prefabricated Forms:
 - 1. The Burke Company.
 - 2. Symons – Dayton Superior.
 - 3. UFP Concrete Forming Systems.
 - 4. Or ENGINEER Approved Equivalent.

- B. Form Coating:
 - 1. The Burke Company.
 - 2. L&M Construction Chemicals.
 - 3. Protex.
 - 4. Or ENGINEER Approved Equivalent.
- C. Form Ties:
 - 1. The Burke Company.
 - 2. Or ENGINEER Approved Equivalent.

2.2 MATERIALS

- A. Forms:
 - 1. Plywood: PS 1, waterproof resin-bonded, exterior type Douglas Fir; face adjacent to concrete Grade B.
 - 2. Fiberboard: FS LL-B-810, Type IX, tempered, waterproof, screen back, concrete form hardboard.
 - 3. Lumber: Straight, uniform width and thickness: and free from knots, offsets, holes, dents, and other surface defects.
 - 4. Chamfer strips: Clear, white pine, surface against concrete planed.
 - 5. Form ties: Removable end, permanently embedded body types with waterstops not requiring auxiliary spreaders, with cones on both ends, embedded portion 1-inch minimum back from concrete face. If not provided with threaded ends, constructed for breaking off ends without damage to concrete.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. In accordance with ACI 347 as modified herein.
- B. Produce hardened concrete to the shape, lines, and dimensions indicated on the Contract Drawings.
- C. Surfaces exposed to view:
 - 1. Prefabricated plywood panel forms, job-built plywood forms, or forms lined with plywood or fiberboard.
 - 2. Lay out in a regular and uniform pattern with long dimensions vertical and joints aligned.
 - 3. Produce finished surfaces free from offsets, ridges, waves, and concave or convex areas.
 - 4. Maximum deviation from a true plane: 1/8 inch within 6 feet.
- D. Plywood or lined forms are not required for surface normally submerged or not normally exposed to view.
- E. Other type of forms may be used for surfaces not restricted to plywood or lined forms as

backing for form lining.

- F. Provide forms above all extended footings; flat segmental forms, 2-foot maximum width, may be used for curved surfaces 25 feet minimum diameter.
- G. When placing concrete against rock, remove all loose pieces of rock and clean exposed surfaces.
- H. Provide forms sufficiently tight to prevent leakage of mortar.
- I. Brace or tie forms to maintain desired position, shape, and alignment during and after concrete placement.
- J. Size and space wailers, studs, internal ties and other form supports so proper working stresses are not exceeded.
- K. Form concrete column supported beams and slabs so column forms may be removed without disturbing beam and slab form supports.
- L. Where top of a wall will be exposed to weathering, stop form on at least 1 side at true line and grade.
- M. Locations to be finished to a specified elevation, slope, or contour, bring form to true line and grade and provide a wooden guide strip at the proper location in the forms for finishing the top surface with a screed or template.
- N. Provide temporary opening at the bottom of columns and wall forms and wherever necessary for cleaning and inspection.
- O. Install form ties on exposed surfaces in uniformly spaced vertical and horizontal rows.
- P. Provide chamfer strips to bevel salient edges and corners. Do not provide for top edges of walls and slabs to be tooled or for edges to be buried.
- Q. Do not remove or disturb until concrete has attained sufficient strength to safely support all dead and live loads.
- R. Leave shoring beneath beams and slabs in place and reinforce as required for construction equipment and materials.
- S. Maintain forms in place for a minimum of 72 hours for length of curing time in accordance with ACI 306/306R when temperature is 45 degrees F and below.
- T. Remove forms carefully to prevent surface gouging, corner or edge breakage and other drainage.

3.2 FIELD QUALITY CONTROL

- A. Reference Section 03 30 00.

3.3 PROTECTION

- A. Reference Section 03 30 00.

END OF SECTION

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SECTION 03 15 00
CONCRETE ACCESSORIES

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Cast-in-place concrete for slab on grade, foundations, equipment pads, and other items identified within the Contract Drawings.
- B. Products Supplied but Not Installed Under This Section:
 - 1. Section 03 15 00 – Concrete Accessories.
- C. Related Sections:
 - 1. Section 03 11 00 – Concrete Forming.
 - 2. Section 03 15 13 – Waterstops.
 - 3. Section 03 60 00 – Grouting.

1.2 REFERENCES

- A. American Concrete Institute (ACI):
 - 1. 318 – Building Code Requirements for Structural Concrete.
 - 2. 347 – Recommended Practice for Concrete Formwork.
 - 3. 350 – Code Requirements for Environmental Engineering Concrete Structures.
 - 4. 546 – Concrete Repair Guide.
- B. American Society for Testing and Materials International (ASTM):
 - 1. A82 – Steel Wire, Plain, for Concrete Reinforcement.
 - 2. A185 – Steel Welded Wire Reinforcement, Plain, for Concrete.

1.3 DEFINITIONS

- A. In accordance with ACI 116R.

1.4 SUBMITTALS

- A. Product Data:
 - 1. Submit manufacturer's descriptive literature and product specifications for each product.
 - 2. Accessories:
 - a. Void form, forms, chamfer strips, form coating, form ties.
 - b. Expansion joint filler.
 - c. Membrane curing compound.
 - d. Bonding admixture and agent.
 - e. Expansion and contraction joint shear bar grease.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Bonding Admixture and Bonding Agent:
 - 1. Sika – Sikalatex.
 - 2. Euclid Chemical – Akkro-7T.
 - 3. Euclid Chemical – Tammsweld.
 - 4. Or ENGINEER Approved Equivalent.
- B. Expansion and contraction joint shear bar grease:
 - 1. No-Ox-ID axle grease.
 - 2. Or ENGINEER Approved Equivalent.

2.2 ACCESSORIES

- A. Expansion joint filler:
 - 1. ASTM D1751, asphalt impregnated fiber board, 1/2 inch thickness unless indicated otherwise on Contract Drawings.
- B. Membrane curing compound:
 - 1. General use: Curing compound conforming to ASTM C309.
 - 2. In potable water chambers: Sodium silicate, certified by the manufacturer as suitable for potable water use.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Reference manufacturer's instructions.
- B. Reference Section 03 30 00.

END OF SECTION

SECTION 03 15 13
WATERSTOPS

PART 1 GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Type 1 - PVC waterstops.
 - 2. Type 2 - Expanding rubber waterstops.
- B. Products Supplied But Not Installed Under This Section:
 - 1. Section 03 15 13 – Waterstops.
- C. Related Sections:
 - 1. Section 03 11 00 – Concrete Forming.
 - 2. Section 03 60 00 – Grouting.
 - 3. Section 07 92 00 – Joint Sealants.

1.2 REFERENCES

- A. American Society for Testing and Materials International (ASTM):
- B. U.S. Army Corps of Engineers (USACE):
 - 1. CRD-C-572 – Specification for Polyvinylchloride Waterstop.

1.3 DEFINITIONS

- A. In accordance with ACI 116R.

1.4 SUBMITTAL

- 1. Submit manufacturer's descriptive literature and product specifications for each product.
- 2. Include data to indicate type of waterstop used and identifying at each point of intended use.

1.5 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing products specified in this Section with minimum 5 years documented experience.

1.6 DELIVERY, STORAGE AND HANDLING

- A. Packing, Shipping, Handling and Unloading:
 - 1. In accordance with manufacturer's instructions.
- B. Acceptance at Site:
 - 1. Inspect shipped materials for damage. Reject damaged materials.

- C. Storage and Protection:
 - 1. In accordance with manufacturer's instructions.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. Type 1 Hydrophobic Waterstops:
 - 1. Sika Corporation U.S.
 - 2. W.R. Grace & Co.
 - 3. Williams Products.
 - 4. Or Approved Equal.
- B. Type 2 Hydrophilic Waterstops:
 - 1. General:
 - a. Adeka Ultra Seal MC-2010M.
 - b. Greenstreak Hydrotite CJ.
 - 2. Sealant, pipe penetrations, base joints, irregular joint surfaces:
 - a. Adeka Ultra Seal P201.
 - b. Greenstreak Leakmaster.
 - 3. Adhesive:
 - a. 3M Company 3M-2141.
 - b. Adeka Ultra Bond.
 - c. Greenstreak Rubber Adhesive.
 - d. Greenstreak Leakmaster.

2.2 MATERIALS

- A. Type 1 Hydrophobic Waterstops:
 - 1. Rubber:
 - a. Dumbbell type, 6 inches wide by 3/8 inches thick with 3/4 inch bead on each edge.
 - 2. PVC:
 - a. Ribbed or serrated, 6-inch wide by 3/8 inch thick, with "U" or "O" bulb closed center section.
- B. Type 2 Hydrophilic Waterstops.
 - 1. As specified under Manufacturers.

PART 3 EXECUTION

3.1 INSTALLATION

- A. Install in accordance with manufacturer's printed instructions and Section 03 30 00.

END OF SECTION

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SECTION 03 30 00
CAST-IN-PLACE CONCRETE

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Cast-in-place concrete for slab on grade, foundations, equipment pads, and other items identified within the Contract Drawings.
- B. Products Installed but Not Supplied Under This Section:
 - 1. Section 03 11 00 – Concrete Forming.
 - 2. Section 03 15 13 – Waterstops.
- C. Related Sections:
 - 1. Section 03 11 00 – Concrete Forming.
 - 2. Section 03 15 13 – Waterstops.
 - 3. Section 03 60 00 – Grouting.
 - 4. Section 31 23 00 – Excavation and Fill.

1.2 REFERENCES

- A. American Concrete Institute (ACI).
 - 1. 211.1 – Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete.
 - 2. 301 – Specifications for Structural Concrete for Buildings.
 - 3. 304 – Guide for Transporting Concrete.
 - 4. 304.2R – Placing Concrete by Pumping Methods.
 - 5. 305 – Hot-Weather Concreting.
 - 6. 306 – Cold-Weather Concreting.
 - 7. 309 – Guide for Consolidation of Concrete.
 - 8. 318 – Building Code Requirements for Structural Concrete.
 - 9. 347 – Recommended Practice for Concrete Formwork.
 - 10. 350 – Code Requirements for Environmental Engineering Concrete Structures.
 - 11. 546 – Concrete Repair Guide.
- B. American Society for Testing and Materials International (ASTM):
 - 1. A82 – Steel Wire, Plain, for Concrete Reinforcement.
 - 2. A185 – Steel Welded Wire Reinforcement, Plain, for Concrete.
 - 3. A615 – Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
 - 4. C33 – Standard Specification for Concrete Aggregates.
 - 5. C94 – Standard Specification for Ready-Mixed Concrete.
 - 6. C128 – Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Fine Aggregate.
 - 7. C127 – Standard Test Method for Density, Relative Density (Specific Gravity), and

Absorption of Coarse Aggregate.

8. C150 – Standard Specification for Portland Cement.
9. C171 – Standard Specification for Sheet Materials for Curing Concrete.
10. C260 – Standard Specification for Air-Entraining Admixtures for Concrete.
11. C309 – Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete.
12. C311 – Standard Test Methods for Sampling and Testing Fly Ash or Natural Pozzolans for Use in Portland-Cement Concrete.
13. C494 – Standard Specification for Chemical Admixtures for Concrete.
14. C595 – Standard Specification for Blended Hydraulic Cements.
15. C618 – Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.
16. C666 – Standard Test Method for Resistance of Concrete to Rapid Freezing and Thawing.
17. C1012 – Standard Test Method for Length Change of Hydraulic-Cement Mortars Exposed to a Sulfate Solution.
18. C1260 – Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method).
19. C1293 – Standard Test Method for Determination of Length Change of Concrete Due to Alkali-Silica Reaction.
20. D994 – Standard Specification for Preformed Expansion Joint Filler for Concrete (Bituminous Type).
21. D1751 – Paving and Structural Construction (Non-extruding and Resilient Bituminous Types).
22. D1752 – Standard Specification for Preformed Sponge Rubber Cork and Recycled PVC Expansion Joint Fillers for Concrete Paving and Structural Construction.

1.3 DEFINITIONS

- A. In accordance with ACI 116R.

1.4 SYSTEM DESCRIPTION

- A. Design Requirements:
 1. In accordance with ASTM C94.
 2. Design concrete in accordance with this Part 2 of this Specification.
 3. Cement meeting sulfate exposure requirements for Class 1 severity exposure as presented in ACI 201.
- B. Performance Requirements:
 1. In accordance with ASTM C94.
 2. Ready-mix concrete:
 - a. Minimum compressive strength conforming to ASTM C39.
 - 1) 28 day: 4,500 pounds per square inch.

- b. Maximum slump at point of placement:
 - 1) 4 inches.
 - c. Maximum volumetric air content at point of placement:
 - 1) 5 to 7 percent.
 - 2) Omit air from trowel finished interior slabs.
- 3. Topping and fill concrete:
 - a. Minimum compressive strength.
 - 1) 28-day: 3,000 pounds per square inch.
 - b. Maximum slump:
 - 1) 2 inches.

1.5 SUBMITTALS

A. Product Data:

- 1. Submit manufacturer's descriptive literature and product specifications for each product.
- 2. Admixtures:
 - a. Indicate admixtures added to concrete at ready mix batch plant.
 - b. Indicate field available admixtures.
- 3. Reinforcing steel:
 - a. Indicate complete reinforcing bar schedule, reinforcing bar details, and erection drawings to conform to ACI 315.
 - b. Indicate each type of reinforcing bar marked with identification corresponding to identification tag on bar.
 - c. Indicate bar sizes, spacing, locations, and quantities of reinforcing steel.
 - d. System fabrication, dimensions, bar sizes, locations of connections, connection details, quantities of reinforcing steel and wire fabric bending and cutting schedules.
 - e. Indicate dimensions, materials, bracing, and arrangement of joints and ties.
- 4. Accessories:
 - a. Void form, forms, chamfer strips, form coating, form ties.
 - b. Expansion joint filler.
 - c. Membrane curing compound.
 - d. Bonding admixture and agent.
 - e. Expansion and contraction joint shear bar grease.

B. Shop Drawings:

- 1. Indicate layouts including dimensions and the following:
 - a. Erection drawings clear, easily legible, and to a minimum scale of:
 - 1) 1/4 inch equals 1 foot.
 - 2) 1/8 inch equals 1 foot if bars in each face are shown in separate views.
 - b. Indicate size and location of pipe penetrations, wall sleeves and embedded

- conduit.
 - c. Indicate pertinent dimensions, materials, bracing, and arrangement of joints and ties.
 - d. Include erection drawings for structural steel.
 - e. Fabricator's detailed requirements for system foundations
 - f. Construction joints: Drawing indicating location of construction joints.
- C. Quality Assurance / Control Submittals:
- 1. Design Data:
 - a. Reports of tentative concrete mix design for structural concrete, concrete topping, and concrete fill as well as testing for each tentative mix design including:
 - 1) Slump and tolerance.
 - 2) Air content and tolerance.
 - 3) Water/cementitious material ratio and tolerance.
 - 4) Total volume of water per cubic yard of ready mix concrete.
 - 5) Brand, type, composition, and quantity of cement with manufacturer and plant location identified.
 - 6) Brand, type, composition and quantity of fly ash.
 - 7) Specific gravity and gradation of each aggregate.
 - 8) Ratio of fine to total aggregate.
 - 9) Surface-dry weight of each aggregate per cubic yard.
 - 10) Brand, type, ASTM designation, active chemical ingredients and quantity of each admixture.
 - 11) Compressive strength based at 7- and 28-day compression tests.
 - 12) Time of initial set.
 - 13) Existing data on proposed design mixes are acceptable if certified and complete.
 - b. Cold weather Curing and Protection: Detailed plan for cold weather curing and protection of concrete. Include requirements and recommendations of ACI 306 and ACI 318.
 - c. Defective Concrete Repair Procedures: As necessary to repair defective concrete.
 - d. Placement Schedule:
 - 1) Placement schedule no later than 48 hours prior to intended placement date.
 - 2) Indicate placement location, quantity, penetration locations, and embedment types and locations.
 - 2. Test Reports:
 - a. Cylinder Compression Test Reports: Submit 2 copies of certified test reports to Contracting Officer for air content and concrete compression testing.
 - b. Fly ash certified test reports:

- 1) Submit suppliers certified fly ash test reports for each shipment delivered to concrete supplier.
 - a) Physical and chemical characteristics.
 - b) Certification of compliance with the specifications.
 - c) Signed by CONTRACTOR and concrete supplier.
 - c. Provide field quality control testing reports detailing results of the tests. Indicate compliance or non-compliance with Contract Documents. Identify corrective action for materials and equipment which fails to pass field tests.
 3. Certificates:
 - a. Submit ACI 301, Concrete Construction Inspector Level II certification for each technician performing field quality control testing services.
 - b. Bill of Lading: Provide for all products and components furnished under this section. At the time of delivery, provide ENGINEER with a copy of each bill of lading.
- D. Closeout Submittals:
 1. 3rd party inspection and testing reports.
 2. Submit all-ready mix concrete delivery tickets.

1.6 QUALITY ASSURANCE

- A. Manufacturer Qualifications:
 1. Acquire cement and aggregate from same source for all work.
- B. Pre-Installation Meeting:
 1. Prior to placement of concrete, conduct a jobsite meeting with the Contracting Officer or designated representative, ENGINEER, CONTRACTOR, concrete subcontractor, installers of related work, concrete ready mix supplier / quality control, 3rd party testing agencies / consultants, and other pertinent entities.
 2. Agenda shall include:
 - a. Mix designs, test of mixes, and Submittals.
 - b. Placement methods, techniques, equipment, and consolidation.
 - c. Performance requirements.
 - d. Placement time from ready mix batch plant to site placement.
 - e. Finishing and curing procedures.
 - f. Admixture types, dosage, performance, and re-dosing.
 - g. Chain of command.

1.7 DELIVERY, STORAGE AND HANDLING

- A. Acceptance at Site:
 1. Ready-Mix Delivery Tickets. Submit delivery tickets for each load at the time of delivery indicating the following:
 - a. Quantity delivered, batch plant name, and batch time.
 - b. Ready mix truck arrival to site.

- c. Ready mix truck begin placement.
- d. Ready mix truck leave site.
- e. Mix design including design strength.
- f. Ready mix batch temperature.
- g. Amount of initial water added at batch plant.
- h. Amount of supplemental field water that may be added without exceeding specified water/cement ratio.
- i. Amount of supplemental field water added after arrival to site.
- j. Elapsed time between when supplemental field water was added and concrete load was in place.
- k. Name of individual authorizing supplemental water and quantity of supplemental water added.
- l. Numerical sequence of delivery by indicating cumulative yardage delivered on each ticket.
- m. Executed copies (signature and date) by CONTRACTOR's authorized agent.

B. Storage and Protection:

- 1. Cement and fly ash: Store in moisture proof enclosures, discard if caked or lumpy.
- 2. Aggregate: Prevent segregation and inclusion of foreign materials; do not use the bottom 6 inches of piles in contact with the ground.
- 3. Reinforcing steel: Store on supports preventing contact with ground and cover to prevent surface corrosion and contamination.
- 4. Rubber and plastic materials: Store in a cool place, do not expose to direct sunlight.

1.8 PROJECT / SITE CONDITIONS

A. Project / Site Environmental Requirements:

- 1. Do not place concrete during rain, sleet, or snow.
- 2. Do not allow rainwater to increase mixing water or damage surface finish.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Cement:

- 1. ASTM C150, Type I/II.

B. Fly Ash:

- 1. ASTM C618, Class C or Class F, except loss on ignition not more than 5 percent.

C. Fine aggregate:

- 1. Clean, natural sand, ASTM C33; no manufactured or artificial sand.

D. Coarse aggregate:

- 1. Crushed rock, natural gravel, or other inert granular material, ASTM C33 except clay and shale particles no more than 1 percent. Free of all materials deleteriously reactive with alkalis in the cement.

E. Water:

1. Clean and free from injurious amounts of oils, acids, alkalis, salts, organic materials, or other substances. Provide mixing water free from chloride ion for pre-stressed concrete or for concrete which will contain aluminum embedments, including that portion of the mixing water contributed in the form of free moisture on the aggregates.

F. Admixtures:

1. Acceleration: High range water reducer.
2. Retarder: ASTM C494, Type D; Grace "*Duratard-HC*," Master Builders "*MC HC*," Protex "*Protard*," Sika Chemical "*Plastiment*," or ENGINEER approved equivalent.
3. Plasticizer: ASTM C494, Type A; Grace "*WRD A-HC*," Sika Chemical "*Plastocrete*," or ENGINEER approved equivalent.
4. Air entraining agent: ASTM C260; Grace "*Darex AEA*," Master Builders "*MB VR*," Protex "*AES*," Sika Chemical "*AEK*," or ENGINEER approved equivalent.

G. Reinforcing Steel:

1. Bars and Beam Stirrups: ASTM A615, Grade 60.
2. Column ties: ASTM A615, Grade 40.
3. Column spirals: ASTM A82.
4. Welded wire fabric: ASTM A185 or A497.
5. Bar supports: PS 7; CRSI Class B or E, fabricated from galvanized wire having PVC coated legs.
6. Tie wire: 16-1/2 gage or heavier, black annealed wire.

2.2 MIXES

A. Ready-mix concrete:

1. Cement content, relationship to coarse aggregate sieve:
 - a. Coarse aggregate sieve: No 4 to 1/2 inch.
 - 1) 2 inch slump: 573 pounds per cubic yard
 - 2) 3 inch slump: 592 pounds per cubic yard
 - 3) 4 inch slump: 611 pounds per cubic yard
 - b. Coarse aggregate sieve: No 4 to 3/4 inch:
 - 1) 2 inch slump: 545 pounds per cubic yard
 - 2) 3 inch slump: 564 pounds per cubic yard
 - 3) 4 inch slump: 583 pounds per cubic yard
 - c. Substitute fly ash in a range of 15 to 20 percent of cement, at ratio of specific gravity of cement divided by specific gravity of fly ash.
2. Water to cementitious material (cement plus fly ash) ratio: 0.45 Maximum.
3. Ratio of fine to total aggregate by volume:
 - a. 1/2 inch coarse aggregate size:
 - 1) Minimum ratio: 0.40
 - 2) Maximum ratio: 0.55

- b. 3/4-inch coarse aggregate size:
 - 1) Minimum ratio: 0.35
 - 2) Maximum ratio: 0.50
 - 4. Initial concrete set period:
 - a. 5–1/2 hours, plus/minus 1 hour after water and cement are added to aggregate in accordance with ASTM C403.
 - 5. Admixtures:
 - a. Content, batching method, and time of introduction in accordance with the manufacturer's recommendations for compliance with this specification.
 - 1) Calcium chloride content shall not exceed 0.05 percent of the cement content by weight.
- B. Concrete topping and fill:
 - 1. Proportions:
 - a. 100 pounds of cement.
 - b. 300-400 pounds of sand and pea gravel mix.
 - c. Less than 5 gallons per sack of cement.
 - 2. Water to cement ratio not greater than 0.45.
 - 3. Acceptable admixtures:
 - a. Air entraining agent.
 - b. Water reducer.

2.3 FABRICATION

- A. Reinforcing Steel: Accurately formed, fabricated in accordance with ACI 315 and 318 except as specified or indicated on Contract Drawings, free from rust, scale and contaminants.

2.4 SOURCE QUALITY CONTROL

- A. Tests / Inspections:
 - 1. Test the proposed concrete mix by a 3rd party for each size and gradation of aggregates and consistency.
 - 2. Aggregates:
 - a. Sample and test according to ASTM C33.
 - b. Determine bulk specific gravity in accordance with ASTM C127 and C128.
- B. Transporting mixed concrete:
 - 1. In accordance with ACI 305R.
 - 2. Do not exceed manufacturer's guaranteed capacity of truck agitators. Maintain the mixed concrete in a thoroughly mixed and uniform mass during hauling.
 - 3. Do not incorporate additional mixing water into the concrete during hauling or after arrival at the delivery point unless ordered by ENGINEER.
 - 4. If additional water is to be incorporated into the concrete, revolve the drum not less than 30 revolutions at mixing speed after the water is added and before placing concrete.

5. The addition of mixing water after testing, and placement has commenced, is not allowed.
6. Furnish a water measuring device in good working condition, mounted on each transit mix truck, for measuring the water added to the mix on the site by the ENGINEER.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Site verification of conditions in accordance with Contract Documents. Inspect and confirm the following:
 1. Reinforcing steel is correctly installed.
 2. Sufficient cover over reinforcing steel.
 3. Correct placement and spacing of conduit.
 4. Correct placement of all penetrations.
 5. Anchors, seats, plates, reinforcement, and other items to be case into concrete are accurately placed, positioned securely, and will not cause hardship in placing concrete.

3.2 PREPARATION

- A. Surface Preparation:
 1. Prepare previously placed concrete by cleaning with steel brush or sandblasting and applying bonding agent in accordance with manufacturer's instructions.
- B. In locations where new concrete is doweled to existing work, drill holes in existing concrete, and insert steel dowels with epoxy resin system.

3.3 INSTALLATION

- A. Reinforcing Steel:
 1. Accurately position reinforcing steel on supports, spacers, hangers, or other reinforcing steel at maximum intervals of 4 feet on center.
 2. Secure with wire ties or suitable clips. Tie a minimum of 50 percent of reinforcement and reinforcement at intersections.
 3. Except at contact splices, minimum clear distances between bars, the greater of:
 - a. Nominal diameter of bars.
 - b. 1.5 times max size of coarse aggregate.
 - c. 3 inches in other locations.
 4. Where reinforcement is placed in 2 layers, place bars in upper layer directly above bars in lower layer.
 5. Do not use brick, plywood or other porous material to support footing steel off the ground. Small precast concrete "adobe" blocks that provide minimum clearances are acceptable.
 6. Splices:
 - a. As specified or indicated on Contract Drawings.
 - b. Do not weld or tack weld reinforcing steel except where specifically indicated on

Contract Drawings.

- c. Remove and replace steel upon which any unauthorized welding has been performed.
- d. When splicing bars in tie beams subject to tensile loading, splice no more than half the bars within a length of 40 bar diameters and hook each spliced bar end 180 degrees.
- e. In beams and suspended slabs, splice top bars at mid-span. Splice bottom bars over supports.
- f. In foundation slabs, splice top bars at supports (walls). Splice bottom bars at mid-span.

7. Embedments:

- a. Accurately position and securely anchor in forms, anchor bolts, steel shapes, conduit, sleeves, masonry anchorages, and other materials to be embedded in concrete.
- b. Electrical Conduits:
 - 1) Install between layers of steel in walls and slabs with steel in both faces. Reference structural drawings for detail.
 - 2) Install under reinforcing steel in slabs with only 1 layer of steel.
 - 3) Reference structural drawings for placement detail.
- c. Anchor bolts:
 - 1) Unless installed in pipe sleeves, provide sufficient threads on anchor bolts to permit a nut on the concrete side of the form or template.
 - 2) Install a second nut on the other side of the form or template.
 - 3) Adjust the nuts to hold the bolt rigidly in the proper position.
- d. Clean embedments before installation.
- e. Clean concrete spatter and other foreign substances from surfaces not in contact with concrete.

B. Concrete placement:

- 1. In accordance with ACI 301 and ASTM 94/C 94M-09.
- 2. Concrete shall be finally placed within 90 minutes of the time that the concrete was batched as identified on the batch ticket. Failure to finish placement of concrete within time frame shall be cause for concrete to be deemed defective.
- 3. Notify ENGINEER a minimum of 24 hours in advance prior to placement.
- 4. Predetermine limits at each pour and place all concrete within limits of pour in one continuous operation.
- 5. Rigidly secure forms, reinforcing steel, embedment, and anchor bolts in proper position.
- 6. Remove all mud, water, ice, snow, frozen material, and debris from space to be occupied by concrete.
- 7. Clean surfaces encrusted with dried concrete from previous concrete operations.
- 8. Convey to the point of final deposit by methods which will prevent separation or loss of ingredients.

9. Place concrete in final position without being moved laterally more than 5 feet.
10. Place concrete in approximately horizontal layers of proper depth for proper compaction, not more than 2 feet.
11. Place subsequent layer while the preceding layer is still plastic.
12. Place and compact concrete in wall or column forms before placing any reinforcing steel in the system to be supported by the walls and columns.
13. Top finish concrete when thoroughly settled.
14. Remove all laitance, debris, and surplus water from the tops of the forms by screeding, scraping or other effective means.
15. Overfill the forms for walls whose tops will be exposed to the weather and screed off the excess after the concrete has settled.
16. Allow concrete in walls and columns to settle at least 2 hours before concrete is placed in structural systems to be supported by the walls and columns.

3.4 CONSTRUCTION

A. Special Techniques:

1. Bonding to cured and hardened concrete:
 - a. Place new concrete on rough, clean, damp faces of existing concrete.
 - b. Remove surface mortar to expose aggregate.
 - c. Clean hardened concrete of all foreign substances, including curing compound, washed with clean water, and keep saturated for 24 hours preceding placement of fresh concrete.
 - d. Apply bonding agent for bonding to hardened concrete.
2. Consolidation:
 - a. Use mechanical vibrators which will maintain 9,000 cycles per minute when immersed in the concrete, 1-1/2 horsepower motor minimum.
 - b. Thoroughly consolidate concrete during and immediately after placement. Honeycombed concrete resulting in leaks is deemed defective concrete.
3. Construction Joints:
 - a. In columns and walls:
 - 1) Install at the underside of beams, girders, haunches, drop panels, column capitals, and at floor panels.
 - 2) Install haunches, drop panels, and column capitals monolithically.
 - 3) Divide walls into panels at maximum 30 foot length intervals. Place concrete in alternating panels unless more than 7 days have elapsed between concrete placements of adjoining panels.
 - 4) Horizontal construction joints are not allowed in walls.
 - b. In beams:
 - 1) Install at the middle of the span unless a beam intersects a girder.
 - 2) If the middle of the span is at an intersection of a beam, offset the joint in the girder a distance equal to twice the beam width.
 - 3) Provide satisfactory means for transferring shear and other forces through

the construction joint.

- c. In suspended slabs:
 - 1) Install at or near the center of span in flat slab.
 - 2) Do not locate a joint between a slab and a concrete beam unless indicated on the Contract Drawings.
 - d. Foundation slabs:
 - 1) Divide foundation slabs into approximate square sections not greater than 40 feet in their longest direction.
 - e. Install construction joints in beams and slabs perpendicular to the planes of their surfaces.
4. Expansion and contraction joints:
- a. Contraction joints:
 - 1) Provide as indicated on the Contract Drawings.
 - 2) Seal all accessible edges.
 - b. Expansion material:
 - 1) Firmly bond to previously poured joint. Face with a suitable adhesive.
 - 2) Pour new concrete directly against joint filler.
5. Watertight Joints:
- a. Provide watertight joints with continuous waterstops at the following locations:
 - 1) Walls and bottom slabs of dry pits or rooms where below finished grade and in contact with backfill or subgrade material on the opposite side.
 - 2) Walls in contact with liquid where the opposite face is above finished grade or exposed in a dry pit or room.
 - 3) Slabs in contact with liquid where the opposite face is exposed in a dry pit or room.
 - 4) Filters and clear water reservoirs.
 - 5) Across construction joints in foundation slabs and walls of tanks and basins.
 - b. Hydrophobic PVC waterstops – Type I:
 - 1) Size and thickness specified in Section 03 15 13.
 - 2) Clean and free of coatings which would weaken the bond with concrete.
 - 3) Continuous through the length of the construction joint.
 - 4) Butt junctions between adjacent sections and securely heat weld together.
 - 5) Maintain in proper position until surrounding concrete is deposited and consolidated.
 - c. Hydrophilic waterstops – Type II:
 - 1) Refer to Section 03 15 13.

3.5 REPAIR / RESTORATION

- A. Aggregate exposure:
 - 1. Expose coarse aggregates to improve bonding.
 - 2. Remove surface mortar from surfaces to be covered later with concrete or mortar

topping.

3.6 RE-INSTALLATION

A. Defective concrete:

1. Concrete not conforming to required lines, details, dimensions, tolerances, or specified performance requirements within this Section.
2. Repair in accordance with ACI 301, Chapter 9.
3. Defective concrete is grounds for replacement.
4. Repair defects in formed concrete surfaces within 24 hours of removing forms.
5. Replace defective concrete within 48 hours.
6. Cut out and remove to honeycombed or otherwise defective concrete.
7. Cut edges square to avoid feathering.

3.7 FIELD QUALITY CONTROL

A. Cast-in-Place Tests:

1. Provide testing services in accordance with ACI 301, 1.6.4.3., Concrete Construction Inspector Level II required, submit certification for technician performing field tests.
2. Perform tests to determine compliance of concrete materials specified within this Section.
3. Conduct all concrete tests at point of placement in accordance with ACI 301, 4.2.2.2 and 4.2.2.4.
4. Test in accordance with ASTM C143 and ASTM C39.
5. If additional field water is added to mixer, to obtain concrete specification and performance compliance, additional testing is required to determine compliance post water addition.
6. Provide the following field tests at a minimum of 1 test per ready mix truck:
 - a. Ambient air temperature.
 - b. Concrete temperature.
 - c. Slump.
 - d. Air content.
 - e. Unit weight.
 - f. Compression tests:
 - 1) In accordance with ASTM C31 and ASTM C39.
 - 2) Provide 1 set of 6 cylinders for every 50 cubic yards or less of concrete placed in a 24 hour period.
 - 3) Provide 1 additional set of 6 cylinders for every additional 50 cubic yards of concrete placed in a 24 hour period.
 - 4) Test 2 cylinders in each set at 7 days.
 - 5) Test 2 cylinders in each set at 28 days.
 - 6) The other 2 cylinders to be tested as directed by ENGINEER.
 - 7) ENGINEER will evaluate compliance in accordance with ACI 214 and 318.

- 8) Mark or tag each set of test cylinders with the date and time of day the cylinders were made, the location in the work where the concrete represented by the cylinders was placed, the delivery truck or batch number, the air content, and the slump.
- 9) Storage facilities for concrete test cylinders:
 - a) Including water necessary, a specially prepared box with high-low thermometer and thermostatically controlled heating devices in accordance with ASTM C31.
- 10) Failure of test cylinder results:
 - a) Upon failure of 28-day test cylinder results, obtain and test three, 4-inch diameter cored samples from area in question.
 - b) Concrete will be considered adequate if average of 3 core tests is at least 85 percent of, and if no single core is less than 75 percent of, the specified 28-day strength.
 - c) In the event concrete is deemed defective, the ENGINEER may order removal and replacement of concrete.
 - d) The cost of the core tests and removal and replacement of defective concrete shall be borne by the CONTRACTOR.
 - e) Fill and repair all core holes as specified for repairing defective concrete.

B. Cast-in-Place Concrete Tank/Vault Testing:

1. Test required for all process water and/or wastewater tanks.
2. Hydrostatic test for concrete structures:
 - a. Prior to backfilling walls, fill each basin to maximum operating water level with potable water. Fill and test each basin separately to check for leaks. Allow 24 hours for initial concrete saturation.
 - b. The water level elevation shall be determined by using a surveyor's level and level rod. After a lapse of additional 24 hours, the water level shall be checked in the same manner. If during the 24 hours the water level has not dropped more than 0.5 inches, the tank will be considered sufficiently watertight.
 - c. If test fails to meet above requirements, the tank shall be drained, repaired, and tested again for water tightness. The CONTRACTOR will pay all costs associated with testing including but not limited to testing, water, and retesting. Damp spots on the exterior wall faces or footings are considered leaks. All leaks shall be repaired on the tank interior by applying concrete water plug, sikaset, plug, or ENGINEER approved equivalent.
 - d. Leak testing water pH shall be adjusted to 7.5 prior to discharging to the sanitary system for disposal. CONTRACTOR to provide potable water for all tests.

3.8 FINISHES

A. Finishing unformed surfaces:

1. Float finish buried or permanently submerged concrete not forming an integral of a structure except as required to attain surface elevations, contours and freedom from

- laitance.
- 2. Screed and initial float finish followed by additional floating, and troweling as required, all other surfaces. In areas with floor drains, maintain floor elevation at walls; pitch surfaces uniformly to drains as indicated on the Contract Drawings.
- 3. Finish concrete floor surfaces in accordance with ACI 301.
- 4. Screeding:
 - a. Screed concrete surfaces to the proper elevation and contours with all aggregates completely embedded in mortar.
 - b. Surface free of irregularities of height or depth more than 1/4 inch measured from a 10 foot straightedge.
- 5. Broom finish:
 - a. Broom finish exterior slabs and exterior concrete stair treads for a non-slip surface.
 - b. Broom after second floating and at right angles to normal foot traffic.
- 6. Troweling:
 - a. Steel trowel finish interior floor surface which will be exposed at the completion of construction or surfaces.
 - b. Trowel to produce a dense, smooth, uniform surface free from blemishes and trowel marks.
- B. Finishing formed surfaces:
 - 1. Remove fins and other surface projections from all formed surfaces, except exterior surfaces that will be in contact with earth backfill and are not specified to be damp-proofed.
 - 2. Remove fins and fill tie hole on surfaces exposed to view.
 - a. Clean, dry and fill tie holes with epoxy grout.
 - 3. Grout clean in accordance with ACI 301, Chapter 10.
 - a. Grout clean surfaces including exterior and interior foundation walls exposed to view (except interior of water retaining structures) to produce a smooth uniform surface free of marks, voids, surface glaze and cement dust.
 - b. Use non-shrink grout mix with bonding agent. Dampen surface and apply with cork or rubber float.

3.9 CLEANING

- A. Clean as recommended by manufacturer. Do not use materials or methods which may damage finish / surface or surrounding construction.

3.10 PROTECTION

- A. Curing and protection:
 - 1. Protect concrete from moisture loss a minimum of 7 days after placement.
 - 2. Keep concrete surfaces adequately wet during curing, in accordance with ACI 308.
 - 3. Maintain rate of temperature change less than 5 degrees Fahrenheit in any 1 hour

- period.
4. Water curing:
 - a. Begin water saturation immediately after initial set.
 - b. Provide complete surface coverage.
 5. Membrane curing:
 - a. Membrane curing compound may be used in lieu of water curing on concrete which will not be covered later with mortar or concrete.
 - b. Spray apply membrane curing compound at not more than 300 square foot per gallon.
 - c. Cover unformed surfaces within 30 minutes of final finishing.
 - d. Protect curing compound against abrasion during the curing period.
- B. Cold weather concreting:
1. In accordance with ACI 306/306R, except as modified herein.
 2. Minimum concrete temperature allowed at the time of mixing:
 - a. Outdoor temperature in shade at placement equals less than 30 degrees Fahrenheit:
 - 1) Minimum concrete temperature equals 70 degrees Fahrenheit.
 - b. Outdoor temperature in shade at placement equals between 30 and 45 degrees Fahrenheit:
 - 1) Minimum concrete temperature equals 70 degrees Fahrenheit.
 3. Do not place with a concrete temperature greater than 80 degrees Fahrenheit.
 4. If temperatures are forecasted to drop below 35 degrees Fahrenheit within a 5 day cure period, maintain the concrete temperature at or above 50 degrees Fahrenheit for 5 days or 70 degrees Fahrenheit for 3 days. Maintain forms in place.
 5. Do not water cure when shaded temperatures are below 40 degrees Fahrenheit.
- C. Hot weather concreting:
1. Conform to ACI 305/305R, except as modified herein.
 2. Do not allow concrete temperature to exceed 80 degrees F at placement.
 3. Do not place concrete when the actual or anticipated evaporation rate equals or exceeds 0.2 pounds per square foot per hour as determined from ACI 305, Fig 2.1.4.

END OF SECTION

SECTION 03 60 00
GROUTING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Grouting of column and equipment baseplates.
 - 2. Grouting of anchors and dowels into existing concrete.
 - 3. Patching cavities in concrete.
 - 4. Other grouting specified or indicated on Contract Drawings.
- B. Related Sections:
 - 1. Section 03 30 00 – Cast-In-Place Concrete.

1.2 REFERENCES

- A. American Society for Testing and Materials International (ASTM):
 - 1. C109 – Standard Test Method for Compressive Strength of Hydraulic Cement Mortars.
 - 2. C157 - Standard Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete.
 - 3. C191 - Standard Test Methods for Time of Setting of Hydraulic Cement by Vicat Needle.

1.3 SUBMITTALS

- A. Product Data:
 - 1. Submit manufacturer's catalog sheet for material indicating test data and physical properties.

1.4 QUALITY ASSURANCE

- A. Conform to applicable industry standard, Corps of Engineers, Specification CRD-C 621— Specification for Non-Shrink Grout.

1.5 DELIVERY, STORAGE AND HANDLING

- A. Packing, Shipping, Handling and Unloading:
 - 1. Reference manufacturer's instructions.
- B. Storage and Protection:
 - 1. Reference manufacturer's instructions.
 - 2. Store indoors away from moisture.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Non-Shrink, Non-Metallic Grout:
 - 1. BASF – Masterflow 928.

2. Sika – SikaGrout 212.
 3. Or ENGINEER Approved Equivalent.
- B. Epoxy Adhesive:
1. Hilti – HIT-HY 200.
 2. Simpson Set-XP.
 3. No Substitutions.

2.2 MATERIALS

- A. Non-Shrink, Non-Metallic Grout:
1. Factory premixed compound consisting of non-metallic aggregate, cement, water reducing and plasticizing agents, capable of developing minimum compressive strength of 4,000 psi in 1 day and 8,000 psi in 7 days.
- B. Epoxy adhesive:
1. Two components consisting of a resin and hardener.
 2. Each component furnished in separate tubes within cartridge.
- C. Water:
1. Clean and free from deleterious substances.

PART 3 - EXECUTION

- A. Non-Shrink, Non-Metallic Grout:
1. Clean concrete surface to receive grout.
 2. Saturate concrete with water for 24 hours prior to grouting and remove excess water just prior to placing grout.
 3. Cold weather conditions:
 - a. Warm concrete, substrate and base plate to 40 degrees F, or above; store grout in warm area.
 - b. Follow manufacturer's recommendations for cold weather application.
 4. Hot weather conditions:
 - a. Use cold mixing water and cool base plate if possible, store grout in cool area.
 - b. Follow manufacturer's recommendations for hot weather application.
 5. Apply to clean, sound surface.
 6. Apply latex bonding agent to hardened concrete, mix-in-grout, or as directed by ENGINEER.
- B. Epoxy Adhesive:
1. Apply only to clean, dry, sound surface.

3.2 APPLICATION

- A. Non-Shrink, Non-Metallic Grout:
1. Place in accordance with manufacturer's instructions.
 2. Mix in a mechanical mixer.

3. Use no more water than necessary to produce flowable grout.
 4. Provide expansion joints on long pours.
 5. Provide air vents where necessary to eliminate air pockets.
 6. Completely fill all spaces and cavities below the top of baseplates.
 7. Provide forms where baseplates and bedplates do not confine grout.
 8. Where exposed to view finish grout edges smooth.
 9. Except where a slope is indicated on the Drawings, finish edges flush at the baseplate, bedplate, member or piece of equipment.
 10. Protect against rapid moisture loss by immediately covering with wet rags and polyethylene sheets or curing compound.
 11. Wet cure grout for 7 days, minimum.
 12. Maintain the temperature at a minimum of 40 degrees F until grout reaches 3,000 psi.
 13. After placement of grout, eliminate excessive external vibration.
- B. Epoxy adhesive:
1. Drill hole to proper diameter and depth.
 2. Clean hole removing debris.
 3. Dispense adhesive into hole.
 4. Insert dowel or threaded rod, slowly turning during insertion.
 5. Obtain manufacturer's field technical assistance as required to insure proper placement.

3.3 SCHEDULES

- A. Non-Shrink, Non-Metallic Grout: General Use:
1. Grouting of column and equipment baseplates.
- B. Epoxy Adhesive:
1. Grouting of dowels and anchor bolts into existing concrete and masonry.

END OF SECTION

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SECTION 04 20 00
UNIT MASONRY

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:

1. Masonry Work as shown on Drawings and as specified herein.
2. Build into masonry all bolts, anchors, reinforcing, frames and accessories required for completion of masonry Work.

B. Related Sections:

1. Division 3 - Concrete.
2. Division 7 - Thermal & Moisture Protection.
3. Division 8 - Openings.

1.2 REFERENCES

A. International Building Code (IBC) (Latest Edition):

1. International Building Code - Chapter 17 Structural Tests and Inspections.
2. International Building Code - Chapter 21 Masonry.

1.3 SUBMITTAL

A. Product Data:

1. Submit manufacturer's descriptive literature and product specifications for each product.
2. Submit data for masonry units and fabricated wire reinforcement, wall ties, anchors, and other accessories:
 - a. Include masonry and mortar product data in material and finishes manual.
3. Submit product literature for masonry accessories.

B. Shop Drawings:

1. Indicate typical layout including dimensions and reinforcement detail.
2. Submit detail drawings of special accessory components not included in the manufacturer's product data.

C. Quality Assurance / Control Submittals:

1. Design Data:
 - a. Submit mix designs for grout for masonry reinforcement. Provide test results from an independent testing laboratory certifying conformance to grout strength requirements and IBC Standard 21-18.
2. Test Reports:

- a. Provide mix design test results from an independent testing laboratory certifying conformance to grout strength requirements and IBC Standard 21-18.
- 3. Certificates:
 - a. Provide certificates stating compliance with specifications for masonry unit grades, types, and classes.
 - b. At time of, or prior to delivery of materials to jobsite a certification letter from supplier of the materials shall be provided to assure materials used in construction are representative of materials used to develop prism test records in accordance with IBC Standard 21, Section 2105.3.3, Item 1.
 - c. Submit qualifications of masonry subcontractor, independent special inspector and testing laboratory.

1.4 QUALITY ASSURANCE

- A. Installer Qualifications: Acceptable to manufacturer with documented experience on at least 10 projects of similar nature in the past 5 years.
- B. Regulatory Requirements:
 - 1. Comply with all requirements of local building codes and all supplements as adopted by governing agency in which jurisdiction the masonry Work is performed.
 - 2. Fire Performance Characteristics:
 - a. Comply with requirements for materials and installation established by governing authorities for construction and fire-resistance rating indicated or required by Code.
 - b. Provide materials and construction identical to those assemblies whose fire endurance has been determined by testing in compliance with ASTM E119 or as acceptable to authority having jurisdiction.
- C. Pre-Installation Meeting:
 - 1. Conduct a pre-installation meeting prior to placement of any masonry materials. Include the Owner, Owner's representative, Subcontractors, and Engineer.

1.5 DELIVERY, STORAGE AND HANDLING

- A. Packing, Shipping, Handling and Unloading
 - 1. Mortar:
 - a. Deliver in sealed unit bags. Identify each bag with project name; material name and type.
 - b. Store stacked no more than two bags high.
- B. Acceptance at Site:
 - 1. Yard age concrete masonry units a minimum of 30 days prior to delivery to jobsite.

C. Storage and Protection:

1. Store all masonry units and materials off the ground in a manner to prevent damage, deterioration, contamination, or wetting by rain, snow or ground water:
 - a. Reject cement which has become caked, partially set or otherwise deteriorated, or any material which has become damaged or contaminated.
 - b. Cover all masonry materials to protect from elements.
2. Protect facing material and all adjoining work against staining:
 - a. Keep tops of walls covered with non-staining waterproof covering when work is not in progress.
 - b. Extend cover 24 inches down face of wall, hold cover securely in place.
 - c. Clean top surface of work of all loose mortar when work is resumed.
3. Prevent grout or mortar from staining face of exposed masonry: Protect all sills, ledges, projections and adjacent materials from damage.
4. Protect and brace masonry walls during construction to prevent damage or loss due to wind.

D. Mortar:

1. Deliver in sealed unit bags or in bulk quantities for onsite silo storage.
2. Identify each bag with project name; material name and type.
3. Store stacked no more than two bags high.

1.6 PROJECT / SITE CONDITIONS

A. Project / Site Environmental Requirements:

1. Hot and cold weather requirements: Reference The Masonry Society (TMS) Masonry Standards Joint Committee (MSJC) specification.
2. Cold weather preparation:
 - a. Remove ice or snow formed on top of foundation wall or base construction where upon masonry will set before beginning work.
 - b. Carefully apply heat until top of surface is dry to the touch.
3. Implement cold weather construction procedures when any of the following conditions exist:
 - a. Ambient temperature falls below 40 degrees Fahrenheit.
 - b. Temperature of masonry units is below 40 degrees Fahrenheit.
 - c. Do not lay masonry units having a temperature below 20 degrees Fahrenheit. Remove visible ice on masonry units prior to placement.
 - d. Heat mortar sand or mixing water to produce mortar temperatures between 55 degrees Fahrenheit and 120 degrees Fahrenheit at the time of mixing. Maintain mortar above 40 degrees Fahrenheit.

- e. When ambient temperature is between 25 degrees and 20 degrees Fahrenheit, use heat sources on both sides of the masonry under construction and install wind breaks when wind velocity is in excess of 15 mph.
 - f. When ambient temperature is below 20 degrees Fahrenheit, provide an enclosure for masonry under construction and use heat sources to maintain temperatures above 32 degrees Fahrenheit within enclosure.
 - g. When mean daily temperature is between 40 degrees and 25 degrees Fahrenheit, protect completed masonry from rain or snow by covering with weather resistive membrane for 24 hours after construction.
 - h. When mean daily temperature is between 25 degrees and 20 degrees Fahrenheit, completely cover completed masonry with insulating blankets or equal protection for 24 hours after construction.
 - i. When mean daily temperature is below 20 degrees Fahrenheit, maintain masonry temperature above 32 degrees Fahrenheit for 24 hours after construction by enclosure with supplementary heat.
 - j. Remove and replace masonry work which has been frozen or damaged by freezing conditions.
 - k. Failure to follow cold weather procedures shall be prima facie evidence that masonry has frozen. Remove and replace such masonry.
4. Cold weather grouting requirements:
- a. The temperature of masonry to be grouted must be greater than 35 degrees Fahrenheit when grout is placed.
 - b. Place grout in masonry at a minimum temperature of 70 degrees Fahrenheit and a maximum temperature of 120 degrees Fahrenheit.
 - c. Maintain grouted masonry above 35 degrees Fahrenheit for 24 hours following placement of grout.
5. Hot weather construction requirements:
- a. Implement hot weather construction procedures when the ambient air temperature exceeds 100 degrees Fahrenheit, or 90 degrees Fahrenheit with a wind velocity greater than 8 mph.
 - b. Do not spread mortar beds more than 4 feet ahead of masonry.
6. Set masonry units within one minute of spreading mortar.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. Packaged lime/cement mortar/sand mix:
 - 1. Dry Mix by Spec Mix from Quikrete Company.

2. Threewitt-Cooper Cement Company.
 3. Or Approved Equal.
- B. Mortar pigment:
1. Solomon Chem/Grind Service A Series.
- C. Horizontal joint reinforcing:
1. As manufactured by Dur-O-Wal, Inc.
 2. Or Approved Equal.
- D. Reinforcing bar positioners:
1. As manufactured by Dur-O-Wal, Inc.
 2. Or Approved Equal.
- 2.2 MATERIALS
- A. Concrete block: Units conforming to ASTM C90 or ASTM C129 for hollow units as required, Type 1 (Moisture Controlled), net area compressive strength of masonry assemblage ($f'm$)=1,900 psi, normal weight. Comply in all respects with the block requirements of the National Concrete Masonry Association. Sizes as shown on Drawings. Provide from a single supplier.
- B. Mortar and grout materials:
1. Portland cement:
 - a. Type I, Type III used for cold weather construction.
 - b. Provide low alkali, Portland cement conforming to ASTM C150.
 - c. Masonry cements or plastic cements are not permitted.
 - d. Do not use fly ash.
 - e. Maximum percentage of alkali: As specified in Table 1A of ASTM C150 for low alkali cement.
 2. Hydrated lime: For masonry purposes - Type S conforming to ASTM C 207.
 3. Sand: ASTM C 144.
 4. Grout aggregates:
 - a. ASTM C 404.
 - b. Size No. 1 for fine aggregate.
 - c. Size No. 8 or 89 for coarse aggregate.
 5. Water: Clear potable water.
- C. Mortar:
1. General: Provide packaged lime/cement mortar/sand.
 2. Design criteria: Type S, 1,800 min psi at 28 days per ASTM C270.
 3. Proportions and mixing: Ready mix mortar. Mix in power mixer for no less than 5 minutes.

D. Grout:

1. Conform to ASTM C476.
2. Provide grout with a minimum 28-day compressive strength (f'g) of 2,000 psi.
3. Fine grout proportions: One Portland cement; not more than 1/10 hydrated lime; 2-1/4 to 3 parts (by volume) damp loose sand.
4. Coarse grout proportions: One Portland cement; not more than 1/10 hydrated lime; 2 to 3 parts (by volume) damp loose sand, and not more than 2 parts (by volume) pea gravel.
5. Proportion water to produce a consistency which will allow pouring without segregation of components.
6. Provide grout slump of 8 inch plus or minus one inch.
7. Provide cohesive and homogeneous grout.

E. Transit-mixed grout:

1. May be used.
2. Continually rotate at idle speed from the time the water is added until the grout is discharged.

F. Steel:

1. Reinforcement bars:
 - a. Billet steel deformed bars, uncoated finish, ASTM A615, Grade 40, for #3 bar, ties and stirrups, Grade 60 for all other.
 - b. Vertical bars: Continuous from top of foundation walls into bond beam at top of wall.
 - c. Horizontal bars: Continuous throughout bond beam.

2.3 ACCESSORIES

A. Horizontal joint reinforcing:

1. Standard ladur type only, fabricated from 9 gage cold-drawn steel wire conforming to ASTM A82, with deformed side rods and longitudinal rods weld connected to perpendicular cross rods spaced 16 inches on center.
2. Hot-dipped galvanized after fabrication per ACI 530.1, coating requirements.
3. Use prefabricated corners and tee sections at all building corners and intersections.
4. Provide with one longitudinal side rod for each bed joint.
5. Provide overall width approximately 1.5 inches to 2 inches less than thickness of wall.

B. Reinforcing bar positioners:

1. D/A 811 for vertical reinforcing applications.
2. Positioners constructed of 9 gage wire with mill galvanized finish, sizes to fit masonry unit.

C. Embedded Flashing Materials:

1. Rubberized-Asphalt Flashing: Composite flashing product consisting of a pliable, adhesive rubberized-asphalt compound, bonded to a high-density, cross-laminated polyethylene film to produce an overall thickness of not less than 0.040 inch (1.0 mm).
2. Available Products:
 - a. Dur-O-Wal Division; Dur-O-Barrier-44.
 - b. Grace Construction Products, a unit of W. R. Grace & Co. - Conn.; Perm-A-Barrier Wall Flashing.
 - c. Heckmann Building Products Inc.; No. 82 Rubberized-Asphalt Thru-Wall Flashing.
 - d. Hohmann & Barnard, Inc.; Textroflash.
 - e. Polyguard Products, Inc.; Polyguard 300.
 - f. Polytite Manufacturing Corp.; Poly-Barrier Self-Adhering Wall Flashing.
 - g. Williams Products, Inc.; Everlastic MF-40.

D. Miscellaneous Masonry Accessories:

1. Compressible Filler: Premolded filler strips complying with ASTM D 1056, Grade 2A1; compressible up to 35 percent; of width and thickness indicated; formulated from urethane.
2. Preformed Control-Joint Gaskets: Made from styrene-butadiene-rubber compound, complying with ASTM D 2000, Designation M2AA-805 and designed to fit standard sash block and to maintain lateral stability in masonry wall; size and configuration as indicated.

E. Cleaning materials:

1. ProSoCo "Sure-Klean 600", "101", or "Vana Trol" as suited to surfaces and conditions and other types as recommended and necessary to clean particular stains or surfaces for natural colored CMU.
2. Use "Heavy Duty Concrete Cleaner" for natural colored CMU.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify field conditions are acceptable and are ready to receive Work.
- B. Verify items provided by other Sections of Work are properly sized and located.
- C. Verify built-in items are in proper location and ready for roughing into masonry work.

3.2 PREPARATION

- A. Direct and coordinate placement of metal anchors supplied to other sections.
- B. Furnish temporary bracing during installation of masonry work.

- C. Maintain in place until building structure provides permanent support.

3.3 INSTALLATION

- A. Establish lines, levels, and coursing indicated:

1. Protect from displacement.
2. Maintain masonry courses to uniform dimension.
3. Form bed and head joints of uniform thickness.

- B. Built-in members:

1. Ascertain from various trades and coordinate where all chases or opening for vents, pipes, wires, ducts, etc., are to go and construct all such chases as shown or required.
2. Build in all anchors, bolts, flashing, wall plugs, nailing strips, beams, etc., as may be required.
3. Place materials according to directions of those who furnish them.
4. Coordinate with electrical trades so outlets are centered on or aligned with masonry joints in exposed work.
5. Fully grout steel door frames set into masonry as wall is being built.

- C. Wetting masonry:

1. Do not wet concrete masonry units.

- D. Bond:

1. Lay all masonry in running bond unless otherwise shown on the Drawings.
2. Lay all masonry so that only finished faces are exposed to view.
3. Provide special units with two finished faces at corner and end wall conditions.

- E. Joining of Work:

1. Where fresh masonry joins masonry that is partially set, clean and lightly wet the exposed surface of the set masonry so as to obtain the best possible bond with the new work.
2. Remove all loose masonry and mortar as work progresses.
3. When it becomes necessary to "stop off" a horizontal run of masonry, rake back in each course and, if grout is used, stop the grout 4 inch back of the rake.
4. Toothing is not permitted for joining new work.
5. Foundation surface which is to receive masonry: Clean and damp.
6. Remove all laitance.
7. In grouted construction when grouting is stopped for 1 hour or longer, stop the grout pour 1-1/2 inches below the top of the last course.
8. Where joining new work to existing or repairing or finishing walls where selective demolition has exposed unfinished masonry or left a void in the masonry, remove existing surrounding masonry and tooth in new masonry to extent required so that all adjacent parallel and perpendicular masonry surfaces have continuous and

unbroken, finished masonry appearance.

F. Joints:

1. All joints in masonry: Slightly concave, almost flush, tooled with an approved jointer.
2. Steel jointers may be used except that stainless steel jointers must be used where white or a light colored mortar is used.
3. Use minimum 16 inch long sled runner at horizontal joints.
4. Fill joints in masonry Work and joints between masonry Work and other material required in connection therewith, with mortar as each course is laid.
5. Solidly fill all bed joints and webs with mortar.
6. Head joints laid with double heads of mortar.
7. Thickness of mortar joints: Uniform and true to dimensions, consistent with masonry unit dimensional tolerances.
8. Joints that will remain concealed may be struck flush.

G. Laying:

1. Lay all masonry units plumb and true to lines with completely filled webs, and head and bed joints.
2. Furrowing of bed joints is not permitted.
3. Rock closures into place with the head joint mortar thrown against two adjacent units in place.
4. Shove all masonry at least 1/2 inch into place.
5. Prevent grout or mortar from staining the face of masonry to be left exposed.
6. If grout or mortar does contact the face of such masonry, remove immediately.
7. Protect adjacent construction from damage during construction.
8. Keep cavity or air space and face of masonry free of mortar droppings.

H. Reinforcement:

1. Refer to Structural Drawings for principal horizontal and vertical reinforcing.
2. All reinforcement continuous.
3. Use continuous horizontal joint reinforcement in multi-wythe construction for bond tie between wythes unless noted otherwise on the Drawings.
4. Vertical reinforcement bars:
 - a. Accurately position and secure against displacement from location shown on Drawings.
 - b. In splicing vertical reinforcement to dowels, the bars shall be placed in contact and wired.
 - c. Place horizontal reinforcement as Work progresses.
 - d. Use bar positioners for vertical reinforcing bars.

- e. Locate vertical bar positioners at top of first masonry course, first course below top of wall with maximum of 4'-0" on center between positioners except where noted otherwise on the Drawings.
5. Horizontal joint reinforcement:
- a. Install in first, second and third bed joints immediately above lintels and below sills at openings.
 - b. Install in bed joints at 8 inches vertically on center in parapet walls above the roof structure.
 - c. Install in bed joints at 16 inches on center throughout vertical wall elsewhere.
 - d. Extend joint reinforcement a minimum of 24 inches past edge of opening except where control joints occur adjacent to openings.
 - e. All other reinforcement shall be continuous except that it shall not pass through vertical masonry expansion joints, except where so noted on Drawings.
 - f. Lap side rods minimum 8 inches at splices.
 - g. Place reinforcement to assure 5/8 inch mortar cover measured from outside face of mortar joint at faces exposed to exterior and not less than 1/2 inch elsewhere.
 - h. Use prefabricated corners at wall intersections and pilasters.
- I. Grouting:
- 1. General:
 - a. Grout spaces less than 2 inches in width using fine grout.
 - b. Grout spaces greater than inches in width using coarse grout.
 - c. Grout lifts not exceed 6 times width of grout space, with maximum height of 48 inches.
 - d. Use low-lift grouting techniques.
 - e. Provide cleanout holes at base of all grout lifts.
 - 2. Placement:
 - a. Place as indicated on Drawings.
 - b. Where not otherwise indicated, provide 1-#5 vertical each side of each opening with a 2 foot minimum extension past sill and head, and 1-#5 vertical full height at all unsupported edges and each side of each control and/or expansion joint.
 - 3. Construct with vertical alignment of cells and other spaces to be grouted to provide continuous unobstructed openings.

4. Solidly fill all bed joints and webs with mortar:
 - a. Struck flush to faces of masonry unit adjacent to grout spaces:
 - 1) Keep mortar droppings out of grout space.
 5. Use mechanical vibrator when grouting to insure proper consolidation of grout in cells:
 - a. Reconsolidate grout after water absorption into masonry units.
 6. When grouting is stopped for one hour or longer, stop pouring of grout 11/2 inches below top of uppermost unit.
 7. Use grout screen below all thru wall bond beams to control flow of grout into insulated cells below.
- J. Control joints:
1. Do not extend joint reinforcement through control joint.
 2. Use preformed neoprene or rubber to provide bond break.
 3. Clean and seal joints.
 4. Locate control joints as indicated on Drawings or as directed by Engineer.
- K. Minimum curing period:
1. 72 hours after building masonry columns or walls before uniform floor or roof loading is applied.
 - a. 5 days before applying a concentrated loads, such as a truss or girder.
- 3.4 CONSTRUCTION
- A. Erection tolerances:
1. Maximum variation from plumb in lines and surfaces of columns, walls, and arises: 1/4 inch in 10 feet, 3/8 inch in a story height of 20 feet maximum.
 2. Maximum variation from plumb for external corners, expansion joints and other conspicuous lines: 1/4 inch in any story or 20 feet maximum.
 3. Maximum variation from level of grades indicated on Drawings for exposed lintels, sills, parapets, horizontal grooves, and other conspicuous lines: 1/4 inch in any bay or 20 feet, nor 1/2 inch in 40 feet or more.
 4. Maximum variation of linear building line from its established position in plan and related portion of columns, walls, and partition: 1/2 inch in any bay or 20 feet maximum, nor 3/4 inch in 40 feet or more.
 5. Maximum variation in cross-sectional dimensions of columns and thickness of walls: Minus 1/4 inch, nor plus 1/2 inch from the dimensions indicated on Drawings.
 6. Maximum variation for steel reinforcement:
 - a. Plus or minus 1/2 inch when distance from centerline of steel to opposite face of masonry is 8 inches or less.
 - b. Plus or minus 1 inch when distance is between 8 and 24 inches.
 - c. Plus or minus 1-1/4 inch when distance is greater than 24 inches.

- d. Plus or minus 2 inches from location along face of wall.

3.5 FIELD QUALITY CONTROL

A. Tests:

1. Provide field testing under provisions of Section 01 45 00:
 - a. Contractor shall coordinate and schedule all tests to determine compliance of masonry materials in accordance with the specifications.
2. Provide prism tests in accordance with IBC Standard 21-17 for hollow masonry:
 - a. Provide set of 5 prisms made and tested prior to start of construction for each of the above mentioned materials.
 - b. During construction provide one set of 3 prisms for each 5,000 square feet of hollow masonry.
 - c. Tested strength of these prisms must equal or exceed 1.33 f'm.

B. Inspections:

1. Special inspections and testing will be performed in accordance with Chapters 17 and 21, International Building Code except as indicated otherwise herein.

C. Independent special inspector:

1. Special inspector at the site shall be specially trained and certified by ICBO to perform special inspection and have at least 5 years continuous experience inspecting masonry.
2. Inspect masonry Work during preparation of masonry wall prisms, sampling, and placing of all hollow masonry units, placement of reinforcement, and immediately prior to and during all grouting of all masonry on the project.
3. Ascertain that all grout spaces are clear and ready to receive grout and that all reinforcing is properly placed and held against displacement during grouting operations.
4. Observe that all grout is properly consolidated and then reconsolidated after 15 minutes using mechanical vibrators.
5. Inspector and testing laboratory shall submit reports of their observations and test results to Engineer.
6. Upon completion of the masonry Work, submit final signed report to Engineer, for distribution to Building Department and Structural Engineer, stating whether, to the best of his/her knowledge, the masonry Work was accomplished in conformance with the Contract Documents.

D. Continuous special inspection shall be provided for the first 40 hours of masonry work and during any grouting operations:

1. Owner reserves the right to require continuous special inspection at any time during performance of masonry Work at no additional cost to Owner if, in the opinion of Engineer or Engineer's subconsultants, performance of masonry Work is not in conformance with Contract Documents.

E. Periodic special inspection as approved by Engineer:

1. Inspections may be made on a periodic basis and satisfy requirements of continuous inspection, provided that an independent special inspector can submit final signed report as required above.
2. Note that continuous inspection shall be required for all grouting operations and during the first 40 hours at the beginning of masonry Work.

3.6 CLEANING

A. Masonry Cleaning:

1. Preparation: Point all holes in exposed masonry, cut out and repoint defective joints to match adjacent Work.
2. Protection:
 - a. Provide coverings and masking to protect plant materials and other non-masonry surfaces from damage due to cleaning operations.
 - b. Remove excess mortar and mortar smears as Work progresses.
3. Environmental conditions:
 - a. Proceed with cleaning operations without special requirements when ambient and substrate temperatures are above 40 degrees F.
 - b. If either the ambient or substrate temperatures are below 40 degrees F, water must be heated to a minimum of 120 degrees F and a maximum of 200 degrees F to achieve acceptable cleaning environmental conditions.
4. Test:
 - a. Test cleaning methods on sample wall panel; leave 1/2 panel uncleaned for comparison purposes.
 - b. Test separate samples of adjacent materials with full strength cleaning materials.
 - c. Obtain Engineer's approval of sample cleaning before proceeding with cleaning of masonry.
5. Clean all exposed unglazed masonry on which no green efflorescence appears.
6. Clean exposed masonry surfaces after mortar and grout is fully cured and as recommended by BIA "Technical Notes 20 Revised". Use cleaning materials specified and in accordance with manufacturer's instructions.
7. Cleaning procedures:
 - a. Thoroughly wet with clear water prior to application of cleaners.
 - b. Apply cleaners immediately and scrub with fiber brushes to remove excess mortar and stains; remove cleaners promptly by rinsing thoroughly with clear water.
 - c. Use bucket and brush hand cleaning method.
 - d. Do not use muriatic acid.

- e. Pre-wetting and rinsing require application of not less than full available water pressure with pressure application at 400 psi preferred.
 - f. Do not use high pressure spray for application of cleaning solutions. Apply with bucket and brush or spray at pressure less than 50 psi.
 - g. Take special care to avoid discoloration of colored mortars.
 - B. Clean and protect glazed surfaces per manufacturer instructions:
 - 1. Marred or damaged glazed faces is cause for rejection.
 - C. Final Cleaning:
 - 1. Remove all debris and excess material resulting from masonry Work and legally dispose of it.
 - 2. As masonry Work progresses, keep clean with burlap or brush and at completion thoroughly clean all masonry Work.
 - 3. Protect all adjacent surfaces susceptible to damage due to masonry installation:
 - a. Thoroughly clean these surfaces upon completion of masonry Work to render to new condition.
- 3.7 PROTECTION
- A. Do not apply loads for at least three days after building masonry columns or walls.

END OF SECTION

SECTION 04 43 13
ADHERED STONE MASONRY VENEER

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Stone masonry adhered to unit masonry backup.

B. Related Requirements:

1. Section 04200 – Unit Masonry
2. Section 067200 – Sheet Metal Flashing & Trim

1.2 ACTION SUBMITTALS

A. Product Data: For each variety of stone, stone accessory, and manufactured product.

B. Samples:

1. For each stone type indicated.
2. For each color of mortar required.

1.3 QUALITY ASSURANCE

A. Mockups: Build mockups to verify selections made under Sample submittals and to demonstrate aesthetic effects and to set quality standards for fabrication and installation.

1. Build mockup of typical wall area as shown on Drawings. Mockup shall be 48" x 48" minimum and include a 90-degree corner. Mockup shall include actual structural backup wall construction, all installation accessories including flashing, lath and fasteners that are intended to be utilized in the final wall. Approval of the mockup by the Owner and Architect is required prior to proceeding with installation on the actual final building.
2. Subject to approval by Owner and Architect, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.4 FIELD CONDITIONS

A. Protection of Stone Masonry: During construction, cover tops of walls, projections, and sills with waterproof sheeting at end of each day's work.

B. Cold-Weather Requirements: Do not use frozen materials or materials mixed or coated with ice or frost. Do not build on frozen substrates. Comply with cold-weather construction requirements contained in TMS 602/ACI 530.1/ASCE 6.

1. Cold-Weather Cleaning: Use liquid cleaning methods only when air temperature is 40 deg F (4 deg C) and above and will remain so until masonry has dried.
- C. Hot-Weather Requirements: Comply with hot-weather construction requirements contained in TMS 602/ACI 530.1/ASCE 6.

PART 2 - PRODUCTS

2.1 SANDSTONE

- A. Sandstone, final selection of product, color and pattern by Owner.
- B. Material Standard:
 1. Maximum Absorption according to ASTM C 97/C 97M.
 2. Minimum Compressive Strength according to ASTM C 170/C 170M.
 3. Classification: II Medium Density, except as follows: absorption, 3 percent by weight maximum; density, 150 lb/cu. ft. minimum; compressive strength, 8000 psi minimum; and modulus of rupture 800 psi minimum.
- C. Varieties and Sources: Subject to compliance with requirements, available stone varieties that may be incorporated into the Work include, but are not limited to, the following:
 1. Basis of Design
 - a. Telluride Stone Company; thin stone veneer.
 - b. Match existing building: Heritage Series; Bear Ranch
 2. Alternative Manufacturers; if matching product is available, these may be considered.
 - a. General Shale; Thin Rock.
 - b. Monarch Stone Company; thin stone veneer.
 - c. Other; Thin stone veneer locally sourced from regional quarry / rock yard.

2.2 MORTAR MATERIALS

- A. Portland Cement: ASTM C 150/C 150M, Type I or Type II, except Type III may be used for cold-weather construction; natural color or white cement may be used as required to produce mortar color indicated.
 1. Low-Alkali Cement: Not more than 0.60 percent total alkali when tested according to ASTM C 114.
- B. Hydrated Lime: ASTM C 207, Type S.
- C. Before retaining "Masonry Cement" Paragraph below, verify that masonry cements have a successful history of use with stone variety selected. Delete if requirements in "Mortar Mixes"

Article limit cementitious materials to portland cement and lime. See the Evaluations in Section 042000 "Unit Masonry" for discussion of masonry cements.

- D. Mortar Pigments: Natural and synthetic iron oxides and chromium oxides, compounded for use in mortar mixes and complying with ASTM C 979/C 979M. Use only pigments with a record of satisfactory performance in stone masonry mortar.
1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Davis Colors; True Tone Mortar Colors.
 - b. Lanxess Corporation; Bayferrox Iron Oxide Pigments.
 - c. Solomon Colors; SGS Mortar Colors.
- E. Colored Portland Cement-Lime Mix: Packaged blend of portland cement, hydrated lime, and mortar pigments. Mix shall produce color indicated or, if not indicated, as selected from manufacturer's standard colors. Pigments shall not exceed 10 percent of portland cement by weight.
1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Holcim (US) Inc.; Rainbow Mortamix Custom Color Cement/Lime.
 - b. Lafarge North America Inc.; Eaglebond.
 - c. Lehigh Cement Company; Lehigh Custom Color Portland/Lime Cement.
 - d. Mutual Materials Co.; DesignMix Colored Mortar Mix.
- F. Aggregate: ASTM C 144 and as follows:
1. For pointing mortar, use aggregate graded with 100 percent passing No. 16 (1.18-mm) sieve.
 2. White Aggregates: Natural white sand or ground white stone.
 3. Colored Aggregates: Natural-colored sand or ground marble, granite, or other sound stone; of color necessary to produce required mortar color.
- G. Latex Additive: Manufacturer's standard water emulsion, serving as replacement for part or all of gaging water, of type specifically recommended by latex-additive manufacturer for use with field-mixed portland cement mortar bed, and not containing a retarder.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Boiardi Products; a QEP company.
 - b. Bostik, Inc.
 - c. C-Cure.
 - d. Custom Building Products.
 - e. Laticrete International, Inc.
 - f. MAPEI Corporation.
 - g. Mer-Krete Systems; ParexLahabra, Inc.
 - h. ProSpec; Bonsal American; a division of Oldcastle Architectural Products Group.
 - i. Southern Grouts & Mortars, Inc.
 - j. Summitville Tiles, Inc.
 - k. TEC Specialty Construction Brands, Inc.; an H. B. Fuller company.

- H. Water: Potable.

2.3 EMBEDDED FLASHING MATERIALS

- A. Metal Flashing: Provide metal flashing, where flashing is exposed or partly exposed and where indicated, complying with SMACNA's "Architectural Sheet Metal Manual and as follows:
1. Stainless Steel: ASTM A 240/A 240M, Type 304, 0.016 inch (0.4 mm) thick.
- B. Flexible Flashing: For flashing unexposed to the exterior, use one of the following unless otherwise indicated:
1. Rubberized-Asphalt Flashing: Composite flashing product consisting of a pliable, adhesive, rubberized-asphalt compound, bonded to a high-density, cross-laminated, polyethylene film to produce an overall thickness of not less than 0.030 inch.
 - a. Products: Subject to compliance with requirements, provide one of the following:
 - 1) Advanced Building Products Inc.; Peel-N-Seal.
 - 2) Carlisle Coatings & Waterproofing; CCW-705-TWF Thru-Wall Flashing.
 - 3) Dayton Superior Corporation, Dur-O-Wal Division; Dur-O-Barrier Thru-Wall Flashing.
 - 4) Fiberweb, Clark Hammerbeam Corp.; Aquaflash 500.
 - 5) Grace Construction Products, a unit of W. R. Grace & Co. - Conn.; Perm-A-Barrier Wall Flashing.
 - 6) Heckmann Building Products Inc.; No. 82 Rubberized-Asphalt Thru-Wall Flashing.
 - 7) Hohmann & Barnard, Inc.; Textroflash.
 - 8) Sandell Manufacturing Co., Inc.; Sando-Seal.
 - 9) Williams Products, Inc.; Everlastic MF-40.

2.4 MISCELLANEOUS MASONRY ACCESSORIES

- A. Weep Products: Use the following unless otherwise indicated:
1. Mesh Weep Holes: Free-draining mesh; made from polyethylene strands, full width of head joint and 2 inches (50 mm) high by thickness of stone masonry; in color selected from manufacturer's standard.
 - a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - 1) CavClear/Archovations, Inc.; CavClear Weep Vents.
 - 2) Mortar Net USA, Ltd.; Mortar Net Weep Vents.
- B. Lath: Use the following as recommended by the stone masonry manufacturer:

1. Expanded Metal Lath: 3.4 lb/sq. yd. (1.8 kg/sq. m), self-furring, diamond-mesh lath complying with ASTM C 847. Fabricate from structural-quality, zinc-coated (galvanized) steel sheet complying with ASTM A 653/A 653M, G60 (Z180).
- C. Rainscreen: Use one of the following as recommended by the stone masonry manufacturer:
- a. Mortar Net USA, Ltd; WallNet
 - b. Cosella-Dorken Products, inc.; Delta Dry

2.5 MASONRY CLEANERS

- A. Proprietary Acidic Cleaner: Manufacturer's standard-strength cleaner designed for removing mortar and grout stains, efflorescence, and other new construction stains from stone masonry surfaces without discoloring or damaging masonry surfaces; expressly approved for intended use by cleaner manufacturer and stone producer.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Diedrich Technologies, Inc.
 - b. Dominion Restoration Products.
 - c. EaCo Chem, Inc.
 - d. Hydrochemical Techniques, Inc.
 - e. Prosoco, Inc.

2.6 FABRICATION

- A. Cut, Split or Select stone to produce pieces of thickness, size, and shape indicated, including details on Drawings and pattern specified.
- B. Gage backs of stones for adhered veneer if more than 81 sq. in. (522 sq. cm) in area.
- C. Thickness of Stone: Provide thickness indicated, but not less than the following:
1. Thickness: 1 inch plus or minus 1/4 inch.
- D. Finish exposed stone faces and edges to comply with requirements indicated for finish and to match approved samples and mockups.

2.7 MORTAR MIXES

- A. General: Do not use admixtures, including pigments, air-entraining agents, accelerators, retarders, water-repellent agents, antifreeze compounds, or other admixtures, unless otherwise indicated.
1. Do not use calcium chloride.
 2. Use portland cement-lime mortar unless otherwise indicated.

3. Mixing Pointing Mortar: Thoroughly mix cementitious and aggregate materials together before adding water. Then mix again, adding only enough water to produce a damp, unworkable mix that will retain its form when pressed into a ball. Maintain mortar in this dampened condition for one to two hours. Add remaining water in small portions until mortar reaches required consistency. Use mortar within 30 minutes of final mixing; do not retemper or use partially hardened material.
- B. Mortar for Stone Masonry: Comply with ASTM C 270, Proportion Specification.
 1. Mortar for Setting Stone: Type S.
 2. Mortar for Pointing Stone: Type N.
 - C. Latex-Modified Portland Cement Setting Mortar: Proportion and mix portland cement, aggregate, and latex additive to comply with latex-additive manufacturer's written instructions.
 - D. Cement-Paste Bond Coat: Mix either neat cement and water or cement, sand, and water to a consistency similar to that of thick cream.
 1. For latex-modified portland cement, setting-bed mortar, substitute latex admixture for part or all of water, according to latex-additive manufacturer's written instructions.
 - E. Mortar for Scratch Coat over Metal Lath: 1 part portland cement, 1/2 part lime, 5 parts loose damp sand, and enough water to produce a workable consistency.
 - F. Mortar for Scratch Coat over Unit Masonry: 1 part portland cement, 1 part lime, 7 parts loose damp sand, and enough water to produce a workable consistency.
 - G. Pigmented Mortar: Use colored cement product or select and proportion pigments with other ingredients to produce color required. Do not add pigments to colored cement products.

PART 3 - EXECUTION

3.1 SETTING STONE MASONRY

- A. Perform necessary field cutting and trimming as stone is set.
 1. Use power saws to cut stone that is fabricated with saw-cut surfaces. Cut lines straight and true, with edges eased slightly to prevent snapping.
 2. Use hammer and chisel to split stone that is fabricated with split surfaces. Make edges straight and true, matching similar surfaces that were shop or quarry fabricated.
 3. Pitch face at field-split edges as needed to match stones that are not field split.
- B. Sort stone before it is placed in wall to remove stone that does not comply with requirements relating to aesthetic effects, physical properties, or fabrication, or that is otherwise unsuitable for intended use.
- C. Arrange stones in pattern for selected stone.

- D. Arrange stones with color and size variations uniformly dispersed for an evenly blended appearance.
- E. Maintain uniform joint widths, except for variations due to different stone sizes and where minor variations are required to maintain bond alignment if any. Lay walls with joints not less than 1/4 inch (6 mm) at narrowest points or more than 1/2 inch (13 mm) at widest points.
- F. Provide sealant joints of widths and at locations indicated.
 - 1. Keep sealant joints free of mortar and other rigid materials.
 - 2. Sealant joints are specified in Section 079200 "Joint Sealants."
- G. Install embedded flashing and weep holes at shelf angles, lintels, ledges, other obstructions to downward flow of water in wall, and where indicated.
- H. Place weep holes in joints where moisture may accumulate, including above shelf angles and at flashing spaced, at 16 inches o.c.

3.2 CONSTRUCTION TOLERANCES

- A. For vertical lines and surfaces for bed joints and lines of exposed lintels, sills parapets, horizontal grooves and other conspicuous lines and for position shown in plan, install thin veneered stone as recommended by the manufacturer.

3.3 INSTALLATION OF ADHERED STONE MASONRY VENEER

- A. Install lath over unit masonry and concrete to comply with ASTM C 1063.
- B. Install scratch coat over metal lath 3/8 inch (10 mm) thick to comply with ASTM C 926.
- C. Coat backs of stone units and face of scratch coat or masonry backup with cement-paste bond coat, then butter both surfaces with setting mortar. Use sufficient setting mortar, so a slight excess will be forced out the edges of stone units as they are set. Tap units into place, completely filling space between units and scratch coat or masonry backup.
- D. Rake out joints for pointing with mortar to depth of not less than 1/2 inch before setting mortar has hardened. Rake joints to uniform depths with square bottoms and clean sides.

3.4 POINTING

- A. Prepare stone-joint surfaces for pointing with mortar by removing dust and mortar particles. Where setting mortar was removed to depths greater than surrounding areas, apply pointing mortar in layers not more than 3/8 inch (10 mm) deep until a uniform depth is formed.
- B. Point stone joints by placing and compacting pointing mortar in layers of not more than 3/8 inch (10 mm) deep. Compact each layer thoroughly, and allow to it become thumbprint hard before applying next layer.

- C. Tool joints, when pointing mortar is thumbprint hard, with a smooth jointing tool to produce the following joint profile:

- 1. Joint Profile: Concave

3.5 ADJUSTING AND CLEANING

- A. In-Progress Cleaning: Clean stone masonry as work progresses. Remove mortar fins and smears before tooling joints.
- B. Final Cleaning: After mortar is thoroughly set and cured, clean stone masonry as follows:
 - 1. Remove large mortar particles by hand with wooden paddles and nonmetallic scrape hoes or chisels.
 - 2. Test cleaning methods on mockup; leave one-half of panel uncleaned for comparison purposes. Obtain Architect's approval of sample cleaning before cleaning stone masonry.
 - 3. Protect adjacent stone and non-masonry surfaces from contact with cleaner by covering them with liquid strippable masking agent, polyethylene film, or waterproof masking tape.
 - 4. Wet wall surfaces with water before applying cleaner; remove cleaner promptly by rinsing thoroughly with clear water.
 - 5. Clean stone masonry by bucket and brush hand-cleaning method described in BIA Technical Note No. 20, Revised II, using job-mixed detergent solution.
 - 6. Clean stone masonry with proprietary acidic cleaner applied according to manufacturer's written instructions.
 - 7. Clean limestone masonry to comply with recommendations in ILI's "Indiana Limestone Handbook."

3.6 EXCESS MATERIALS AND WASTE

- A. Excess Stone: Stack excess stone where directed by Owner for Owner's use.
- B. Disposal as Fill Material: Dispose of clean masonry waste, including mortar and excess or soil-contaminated sand, by crushing and mixing with fill material as fill is placed.
 - 1. Do not dispose of masonry waste as fill within 18 inches (450 mm) of finished grade.

END OF SECTION

SSECTION 05 05 19
POST-INSTALLED CONCRETE ANCHORS

PART 1 GENERAL

1.1 SUMMARY

- A. Section Includes: Equipment anchor bolts, structural anchor bolts, and expansion anchors.
- B. Related Sections:
 - 1. Section 03 30 00 - Cast-in-Place Concrete.
 - 2. Section 03 60 00 - Grouting.

1.2 REFERENCES

- A. American National Standards Institute:
 - 1. ANSI/ASME B18.16.3M - Dimensional Requirements for Prevailing-Torque Steel Metric Hex Nuts and Hex Flange Nuts.
 - 2. ANSI/ASME B18.21.1 - Washers: Helical Spring-Lock, Tooth Lock, and Plain Washers (Inch Series).
 - 3. ANSI/ASME B18.22.1 - Plain Washers.
 - 4. ANSI/ASME B18.23.1 - Beveled Washers.
- B. American Society for Testing and Materials International (ASTM):
 - 1. ASTM A36 - Standard Specification for Carbon Structural Steel.
 - 2. ASTM A53 - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
 - 3. ASTM A193 - Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications.
 - 4. ASTM A307 - Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60,000 psi Tensile Strength.
 - 5. ASTM A780 - Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings.
 - 6. ASTM F3125 - Standard Specification for High Strength Structural Bolts, Steel and Alloy Steel, Heat Treated, 120 ksi (830 MPa) and 150 ksi (1040 MPa) Minimum Tensile Strength, Inch and Metric Dimensions.

1.3 SUBMITTAL

- A. Product Data:
 - 1. Submit manufacturer's descriptive literature and product specifications for each product.

- B. Shop Drawings:
 - 1. Provide sizes and dimensions. Indicate or identify location where anchor bolts are to be used.

1.4 QUALITY ASSURANCE

- A. Unless otherwise specified or shown on the Contract Drawings, anchor bolts for equipment provided under this Contract shall be designed and sized by the responsible equipment manufacturer.
- B. Unless otherwise specified, the Contractor shall provide and install all anchor bolts for this Contract in accordance with the responsible manufacturer's design recommendations or as shown on the Contract Drawings.
- C. Anchor bolt templates for equipment shall be provided by the responsible manufacturer.

1.5 DELIVERY, STORAGE AND HANDLING

- A. Packing, Shipping, Handling and Unloading:
 - 1. Deliver anchor bolts and templates in time to permit setting when structural concrete is placed.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. Expansion Anchors:
 - 1. ITW Read Head.
 - 2. Hilti.
 - 3. Or Approved Equal.

2.2 MATERIALS

- A. Bolts or threaded rods:
 - 1. General use: Galvanized carbon steel ASTM A325.
 - 2. Submerged service: Stainless steel ASTM 193, Grade 303 or 305.
 - 3. 304/316 Stainless steel where indicated on Contract Drawings.
- B. Nuts:
 - 1. Same material as bolts.
 - 2. Carbon steel: ASTM A307 Grade B heavy hexagonal.
 - 3. Self-locking: ANSI B18.16.3, Grade A.
- C. Washers:
 - 1. Same material as bolts.

2. Flat: ANSI B18.22.1.
 3. Locking: Spring type, ANSI B.18.21.1.
- D. Sleeves:
1. Pipe: ASTM A53.
 2. Bearing plates: ASTM A36.
 3. Hot dip galvanize after fabrication.
- E. Expansion anchors:
1. General use: 304/316 Stainless steel.
 2. Submerged service: 304/316 Stainless steel.
 3. In hardened concrete and grouted masonry:
 - a. Type "A": Wedge type, FS FF-S-325, Group II, Type 4, Class 1.
 - b. Type "B": Self-drilling, FS FF-S-325, Group III, Type 1, Flush type.
 - c. Type "C": Non-drilling, internally threaded, FS FF-S-325, Group VIII, Type 1 Drop in.
 - d. Type "D": Non-drilling, externally threaded, FS-S-325, Group VIII, Type 2.
 4. In hollow and solid masonry:
 - a. Type "E": Lag shield FS FF-S-325, Group II, Type 1, Class 1.
 - b. Type "F": Split sleeve, FS FF-S-325, Group II, Type 3, Class 3.

2.3 FABRICATION

- A. Bolts: Carbon steel, high strength, size as required for piping flanges.
- B. Anchor Bolts-3/4 inch minimum diameter except as indicated by equipment manufacturer:
1. General use: L-shaped hook type for structural steel framing and anchoring equipment.
 2. Specific use: as indicated by equipment manufacturer.
- C. Sleeved anchor bolts:
1. Centered in pipe sleeve.
 2. Sleeve ID: Approximately 2-1/2 times bolt OD.
 3. Sleeve length: Approximately 8 times bolt OD.
 4. Bearing plate minimum thickness: 1/2 times bolt OD.
- D. Through bolts with:
1. Sleeved with bearing plates.
 2. Bearing plates welded to bolt and plate welded to sleeve.

3. Dimensions: As specified for sleeved anchor bolts.

E. Expansion Anchors: 5/8 inch maximum diameter, length as required for proper embedment.

PART 3 EXECUTION

3.1 EXAMINATION

A. Site verification of conditions:

1. Verify that holes for anchor bolts in forms and templates match applicable building shop Contract Drawings.

3.2 INSTALLATION

A. Anchor bolts-General use:

1. Provide for structural steel framing and anchoring equipment.
2. Where installed in cast-in-place concrete, install a nut on the concrete side of the form or supporting template.
3. Provide 3 nuts for each anchor bolt for which a lock nut is indicated, 2 for others.

B. Expansion anchors:

1. Install in accordance with the manufacturer's instructions.
2. General use: Where required for pipe supports, anchoring wall panels and miscellaneous anchor requirements.
3. Do not use cinch anchors.
4. Minimum embedment: 4 bolt diameters or per manufacturer's recommendations, whichever is greater.
5. Minimum distance between expansion anchor centerline any edge or exterior corner of concrete: 4-1/2 bolt hole diameters.

3.3 SCHEDULES

A. Expansion anchors:

1. In hardened concrete and grouted masonry: Type "A," "B," "C," or "D," contractor's option, unless type is indicated on Contract Drawings.

B. In hollow and solid masonry: Type "E" or "F," contractor's option, unless type is indicated on Drawings.

END OF SECTION

**SECTION 05 12 00
STRUCTURAL STEEL**

PART 1 GENERAL

1.1 SUMMARY

- A. Section Includes: Structural steel members for roof framing.
- B. Related Sections:
 - 1. Section 03 60 00 - Grouting.
 - 2. Section 04 20 00 - Unit Masonry.
 - 3. Section 05 21 00 - Steel Joists.
 - 4. Section 05 31 00 - Steel Deck.
 - 5. Section 09 90 00 – Painting and Protective Coatings.

1.2 REFERENCES

- A. ASTM A992 - Structural Steel.
- B. ASTM A36 - Structural Steel.
- C. ASTM A108 - Steel Bars, Carbon, Cold-Finished, Standard Quality.
- D. ASTM A123 - Zinc (Hot Dipped Galvanized) Coatings on Iron and Steel Products.
- E. ASTM A153 - Zinc Coating (Hot Dip) on Iron and Steel Hardware.
- F. ASTM A307 - Carbon Steel Threaded Standard Fasteners.
- G. AWS D1.1 - Structural Welding Code.
- H. SSPC (Steel Structures Painting Council) - Steel Structures Painting Manual.
- I. UL - Fire Resistance Directory.
- J. Warnock Hersey - Certification Listings.

1.3 SUBMITTAL

- A. Product Data:
 - 1. Submit manufacturer's descriptive literature and product specifications for each product.
- B. Shop Drawings:
 - 1. Indicate typical layout including dimensions and show complete details and schedules (if required) for fabrication, assembly, and erection. Furnish anchor bolts required for installation in other work; furnish templates for bolt installation.
 - 2. Submit drawings showing measured dimensions.
 - 3. Submit detail drawings of special accessory components not included in the manufacturer's product data.

- C. Quality Assurance / Control Submittals:
 - 1. Certificates:
 - a. Submit certificates for certified welders.

1.4 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing products specified in this Section with minimum 5 years documented experience.
- B. Fabricator Qualifications: Company specializing in fabricating work specified in this Section with minimum 5 years documented experience.
- C. Installer Qualifications: Acceptable to manufacturer with documented experience on at least 5 projects of similar nature in the past 5 years.

PART 2 PRODUCTS

2.1 MATERIALS

- A. Wide flange shapes—ASTM A992.
- B. Steel plates, Shapes other than wide flange, Bars—ASTM A36.
- C. Cold-formed steel tubing—ASTM A500, Grade B.
- D. Steel pipe—ASTM A53, Type E or S, Grade B.

2.2 COMPONENTS

- A. Headed anchor bolts—ASTM F1554, Grade 55.
- B. Fasteners—ASTM A 325 or A 490: High-strength threaded bolts and nuts, provide twist-off type indicator bolts for all structural bolted connections.
- C. Welding Electrodes: ASTM A5.1 or A5.5, E70-XX electrodes.
- D. Connections: As shown on final shop Drawings. Use high-strength bolts for field connections, except as otherwise indicated:
 - 1. Comply with AWS Code for procedures, appearance, and quality of welds.

2.3 ACCESSORIES

- A. Shop painting: Paint all structural steel work, except members or portions of members embedded in concrete or mortar and contact areas to be welded or riveted.
 - 1. Shop paint shall be SSPC-Paint 13.
 - 2. Clean steel free of loose mill scale, rust, oil, and grease according to SSPC SP1.
 - 3. Clean galvanized surfaces according to ASTM D2092.
 - 4. Apply one coat of catalyzed epoxy prime paint to provide a minimum dry film thickness of 4.0 mils.
 - 5. Apply one coat of catalyzed epoxy primer to provide a minimum dry film thickness of 4 mils.
 - 6. Apply one coat of polyurethane to a minimum dry film thickness of 4 mils.

2.4 FABRICATION

A. Fabrication Tolerances:

1. Comply with AISC "Specifications" and final shop Drawings. Mark and match-mark units for field assembly.

2.5 FINISHES

- ### A. Shop prime and finish all structural steel under provisions of Section 09 90 00.

PART 3 EXECUTION

3.1 ERECTION

- #### A. Comply with AISC Code and Specifications and maintain work in safe and stable condition during erection. Provide temporary bracing and shoring as required; remove when final connections placed:
1. Set baseplates on cleaned bearing surfaces, using wedges or other adjustments as required. Solidly pack open spaces with bedding mortar. Use commercial nonshrink grout material.
 2. Splice members only where shown on structural drawings.
 3. Touch-up prime paint after erection. Clean field welds, bolted connections, and abraded areas and apply same type paint as used in shop.

3.2 CONSTRUCTION

A. Interface with Other Work:

1. Fabricate structural steel members to provide holes for securing other work and for passage of other work through steel framing as indicated.

3.3 CLEANING

- #### A. Clean as recommended by manufacturer. Do not use materials or methods which may damage finish / surface or surrounding construction.

3.4 PROTECTION

- #### A. Paint exposed interior and exterior structural steel in accordance with Section 09 90 00.

END OF SECTION

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**SECTION 05 21 00
STEEL JOISTS**

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:

1. Open web steel joists, with bridging, attached seats and anchors.
2. Loose bearing plates, headed anchor studs and anchor bolts for site placement.
3. Framed roof openings greater than 18 inches.

B. Related Sections:

1. Section 03 60 00 - Grouting.
2. Section 04 20 00 - Unit Masonry.
3. Section 05 12 00 - Structural Steel.
4. Section 05 31 0 - Steel Deck.

1.2 REFERENCES

- A. ASTM A36 - Structural Steel.
- B. ASTM A108 - Steel Bars, Carbon, Cold-Finished, Standard Quality.
- C. ASTM A123 - Zinc (Hot Dipped Galvanized) Coatings on Iron and Steel Products.
- D. ASTM A153 - Zinc Coating (Hot Dip) on Iron and Steel Hardware.
- E. ASTM A992 - Structural Steel.
- F. AWS D1.1 - Structural Welding Code.
- G. FM - Roof Assembly Classifications.
- H. SJI (Steel Joist Institute) - Specifications, Load tables, and Weight Tables for Steel Joists and Joist Girders.
- I. SSPC (Steel Structures Painting Council) - Steel Structures Painting Manual.
- J. UL - Fire Resistance Directory.
- K. Warnock Hersey - Certification Listings.

1.3 SUBMITTALS

A. Product Data:

1. Submit manufacturer's descriptive literature and product specifications for each product.

B. Shop Drawings:

1. Indicate typical layout including dimensions and standard designations, configuration, sizes, spacing, locations of joists, joist leg extensions.

2. Submit data to indicate Joist coding, bridging, connections and attachments, and cambers.
3. Submit drawings showing measured dimensions.
4. Submit detail drawings of special accessory components not included in the manufacturer's product data.

C. Quality Assurance / Control Submittals

1. Certificates:
 - a. Submit manufacturer's certificates, certifying welders employed on the Work, verifying AWS qualification within the previous 12 months.
 - b. Submit applicable mill certificates.

1.4 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing products specified in this Section with minimum 5 years documented experience.
- B. Fabricator Qualifications: Company specializing in fabricating work specified in this Section with minimum 5 years documented experience.
 1. Fabricator work shall be certified by SJI.
- C. Erector Qualifications: Acceptable to manufacturer with documented experience on at least 5 projects of similar nature in the past 5 years.
- D. Perform Work in accordance with SJI, load tables, and weight tables.
- E. Maintain one copy of each document on site.
- F. Design connections not detailed on the Drawings under the direct supervision of a Professional Structural Engineer experienced in design of this Work and licensed in the State of Colorado.

1.5 DELIVERY, STORAGE AND HANDLING

- A. Packing, Shipping, Handling and Unloading:
 1. Deliver, handle, store, and protect products under provisions of Section 01 60 00 and to SJI requirements.

PART 2 PRODUCTS

2.1 MATERIALS

- A. Open web joists members: SJI Type K.

2.2 COMPONENTS

- A. Structural steel for supplementary framing and joist leg extensions: ASTM A36.
- B. Headed anchor studs.

2.3 ACCESSORIES

- A. Welding materials: AWS D1.1; type required for materials being welded.

- B. Shop and touch-up primer: SSPC 15, Type 1, red oxide.
- C. Hot dip galvanized: ASTM A123.

2.4 FABRICATION

- A. Shop Assembly:
 - 1. Fabricate to achieve end bearing as indicated on the Drawings.
 - 2. Frame special sized openings in joist web framing as detailed.
 - 3. Provide top chord extensions as indicated.

2.5 FINISHES

- A. Shop prime and finish all joists and joist accessories under provisions of Section 09 90 00.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verification of existing conditions prior to beginning work.

3.2 PREPARATION

- A. Protection:
 - 1. All joists and accessories shall be shop coated with one primer coat of catalyzed epoxy primer to provide a minimum dry film thickness of 3 mils.
- B. Surface Preparation:
 - 1. Prepare joist component surfaces in accordance with SSPC-SP 2 or SSPC-SP3.
 - 2. Clean and remove loose scale, heavy rust and other foreign materials from fabricated joists and accessories.
 - 3. Hot dip galvanize all joists and joist accessories for areas indicated on the drawings.

3.3 ERECTION

- A. Erect and bear joists on supports.
- B. Allow for erection loads. Provide sufficient temporary bracing to maintain framing safe, plumb, and in true alignment.
- C. Coordinate placement of anchors in concrete and masonry construction for securing bearing plates and angles.
- D. After joist alignment and installation of framing, field weld joist seat to bearing plates.
- E. Position and field weld joist chord extensions and wall attachments as detailed.
- F. Frame roof openings in accordance with the Drawings.
- G. Do not permit erection of decking until joists are braced, and secured or until completion of erection and installation of permanent bridging and bracing.
- H. Do not field cut or alter structural members without approval of joist manufacturer.

II Erection Tolerances:

1. Maximum variation from plumb: 1/4 inch.
2. Maximum offset from true alignment: 1/4 inch.

3.4 CLEANING

- A. Clean as recommended by manufacturer. Do not use materials or methods which may damage finish / surface or surrounding construction.

END OF SECTION

SECTION 05 31 00
STEEL DECK

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:

1. Roof deck.
2. Accessories:
 - a. Formed steel cant strips, eave strips, and valley strips.
 - b. Framing for openings up to and including 18 inches.
 - c. Bearing plates and angles.

B. Related Sections:

1. Section 04 20 00 - Unit Masonry.

1.2 REFERENCES

- A. ASTM A36 - Structural Steel.
- B. ASTM A446 - Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip process, Structural (Physical) Quality.
- C. ASTM A525 - Steel Sheet, Zinc-Coated, Galvanized by the Hot-Dip Process.
- D. ASTM A992 - Structural Steel.
- E. AWS D1.1 - Structural Welding Code.
- F. FM - Roof Assembly Classifications.
- G. SDI (Steel Deck Institute - Design Manual for Composite Decks, Form Decks, Roof Decks, Cellular Metal Floor Deck with Electrical Distribution.
- H. SSPC (Steel Structures Painting Council - Painting Manual.
- I. UL - Fire Resistance Directory.

1.3 SYSTEM DESCRIPTION

A. Design Requirements:

1. Design metal deck in accordance with SDI Design Manual.

1.4 SUBMITTALS

A. Product Data:

1. Submit manufacturer's descriptive literature and product specifications for each product.
2. Include data to indicate deck profile characteristics and dimensions, structural properties, finishes, and section properties.

B. Shop Drawings:

1. Indicate typical layout including dimensions and include layout and type of deck

panels, anchorage details, reinforcing channels, pans, deck openings, special jointing, accessories, and attachments to other construction.

2. Submit drawings showing measured dimensions.
3. Submit detail drawings of special accessory components not included in the manufacturer's product data.

C. Quality Assurance / Control Submittals:

1. Certificates:
 - a. Certify welders employed on the Work, verifying AWS qualification within the previous 12 months.
2. Manufacturer's Instructions:
 - a. Submit manufacturer's installation instructions.

1.5 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing products specified in this Section with minimum 5 years documented experience.
- B. Fabricator Qualifications: Company specializing in fabricating work specified in this Section with minimum 5 years documented experience.
- C. Installer Qualifications: Acceptable to manufacturer with documented experience on at least 5 projects of similar nature in the past 5 years.
- D. Welding: Quality procedures and personnel according to AWS D1.1, "Structural Welding Code—Steel," and AWS D1.3, "Structural Welding Code—Sheet Steel.
- E. Fire-Test-Response Characteristics: Where indicated, provide steel deck units identical to those steel deck units tested for fire resistance per ASTM E 119 by a testing and inspection agency acceptable to authorities having jurisdiction.
- F. AISI specifications: Calculate structural characteristics of steel deck accordance to AISI's "Specification for the Design of Cold-Formed Steel Structural Members".
- G. Design deck layout, spans, fastening, and joints under direct supervision of a Professional Structural Engineer experienced in design of this Work and licensed in the State of Colorado.
- H. Certifications
 1. Certify that Products meet or exceed specified requirements.

1.6 DELIVERY, STORAGE AND HANDLING

- A. Storage and Protection
 1. Cut plastic wrap to encourage ventilation.
 2. Store deck on dry wood sleepers; slope for positive drainage.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturer's Names:
 - 1. Consolidated Systems, Inc.
 - 2. EPIC Metals Corporation.
 - 3. Vulcraft.
 - 4. Verco.
 - 5. Or Approved Equal.

2.2 MATERIALS

- A. Sheet steel: ASTM A653, Grade 33 or higher; with G90 galvanized coating conforming to ASTM A924.

2.3 COMPONENTS

- A. Bearing plates angles: ASTM A36 steel.
- B. Welding materials: AWS D1.1.

2.4 ACCESSORIES

- A. Steel deck manufacturer's standard accessory materials, including mechanical fasteners, closure strip, pour stops, and closures for deck.
- B. Shear connectors: ASTM A 108, Grades 1010 through 1020 headed stud type, cold-finished carbon steel.
- C. Metal closure strips and cant strips: Formed sheet steel, 20 gage thick, 45 degree slope, 3-1/2 inches nominal width and height, flange for attachment.
- D. Valley strips and eave strips: Fabricated of metal of same type and finish as deck.
- E. Weld washers: Mild steel, uncoated, 3/4 inch outside diameter, 1/8 inch thick.
- F. Galvanizing repair paint: ASTM A 780, with dry film containing a minimum of 94 percent zinc dust by weight.
- G. Touch-up primer for galvanized surfaces: SSPC 20 Type I—Inorganic.

2.5 FINISHES

- A. Shop prime and finish all steel deck under provisions of Section 09 90 00.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Site verification of conditions prior to beginning work.

3.2 INSTALLATION

- A. Install units plumb, level, square and free from warp or twist while maintaining dimensional tolerances and alignment with surrounding construction / adjacent surfaces.

- B. Install deck panels and accessories in accordance with applicable specifications and commentary in SDI Publication No. 29, manufacturer's written instructions, and requirements of this Section.
- C. Place deck panels on supporting frame and adjust to final position with ends accurately aligned and bearing on supporting frame before being permanently fastened. Do not stretch or contract slide-lap interlocks:
 - 1. Bear deck on masonry support surfaces with 6 inches minimum bearing. Align and level.
 - 2. Bear deck on steel supports with 3 inches minimum bearing. Align and level.
- D. Place deck panels flat and square and fasten to supporting frame without warp or deflection.
- E. Fasten ribbed deck to steel support members at ends and intermediate supports with fusion (puddle) welds through weld washers at 12 inches O.C. maximum, parallel with the deck flute and at every other transverse flute (5 minimum per panel).
- F. Cut and neatly fit deck panels and accessories around openings and other work projecting through or adjacent to decking.
- G. Provide additional reinforcement and closure pieces at openings as required for strength, continuity of decking, and support of other work.
- H. Weld in accordance with AWS D1.1. Comply with AWS requirements and procedures for manual shielded metal arc welding, appearance and quality of welds, and methods used for correcting welding work:
 - 1. Weld male/female side laps at 18 inches O.C. maximum.
- I. Reinforce steel deck openings from 6 inches to 24 inches in size with 2 inches by 2 inches by 1/4 inch steel angles. Place framing angles perpendicular to flutes; extend minimum 2'-0" beyond each side of opening and fusion weld to deck at each flute.
- J. Roof deck accessories: Install sump pans, finish strips, cover plates, end closures, and reinforcing channels according to deck manufacturer's written instructions. Weld to substrate to provide a complete deck installation:
 - 1. Install 6 inches minimum wide sheet steel cover plates, of same thickness as deck, where deck changes direction. Fusion weld 18 inches O.C. maximum.
 - 2. Install sheet steel closures and angle flashings to close openings between deck and walls, columns, and openings.
 - 3. Install single row of foam flute closures above walls and partitions perpendicular to deck flutes.
 - 4. Place metal cant strips in position and fusion weld.
 - 5. Immediately after welding deck and other metal components in position, coat welds, burned areas, and damaged surface coating, with touch-up prime paint.
 - 6. Provide and install steel angles at the perimeter of the roof, where the deck abuts masonry or concrete walls.

3.3 REPAIR / RESTORATION

- A. Prepare and repair damaged galvanized coatings on both surfaces of deck with galvanized repair paint according to ASTM A 780 and manufacturer's written instructions.

3.4 FIELD QUALITY CONTROL

- A. Inspections:
 - 1. Field welds will be subject to inspection.
 - 2. Remove and replace work that does not comply with specified requirements.

3.5 ADJUSTING

- A. Adjust parts for smooth, uniform operation.

3.6 CLEANING

- A. Clean as recommended by manufacturer. Do not use materials or methods which may damage finish / surface or surrounding construction.

END OF SECTION

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**SECTION 05 40 00
COLD-FORMED METAL FRAMING**

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Load-bearing roof over-framing

1.2 PREINSTALLATION MEETINGS

- A. Preinstallation Conference:** Conduct conference at Project site.

1.3 ACTION SUBMITTALS

A. Product Data: For the following:

1. Cold-formed steel framing materials.
2. Load-bearing wall framing.
3. Vertical deflection clips.
4. Single deflection track.
5. Double deflection track.
6. Drift clips.
7. Post-installed anchors.
8. Power-actuated anchors.

B. Shop Drawings:

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

1.4 INFORMATIONAL SUBMITTALS

- A. Welding certificates.**
- B. Product certificates.**
- C. Product test reports.**

1.5 QUALITY ASSURANCE

- A. Testing Agency Qualifications:** Qualified according to ASTM E329 for testing indicated.
- B. Product Tests:** Mill certificates or data from a qualified independent testing agency.
- C. Retain "Welding Qualifications"**
- D. Welding Qualifications:** Qualify procedures and personnel according to the following:
1. AWS D1.1/D1.1M, "Structural Welding Code - Steel."
 2. AWS D1.3/D1.3M, "Structural Welding Code - Sheet Steel."

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Cold-Formed Steel Framing Standards: Unless more stringent requirements are indicated, framing complies with AISI S100 and ASTM C955 and AISI S200.
- B. Fire-Resistance Ratings: Comply with ASTM E119; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

2.2 COLD-FORMED STEEL FRAMING MATERIALS

- A. Framing Members, General: Comply with AISI S200 and ASTM C955, for conditions indicated.

2.3 LOAD-BEARING ROOF OVERFRAMING

- A. Steel Studs: Manufacturer's standard C-shaped steel studs, of web depths indicated, punched, with stiffened flanges, and as follows:
 - 1. Minimum Base-Metal Thickness: As indicated on drawings
 - 2. Flange Width: As indicated on drawings
- B. Steel Track: Manufacturer's standard U-shaped steel track, of web depths indicated, unpunched, with straight flanges, and matching minimum base-metal thickness of steel studs.
- C. Steel Box or Back-to-Back Headers: Manufacturer's standard C-shapes used to form header beams, of web depths indicated, unpunched, as indicated on drawings.
 - 1. Minimum Thickness: As indicated on drawings
 - 2. Flange Width: As indicated on drawings

2.4 FRAMING ACCESSORIES

- A. Fabricate steel-framing accessories from ASTM A1003/A1003M, Structural Grade, Type H, metallic coated steel sheet, of same grade and coating designation used for framing members.
- B. Provide accessories of manufacturer's standard thickness and configuration, unless otherwise indicated.

2.5 ANCHORS, CLIPS, AND FASTENERS

- A. Steel Shapes and Clips: ASTM A36/A36M, zinc coated by hot-dip process according to ASTM A123/A123M.
- B. Anchor Bolts: ASTM A36, [Grade 36/ICC-ES AC01 and ICC-ES AC193 are for expansion anchors in masonry and mechanical anchors in concrete respectively, and ICC-ES AC58 and ICC-ES AC308 are for adhesive anchors in masonry and concrete. Do not use expansion-type anchors where expansion can cause damage to the substrate material.
- C. Post-Installed Anchors: Fastener systems with bolts of same basic metal as fastened metal, if visible, unless otherwise indicated; with working capacity greater than or equal to the design load, according to an evaluation report acceptable to authorities having jurisdiction, based on ICC-ES AC01 as appropriate for the substrate.
 - 1. Uses: Securing cold-formed steel framing to structure.

- D. Power-Actuated Anchors: Fastener systems with working capacity greater than or equal to the design load, according to an evaluation report acceptable to authorities having jurisdiction, based on ICC-ES AC70.
- E. Mechanical Fasteners: ASTM C1513, corrosion-resistant-coated, self-drilling, self-tapping, steel drill screws.
 - 1. Head Type: Low-profile head beneath sheathing; manufacturer's standard elsewhere.

2.6 MISCELLANEOUS MATERIALS

- A. Galvanizing Repair Paint: ASTM A780/A780M Retain "Cement Grout" or "Nonmetallic, Nonshrink Grout"
- B. Cement Grout: Portland cement, ASTM C150/C150M, Type I; and clean, natural sand, ASTM C404. Mix at ratio of 1 part cement to 2-1/2 parts sand, by volume, with minimum water required for placement and hydration.
- C. Nonmetallic, Nonshrink Grout: Factory-packaged, nonmetallic, noncorrosive, nonstaining grout, complying with ASTM C1107/C1107M, and with a fluid consistency and 30-minute working time.
- D. Shims: Load-bearing, high-density, multimer, nonleaching plastic; or cold-formed steel of same grade and metallic coating as framing members supported by shims.
- E. Sill Sealer Gasket: Closed-cell neoprene foam, 1/4 inch (6 mm) thick, selected from manufacturer's standard widths to match width of bottom track or rim track members as required.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Before sprayed fire-resistive materials are applied, attach continuous angles, supplementary framing, or tracks to structural members indicated to receive sprayed fire-resistive materials.
- B. After applying sprayed fire-resistive materials, remove only as much of these materials as needed to complete installation of cold-formed framing without reducing thickness of fire-resistive materials below that required to obtain fire-resistance ratings indicated. Protect remaining fire-resistive materials from damage.
- C. Install load-bearing shims or grout between the underside of load-bearing wall bottom track and the top of foundation wall or slab at locations with a gap larger than 1/4 inch (6 mm) to ensure a uniform bearing surface on supporting concrete or masonry construction.
- D. Install sill sealer gasket at the underside of wall bottom track or rim track and at the top of foundation wall or slab at stud or joist locations.

3.2 INSTALLATION, GENERAL

- A. Cold-formed steel framing may be shop or field fabricated for installation, or it may be field assembled.
- B. Install cold-formed steel framing according to AISI S200, AISI S202, and manufacturer's written instructions unless more stringent requirements are indicated.

- C. Install cold-formed steel framing and accessories plumb, square, and true to line, and with connections securely fastened.
- D. Install framing members in one-piece lengths unless splice connections are indicated for track or tension members.
- E. Install temporary bracing and supports to secure framing and support loads equal to those for which structure was designed. Maintain braces and supports in place, undisturbed, until entire integrated supporting structure has been completed and permanent connections to framing are secured.
- F. Do not bridge building expansion joints with cold-formed steel framing. Independently frame both sides of joints.
- G. Install insulation, specified in Section 072100 "Thermal Insulation," in framing-assembly members, such as headers, sills, boxed joists, and multiple studs at openings, that are inaccessible on completion of framing work.
- H. Fasten hole-reinforcing plate over web penetrations that exceed size of manufacturer's approved or standard punched openings.

3.3 INSTALLATION OF LOAD-BEARING ROOF OVER-FRAMING

- A. Install continuous top and bottom tracks sized to match studs. Align tracks accurately and securely anchor at corners and ends, and at spacings as follows:
 - 1. Anchor Spacing: To match stud spacing
- B. Squarely seat studs against top and bottom tracks, with gap not exceeding 1/8 inch (3 mm) between the end of wall-framing member and the web of track.
 - 1. Fasten both flanges of studs to top and bottom tracks.
 - 2. Space studs as follows:
 - a. Stud Spacing: As indicated on Drawings.
- C. Set studs plumb, except as needed for diagonal bracing or required for nonplumb walls or warped surfaces and similar configurations.
- D. Align studs vertically where floor framing interrupts wall-framing continuity. Where studs cannot be aligned, continuously reinforce track to transfer loads.
- E. Align floor and roof framing over studs according to AISI S200, Section C1. Where framing cannot be aligned, continuously reinforce track to transfer loads.
- F. Anchor studs abutting structural columns or walls, including masonry walls, to supporting structure.
- G. Install headers over wall openings wider than stud spacing. Locate headers above openings. Fabricate headers of compound shapes indicated or required to transfer load to supporting studs, complete with clip-angle connectors, web stiffeners, or gusset plates.
 - 1. Frame wall openings with not less than a double stud at each jamb of frame. Fasten jamb members together to uniformly distribute loads.
 - 2. Install tracks and jack studs above and below wall openings. Anchor tracks to jamb studs with clip angles or by welding, and space jack studs same as full-height wall studs.
- H. Install supplementary framing, blocking, and bracing in stud framing indicated to support fixtures, equipment, services, casework, heavy trim, furnishings, and similar work requiring attachment to framing.

1. If type of supplementary support is not indicated, comply with stud manufacturer's written recommendations and industry standards in each case, considering weight or load resulting from item supported.
- I. Install horizontal bridging in stud system, spaced vertically 48 inches (1220 mm) Fasten at each stud intersection.
 1. Channel Bridging: Cold-rolled steel channel, welded or mechanically fastened to webs of punched studs with a minimum of two screws into each flange of the clip angle for framing members up to 6 inches (150 mm) deep.
 2. Strap Bridging: Combination of flat, taut, steel sheet straps of width and thickness indicated and stud-track solid blocking of width and thickness to match studs. Fasten flat straps to stud flanges, and secure solid blocking to stud webs or flanges.
 3. Bar Bridging: Proprietary bridging bars installed according to manufacturer's written instructions.
- J. Install steel sheet diagonal bracing straps to both stud flanges; terminate at and fasten to reinforced top and bottom tracks. Fasten clip-angle connectors to multiple studs at ends of bracing and anchor to structure.
- K. Install miscellaneous framing and connections, including supplementary framing, web stiffeners, clip angles, continuous angles, anchors, and fasteners, to provide a complete and stable wall-framing system.

3.4 INSTALLATION TOLERANCES

- A. Install cold-formed steel framing level, plumb, and true to line to a maximum allowable tolerance variation of 1/8 inch in 10 feet (1:960) and as follows:
 1. Space individual framing members no more than plus or minus 1/8 inch (3 mm) from plan location. Cumulative error are not to exceed minimum fastening requirements of sheathing or other finishing materials.

3.5 REPAIRS

- A. Galvanizing Repairs: Prepare and repair damaged galvanized coatings on fabricated and installed cold-formed steel framing with galvanized repair paint according to ASTM A780/A780M and manufacturer's written instructions.

3.6 FIELD QUALITY CONTROL

- A. Testing: Owner will engage a qualified independent testing and inspecting agency to perform field tests and inspections and prepare test reports.
- B. Field and shop welds will be subject to testing and inspecting.
- C. Testing agency will report test results promptly and in writing to Contractor and Architect.
- D. Cold-formed steel framing will be considered defective if it does not pass tests and inspections.
- E. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.

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SECTION 05 41 00
PRE-ENGINEERED, PRE-FABRICATED LIGHT GAUGE STEEL ROOF TRUSSES

PART 1 - GENERAL

1.1 REFERENCES

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.
 - 1. AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)
 - a) ASTM A 653
 - i. (2000) Steel Sheet, Zinc-Coated
 - ii. (Galvanized) or Zinc-Iron Alloy-Coated
 - iii. (Galvannealed) by the Hot-Dip Process
 - b) ASTM A 780 (2000) Repair of Damaged and Uncoated areas of Hot-Dipped Galvanized Coatings
 - 2. AMERICAN WELDING SOCIETY (AWS)
 - a) AWS D1.1 (2000) Structural Welding Code – Steel
 - b) AWS D1.3 (1998) Structural Welding Code – Sheet Steel

1.2 SUBMITTALS

- A. SD-03 Product Data
 - 1. Cold-formed steel framing
 - 2. Accessory
 - 3. Submit manufacturer's product data and installation instructions for each type of cold-formed steel framing and accessory required.
- B. SD-02 Shop Drawings
 - 1. Cold-formed steel framing
 - 2. Submit shop drawings showing member, type, location, spacing, size, and gage of members, method of attachment to supporting members and all necessary erection details. Include supplemental bracing, strapping, splices, bridging, accessories, and details required for proper installation.
 - 3. Submit detailed floor truss and roof truss layouts
 - 4. Submit truss drawings, sealed and signed by a qualified registered Professional Engineer, verifying truss' ability to meet local code and design requirements.
 - 5. Include:
 - 1) Description of design criteria
 - 2) Engineering analysis depicting member stresses and truss deflection.
 - 3) Truss member sizes and gauges and connections at truss joints.
 - 4) Truss support reactions.
 - 5) Top chord, Bottom chord and Web bracing requirements.

1.3 PERFORMANCE REQUIREMENTS

- A. AISI "Specifications"
 - 1. Calculate structural characteristics of cold-formed steel truss members according to AISI's "Specification for the Design of Cold-Formed Steel Structural Members, 1986 (1990)."

- B. Structural Performance
 - 1. Design, engineer, fabricate, and erect cold-formed steel trusses to withstand specified design loads within limits and under conditions required.
- C. Design Loads: As specified.
- D. Deflections: Live load deflection meeting the following (unless otherwise specified):
 - 1. Roof Trusses: Vertical deflection less than or equal to 1/240 of the span.
- E. Design framing systems to provide for movement of framing members without damage or overstressing, sheathing failure, connection failure, undue strain on fasteners and anchors, or other detrimental effects when subject to a maximum ambient temperature change (range) of 120 deg F (67 deg C).

1.4 QUALITY ASSURANCE

- A. Fabricator Qualifications
 - a. Fabrication shall be performed by a cold-formed steel truss fabricator with experience designing and fabricating cold-formed steel truss systems equal in material, design, and extent to the systems required for this Project.
 - 1) Cold Formed steel truss system installation shall be performed by an experienced installer approved by the steel truss system fabricator.
- B. Welding Standards
 - a. Comply with applicable provisions of AWS D1.1 "Structural Welding Code-Steel" and AWS D1.3 "Structural Welding Code-Sheet Steel."
 - 1) Qualify welding processes and welding operators in accordance with AWS "Standard Qualification Procedure."

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Deliver materials in manufacturer's unopened containers or bundles, fully identified by name, brand, type and grade. Exercise care to avoid damage during unloading, storing and erection.
- B. Store trusses on blocking, pallets, platforms or other supports off the ground and in an upright position sufficiently braced to avoid damage from excessive bending.
- C. Protect trusses and accessories from corrosion, deformation, damage and deterioration when stored at job site. Keep trusses free of dirt and other foreign matter.

1.6 PROJECT CONDITIONS

During construction, adequately distribute all loads applied to trusses so as not to exceed the carrying capacity of any one joist, truss or other component.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

2.2 COMPONENTS

- A. Provide manufacturer's standard steel truss members, bracing, bridging, blocking, reinforcements, fasteners and accessories with each type of steel framing required, as recommended by the manufacturer for the applications indicated and as needed to provide a complete light gauge cold formed steel truss system.

2.3 MATERIALS

- A. Materials
 - a. All component gauges: Fabricate components of structural quality steel sheet per ASTM A 653 with a minimum yield strength of 40,000 psi.
 - b. Bracing, bridging and blocking members: Fabricate components of commercial quality steel sheet per ASTM A 653 with a minimum yield strength of 33,000 psi.
- B. Steel Truss Components
 - a. Provide sizes, shapes, and minimum gages indicated.
 - b. For all members, except as noted below: 16 ga., 0.0350 inch (0.91 mm).
 - c. Truss top chords where steel diaphragms are attached 12 ga., .1054 inch (2.75 mm).

2.4 ANCHORS, CLIPS, AND FASTENERS

- A. Steel Shapes and Clips: ASTM A36/A36M, zinc coated by hot-dip process according to ASTM A123/A123M.
- B. Anchor Bolts: ASTM A36, [Grade 36] ICC-ES AC01 and ICC-ES AC193 are for expansion anchors in masonry and mechanical anchors in concrete respectively, and ICC-ES AC58 and ICC-ES AC308 are for adhesive anchors in masonry and concrete. Do not use expansion-type anchors where expansion can cause damage to the substrate material.
- C. Post-Installed Anchors: Fastener systems with bolts of same basic metal as fastened metal, if visible, unless otherwise indicated; with working capacity greater than or equal to the design load, according to an evaluation report acceptable to authorities having jurisdiction, based on ICC-ES AC01 as appropriate for the substrate.
 - 1. Uses: Securing cold-formed steel framing to structure.
- D. Power-Actuated Anchors: Fastener systems with working capacity greater than or equal to the design load, according to an evaluation report acceptable to authorities having jurisdiction, based on ICC-ES AC70.
- E. Mechanical Fasteners: ASTM C1513, corrosion-resistant-coated, self-drilling, self-tapping, steel drill screws.
 - 1. Head Type: Low-profile head beneath sheathing; manufacturer's standard elsewhere.

2.5 MISCELLANEOUS MATERIALS

- A. Galvanizing Repair Paint: ASTM A780/A780M Retain "Cement Grout" or "Nonmetallic, Nonshrink Grout"

- B. Cement Grout: Portland cement, ASTM C150/C150M, Type I; and clean, natural sand, ASTM C404. Mix at ratio of 1 part cement to 2-1/2 parts sand, by volume, with minimum water required for placement and hydration.
- C. Nonmetallic, Nonshrink Grout: Factory-packaged, nonmetallic, noncorrosive, nonstaining grout, complying with ASTM C1107/C1107M, and with a fluid consistency and 30-minute working time.
- D. Shims: Load-bearing, high-density, multimonomer, nonleaching plastic; or cold-formed steel of same grade and metallic coating as framing members supported by shims.
- E. Sill Sealer Gasket: Closed-cell neoprene foam, 1/4 inch (6 mm) thick, selected from manufacturer's standard widths to match width of bottom track or rim track members as required.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Before sprayed fire-resistive materials are applied, attach continuous angles, supplementary framing, or tracks to structural members indicated to receive sprayed fire-resistive materials.
- B. After applying sprayed fire-resistive materials, remove only as much of these materials as needed to complete installation of cold-formed framing without reducing thickness of fire-resistive materials below that required to obtain fire-resistance ratings indicated. Protect remaining fire-resistive materials from damage.
- C. Install load-bearing shims or grout between the underside of load-bearing wall bottom track and the top of foundation wall or slab at locations with a gap larger than 1/4 inch (6 mm) to ensure a uniform bearing surface on supporting concrete or masonry construction.
- D. Install sill sealer gasket at the underside of wall bottom track or rim track and at the top of foundation wall or slab at stud or joist locations.

3.2 INSTALLATION, GENERAL

- A. Cold-formed steel framing may be shop or field fabricated for installation, or it may be field assembled.
- B. Install cold-formed steel framing according to AISI S200, AISI S202, and manufacturer's written instructions unless more stringent requirements are indicated.
- C. Install cold-formed steel framing and accessories plumb, square, and true to line, and with connections securely fastened.
- D. Install framing members in one-piece lengths unless splice connections are indicated for track or tension members.
- E. Install temporary bracing and supports to secure framing and support loads equal to those for which structure was designed. Maintain braces and supports in place, undisturbed, until entire integrated supporting structure has been completed and permanent connections to framing are secured.
- F. Do not bridge building expansion joints with cold-formed steel framing. Independently frame both sides of joints.

- G. Install insulation, specified in Section 072100 "Thermal Insulation," in framing-assembly members, such as headers, sills, boxed joists, and multiple studs at openings, that are inaccessible on completion of framing work.
- H. Fasten hole-reinforcing plate over web penetrations that exceed size of manufacturer's approved or standard punched openings.

3.3 INSTALLATION OF LOAD-BEARING WALL FRAMING

- A. Install continuous top and bottom tracks sized to match studs. Align tracks accurately and securely anchor at corners and ends, and at spacings as follows:
 - 1. Anchor Spacing: To match stud spacing
- B. Squarely seat studs against top and bottom tracks, with gap not exceeding 1/8 inch (3 mm) between the end of wall-framing member and the web of track.
 - 1. Fasten both flanges of studs to top and bottom tracks.
 - 2. Space studs as follows:
 - a. Stud Spacing: As indicated on Drawings.
- C. Set studs plumb, except as needed for diagonal bracing or required for nonplumb walls or warped surfaces and similar configurations.
- D. Align studs vertically where floor framing interrupts wall-framing continuity. Where studs cannot be aligned, continuously reinforce track to transfer loads.
- E. Align floor and roof framing over studs according to AISI S200, Section C1. Where framing cannot be aligned, continuously reinforce track to transfer loads.
- F. Anchor studs abutting structural columns or walls, including masonry walls, to supporting structure.
- G. Install headers over wall openings wider than stud spacing. Locate headers above openings. Fabricate headers of compound shapes indicated or required to transfer load to supporting studs, complete with clip-angle connectors, web stiffeners, or gusset plates.
 - 1. Frame wall openings with not less than a double stud at each jamb of frame. Fasten jamb members together to uniformly distribute loads.
 - 2. Install tracks and jack studs above and below wall openings. Anchor tracks to jamb studs with clip angles or by welding, and space jack studs same as full-height wall studs.
- H. Install supplementary framing, blocking, and bracing in stud framing indicated to support fixtures, equipment, services, casework, heavy trim, furnishings, and similar work requiring attachment to framing.
 - 1. If type of supplementary support is not indicated, comply with stud manufacturer's written recommendations and industry standards in each case, considering weight or load resulting from item supported.
- I. Install horizontal bridging in stud system, spaced vertically 48 inches (1220 mm) Fasten at each stud intersection.
 - 1. Channel Bridging: Cold-rolled steel channel, welded or mechanically fastened to webs of punched studs with a minimum of two screws into each flange of the clip angle for framing members up to 6 inches (150 mm) deep.
 - 2. Strap Bridging: Combination of flat, taut, steel sheet straps of width and thickness indicated and stud-track solid blocking of width and thickness to match studs. Fasten flat straps to stud flanges, and secure solid blocking to stud webs or flanges.

- 3. Bar Bridging: Proprietary bridging bars installed according to manufacturer's written instructions.
 - J. Install steel sheet diagonal bracing straps to both stud flanges; terminate at and fasten to reinforced top and bottom tracks. Fasten clip-angle connectors to multiple studs at ends of bracing and anchor to structure.
 - K. Install miscellaneous framing and connections, including supplementary framing, web stiffeners, clip angles, continuous angles, anchors, and fasteners, to provide a complete and stable wall-framing system.
- 3.4 INSTALLATION TOLERANCES
- A. Install cold-formed steel framing level, plumb, and true to line to a maximum allowable tolerance variation of 1/8 inch in 10 feet (1:960) and as follows:
 - 1. Space individual framing members no more than plus or minus 1/8 inch (3 mm) from plan location. Cumulative error are not to exceed minimum fastening requirements of sheathing or other finishing materials.
- 3.5 REPAIRS
- A. Galvanizing Repairs: Prepare and repair damaged galvanized coatings on fabricated and installed cold-formed steel framing with galvanized repair paint according to ASTM A780/A780M and manufacturer's written instructions.
- 3.6 FIELD QUALITY CONTROL
- A. Testing: Owner will engage a qualified independent testing and inspecting agency to perform field tests and inspections and prepare test reports.
 - B. Field and shop welds will be subject to testing and inspecting.
 - C. Testing agency will report test results promptly and in writing to Contractor and Architect.
 - D. Cold-formed steel framing will be considered defective if it does not pass tests and inspections.
 - E. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.

END OF SECTION

**SECTION 05 50 00
METAL FABRICATIONS**

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Steel framing and supports for mechanical and electrical equipment.
 - 2. Steel framing and supports for applications where framing and supports are not specified in other Sections.
 - 3. Shelf angles.
 - 4. Metal ladders.
 - 5. Metal ships' ladders and pipe crossovers.
 - 6. Metal floor plate and supports.
 - 7. Miscellaneous steel trim including steel angle corner guards and loading-dock edge angles.
 - 8. Metal bollards.
 - 9. Abrasive metal nosings treads and thresholds.
 - 10. Loose bearing and leveling plates for applications where they are not specified in other Sections.
- B. Products furnished, but not installed, under this Section:
 - 1. Loose steel lintels.
 - 2. Anchor bolts, steel pipe sleeves, slotted-channel inserts, and wedge-type inserts indicated to be cast into concrete or built into unit masonry.
 - 3. Steel weld plates and angles for casting into concrete for applications where they are not specified in other Sections.

1.2 REFERENCES

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Related Sections:
 - 1. Section 03 30 00 "Cast-In-Place Concrete" for installing anchor bolts, steel pipe sleeves, slotted-channel inserts, wedge-type inserts, and other items cast into concrete.
 - 2. Section 05 51 00 "Metal Stairs."

1.3 ADMINISTRATIVE REQUIREMENTS

- A. Coordination
 - 1. Coordinate selection of shop primers with topcoats to be applied over them. Comply with paint and coating manufacturers' written recommendations to ensure that shop primers and topcoats are compatible with one another.
 - 2. Coordinate installation of anchorages and steel weld plates and angles for casting into concrete. Furnish setting drawings, templates, and directions for installing anchorages, including sleeves, concrete inserts, anchor bolts, and items with integral

anchors, that are to be embedded in concrete or masonry. Deliver such items to Project site in time for installation.

1.4 SUBMITTALS

A. Action Submittals

1. Product Data: For the following:
 - a. Metal nosings and treads.
 - b. Paint products.
 - c. Grout.
2. Shop Drawings: Show fabrication and installation details for metal fabrications.
 - a. Include plans, elevations, sections, and details of metal fabrications and their connections. Show anchorage and accessory items.
3. Samples for Verification: For each type and finish of extruded nosing and tread.
4. Delegated-Design Submittal: For installed products indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional ENGINEER responsible for their preparation.

B. Informational Submittals

1. Mill Certificates: Signed by manufacturers of stainless-steel certifying that products furnished comply with requirements.
2. Welding certificates.
3. Paint Compatibility Certificates: From manufacturers of topcoats applied over shop primers certifying that shop primers are compatible with topcoats.

1.5 QUALITY ASSURANCE

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

1. AWS D1.1, "Structural Welding Code - Steel."
2. AWS D1.2, "Structural Welding Code - Aluminum."
3. AWS D1.6, "Structural Welding Code - Stainless Steel."

1.6 SITE CONDITIONS

- ##### A. Field Measurements: Verify actual locations of walls and other construction contiguous with metal fabrications by field measurements before fabrication.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Design ladders, including comprehensive engineering analysis by a qualified professional ENGINEER, using performance requirements and design criteria indicated.
- B. Structural Performance of Aluminum Ladders: Aluminum ladders, including landings, shall withstand the effects of loads and stresses within limits and under conditions specified in ANSI A14.3.
- C. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes acting on exterior metal fabrications by preventing buckling, opening of joints,

overstressing of components, failure of connections, and other detrimental effects.

1. Temperature Change: 120 degrees F, ambient; 180 degrees F, material surfaces.

2.2 METALS, GENERAL

- A. Metal Surfaces, General: Provide materials with smooth, flat surfaces unless otherwise indicated. For metal fabrications exposed to view in the completed Work, provide materials without seam marks, roller marks, rolled trade names, or blemishes.

2.3 FERROUS METALS

- A. Steel Plates, Shapes, and Bars: ASTM A36.
- B. Stainless-Steel Sheet, Strip, and Plate: ASTM A240 or ASTM A666, Type 316L.
- C. Stainless-Steel Bars and Shapes: ASTM A276, Type 316L.
- D. Rolled-Stainless-Steel Floor Plate: ASTM A793.
- E. Steel Tubing: ASTM A500, cold-formed steel tubing.
- F. Steel Pipe: ASTM A53, standard weight (Schedule 40) unless otherwise indicated.
- G. Slotted Channel Framing: Cold-formed metal box channels (struts) complying with MFMA-4.
 1. Size of Channels: 1-5/8 by 1-5/8 inches or as indicated.
 2. Material: Galvanized steel, ASTM A653, structural steel, Grade 33, with G90 coating; 0.108-inch nominal thickness.

2.4 NONFERROUS METALS

- A. Aluminum Plate and Sheet: ASTM B209, Alloy 6061-T6.
- B. Aluminum Extrusions: ASTM B221, Alloy 6063-T6.
- C. Aluminum-Alloy Rolled Tread Plate: ASTM B632, Alloy 6061-T6.

2.5 FASTENERS

- A. General: Unless otherwise indicated, provide Type 316 stainless-steel fasteners. Select fasteners for type, grade, and class required.
 1. Provide stainless-steel fasteners for fastening aluminum.
 2. Provide stainless-steel fasteners for fastening stainless steel.
 3. Provide stainless-steel fasteners for fastening nickel silver.
 4. Provide bronze fasteners for fastening bronze.
- B. Stainless-Steel Bolts and Nuts: Regular hexagon-head annealed stainless-steel bolts, ASTM F593; with hex nuts, ASTM F594; and, where indicated, flat washers; Alloy Group 2.
- C. Anchor Bolts: ASTM F1554, Grade 36, of dimensions indicated; with nuts, ASTM A563; and, where indicated, flat washers.
 1. Hot-dip galvanized or provide mechanically deposited, zinc coating where item being fastened is indicated to be galvanized.
- D. Eyebolts: ASTM A489.
- E. Machine Screws: ASME B18.6.3.
- F. Lag Screws: ASME B18.2.1.

- G. Wood Screws: Flat head, ASME B18.6.1.
- H. Plain Washers: Round, ASME B18.22.1.
- I. Lock Washers: Helical, spring type, ASME B18.21.1.
- J. Cast-in-Place Anchors in Concrete: Either threaded type or wedge type unless otherwise indicated; galvanized ferrous castings, either ASTM A47 malleable iron or ASTM A27 cast steel. Provide bolts, washers, and shims as needed, all hot-dip galvanized per ASTM F2329.
- K. Post-Installed Anchors: Torque-controlled expansion anchors or chemical anchors.
 - 1. Material: Alloy Group 2 stainless-steel bolts, ASTM F593, and nuts, ASTM F594.

2.6 MISCELLANEOUS MATERIALS

- A. Welding Rods and Bare Electrodes: Select according to AWS specifications for metal alloy welded.
- B. Shop Primers: Provide primers that comply with Section 09 90 00 "Painting and Protective Coatings."
- C. Galvanizing Repair Paint: High-zinc-dust-content paint complying with SSPC-Paint 20 and compatible with paints specified to be used over it.
- D. Bituminous Paint: Cold-applied asphalt emulsion complying with ASTM D1187.
- E. Nonshrink, Nonmetallic Grout: Factory-packaged, nonstaining, noncorrosive, nongaseous grout complying with ASTM C1107. Provide grout specifically recommended by manufacturer for interior and exterior applications.
- F. Anti-Seize Lubricant: Loctite LB 8023 Marine Grade Anti-Seize lubricant or approved equal.

2.7 FABRICATION, GENERAL

- A. Shop Assembly: Preassemble items in the shop to greatest extent possible. Disassemble units only as necessary for shipping and handling limitations. Use connections that maintain structural value of joined pieces. Clearly mark units for reassembly and coordinated installation.
- B. Cut, drill, and punch metals cleanly and accurately. Remove burrs and ease edges to a radius of approximately 1/32 inch unless otherwise indicated. Remove sharp or rough areas on exposed surfaces.
- C. Form bent-metal corners to smallest radius possible without causing grain separation or otherwise impairing work.
- D. Form exposed work with accurate angles and surfaces and straight edges.
- E. Weld corners and seams continuously to comply with the following:
 - 1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
 - 2. Obtain fusion without undercut or overlap.
 - 3. Remove welding flux immediately.
 - 4. At exposed connections, finish exposed welds and surfaces smooth and blended so no roughness shows after finishing.
- F. Form exposed connections with hairline joints, flush and smooth, using concealed fasteners

or welds where possible. Where exposed fasteners are required, use Phillips flat-head (countersunk) fasteners unless otherwise indicated. Locate joints where least conspicuous.

- G. Fabricate seams and other connections that will be exposed to weather in a manner to exclude water. Provide weep holes where water may accumulate.
- H. Cut, reinforce, drill, and tap metal fabrications as indicated to receive finish hardware, screws, and similar items.
- I. Provide for anchorage of type indicated, coordinate with supporting structure. Space anchoring devices to secure metal fabrications rigidly in place and to support indicated loads.
 - 1. Where units are indicated to be cast into concrete or built into masonry, equip with integrally welded steel strap anchors, 1/8 by 1-1/2 inches, with a minimum 6-inch embedment and 2-inch hook, not less than 8 inches from ends and corners of units and 24 inches on centers, unless otherwise indicated.

2.8 MISCELLANEOUS FRAMING AND SUPPORTS

- A. General: Provide steel framing and supports not specified in other Sections as needed to complete the Work.
- B. Fabricate units from steel shapes, plates, and bars of welded construction unless otherwise indicated. Fabricate to sizes, shapes, and profiles indicated and as necessary to receive adjacent construction.
 - 1. Fabricate units from slotted channel framing where indicated.
 - 2. Furnish inserts for units installed after concrete is placed.
- C. Galvanize miscellaneous framing and supports where indicated.
- D. Prime miscellaneous framing and supports with primer specified in Section 09 90 00 "Painting and Protective Coatings" where indicated.

2.9 SHELF ANGLES

- A. Fabricate shelf angles from steel angles of sizes indicated and for attachment to concrete framing. Provide horizontally slotted holes to receive 3/4-inch bolts, spaced not more than six inches from ends and 24 inches on centers, unless otherwise indicated.
 - 1. Provide mitered and welded units at corners.
 - 2. Provide open joints in shelf angles at expansion and control joints. Make open joint approximately two inches larger than expansion or control joint.
- B. For cavity walls, provide vertical channel brackets to support angles from backup masonry and concrete.
- C. Galvanize shelf angles where indicated.
- D. Prime shelf angles where indicated with primer specified in Section 09 90 00 "Painting and Protective Coatings."
- E. Furnish wedge-type concrete inserts, complete with fasteners, to attach shelf angles to cast-in-place concrete.

2.10 METAL LADDERS

- A. General:

1. Comply with ANSI A14.3 unless otherwise indicated.
- B. Steel Ladders:
1. Space siderails 18 inches (457 mm) apart unless otherwise indicated.
 2. Siderails: Continuous, 1/2-by-2-1/2-inch (12.7-by-64-mm) steel flat bars, with eased edges.
 3. Rungs: 3/4-inch (19-mm) square steel bars.
 4. Fit rungs in centerline of siderails; plug-weld and grind smooth on outer rail faces.
 5. Provide nonslip surfaces on top of each rung, either by coating rung with aluminum-oxide granules set in epoxy-resin adhesive or by using a type of manufactured rung filled with aluminum-oxide grout.
 6. Provide nonslip surfaces on top of each rung by coating with abrasive material metallically bonded to rung.
 - a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - 1) IKG Industries, a division of Harsco Corporation; Mebac.
 - 2) SlipNOT Metal Safety Flooring, a W. S. Molnar company; SlipNOT.
 7. Provide platforms as indicated fabricated from welded or pressure-locked steel bar grating, supported by steel angles. Limit openings in gratings to no more than [1/2 inch (12 mm)] [3/4 inch (19 mm)] in least dimension.
 8. Support each ladder at top and bottom and not more than 60 inches o.c. with welded or bolted steel brackets.
 9. Galvanize ladders, including brackets and fasteners.
 10. Prime ladders, including brackets and fasteners, with zinc-rich primer. primer specified in Section 09 90 00 "Painting and Protective Coatings."
- C. Aluminum Ladders:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. ACL Industries, Inc.
 - b. Alco-Lite Industrial Products.
 - c. Halliday Products.
 - d. O'Keeffe's Inc.
 - e. Precision Ladders, LLC.
 - f. Royalite Manufacturing, Inc.
 - g. Thompson Fabricating, LLC.
 2. Space siderails 18 inches (457 mm) apart unless otherwise indicated.
 3. Siderails: Continuous extruded-aluminum channels or tubes, not less than 2-1/2 inches (64 mm) deep, 3/4 inch (19 mm) wide, and 1/8 inch (3.2 mm) thick.
 4. Rungs: Extruded-aluminum tubes, not less than 3/4 inch (19 mm) deep and not less than 1/8 inch (3.2 mm) thick, with ribbed tread surfaces.
 5. Fit rungs in centerline of siderails; fasten by welding or with stainless-steel fasteners or brackets and aluminum rivets.

6. Provide platforms as indicated fabricated from pressure-locked aluminum bar grating or extruded-aluminum plank grating, supported by extruded-aluminum framing. Limit openings in gratings to no more than 1/2 inch (12 mm) in least dimension.
7. Support each ladder at top and bottom and not more than 60 inches o.c. with welded or bolted aluminum brackets.

2.11 METAL SHIPS' LADDERS AND PIPE CROSSOVERS

- A. Provide metal ships' ladders and pipe crossovers where indicated. Fabricate of open-type construction with channel or plate stringers and pipe and tube railings unless otherwise indicated. Provide brackets and fittings for installation.
 1. Fabricate ships' ladders and pipe crossovers, including railings from aluminum.
 2. Fabricate treads and platforms from pressure-locked aluminum bar grating extruded-aluminum plank grating. Limit openings in gratings to no more than [1/2 inch (12 mm)] [3/4 inch (19 mm)] in least dimension.
 3. Fabricate treads and platforms from rolled-aluminum-alloy tread plate abrasive-surface floor plate.
 4. Comply with applicable railing requirements in Section 05 52 13 "Pipe and Tube Railings."
- B. Galvanize exterior steel ships' ladders and pipe crossovers, including treads, railings, brackets, and fasteners.
- C. Prime exterior steel ships' ladders and pipe crossovers, including treads, railings, brackets, and fasteners, with primer specified in Section 09 90 00 "Painting and Protective Coatings."

2.12 METAL FLOOR PLATE

- A. Fabricate from rolled-aluminum-alloy tread abrasive-surface floor plate of thickness indicated below:
 1. Thickness: Min 3/8 inch (9.5 mm) or as indicated in plans.
- B. Provide grating sections where indicated fabricated from extruded-aluminum plank grating. Limit openings in gratings to no more than 1/2 inch (12 mm) in least dimension.
- C. Provide aluminum angle supports as indicated.
- D. Include aluminum angle stiffeners and fixed and removable sections as indicated.
- E. Provide flush aluminum bar drop handles for lifting removable sections, one at each end of each section.

2.13 MISCELLANEOUS STEEL TRIM

- A. Unless otherwise indicated, fabricate units from steel shapes, plates, and bars of profiles shown with continuously welded joints and smooth exposed edges. Miter corners and use concealed field splices where possible.
- B. Provide cutouts, fittings, and anchorages as needed to coordinate assembly and installation with other work.
 1. Provide with integrally welded steel strap anchors for embedding in concrete or masonry construction.
- C. Galvanize miscellaneous steel trim where indicated.

- D. Prime miscellaneous steel trim with primer specified in Section 09 90 00 "Painting and Protective Coatings."

2.14 METAL BOLLARDS

- A. Fabricate metal bollards from Schedule 80 steel pipe.
- B. Fabricate bollards with 3/4-inch thick steel baseplates for bolting to concrete slab. Drill baseplates at all four corners for 3/4-inch anchor bolts.
 - 1. Where bollards are to be anchored to sloping concrete slabs, angle baseplates for plumb alignment of bollards.
- C. Galvanize bollards.

2.15 ABRASIVE METAL NOSINGS

- A. Cast-Metal Units: Cast aluminum, with an integral-abrasive, as-cast finish consisting of aluminum oxide, silicon carbide, or a combination of both. Fabricate units in lengths necessary to accurately fit openings or conditions.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. American Safety Tread Co., Inc.
 - b. Balco Inc.
 - c. Barry Pattern & Foundry Co., Inc.
 - d. Granite State Casting Co.
 - e. Safe-T-Metal Company, Inc.
 - f. Wooster Products Inc.
 - 2. Nosings: Cross-hatched units, 4 inches wide with 1-inch lip, for casting into concrete steps.
- B. Extruded Units: Aluminum, with abrasive filler consisting of aluminum oxide, silicon carbide, or a combination of both, in an epoxy-resin binder. Fabricate units in lengths necessary to accurately fit openings or conditions.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. ACL Industries, Inc.
 - b. American Safety Tread Co., Inc.
 - c. Amstep Products.
 - d. Armstrong Products, Inc.
 - e. Balco Inc.
 - f. Granite State Casting Co.
 - g. Wooster Products Inc.
 - 2. Provide ribbed units, with abrasive filler strips projecting 1/16 inch above aluminum extrusion.
 - 3. Nosings: Square-back units, 4 inches wide, for casting into concrete steps.
- C. Provide anchors for embedding units in concrete, either integral or applied to units, as

standard with manufacturer.

- D. Apply bituminous paint to concealed surfaces of cast-metal units.
- E. Apply clear lacquer to concealed surfaces of extruded units.

2.16 LOOSE BEARING AND LEVELING PLATES

- A. Provide loose bearing and leveling plates for steel items bearing on masonry or concrete construction. Drill plates to receive anchor bolts and for grouting.
- B. Galvanize plates where indicated.
- C. Prime plates with primer specified in Section 09 90 00 "Painting and Protective Coatings."

2.17 LOOSE STEEL LINTELS

- A. Fabricate loose steel lintels from steel angles and shapes of size indicated for openings and recesses in masonry walls and partitions at locations indicated. Fabricate in single lengths for each opening unless otherwise indicated. Weld adjoining members together to form a single unit where indicated.
- B. Size loose lintels to provide bearing length at each side of openings equal to 1/12 of clear span but not less than eight inches unless otherwise indicated.
- C. Galvanize loose steel lintels where indicated.
- D. Prime loose steel lintels where indicated with primer specified in Section 09 90 00 "Painting and Protective Coatings."

2.18 STEEL WELD PLATES AND ANGLES

- A. Provide steel weld plates and angles not specified in other Sections, for items supported from concrete construction as needed to complete the Work. Provide each unit with no fewer than two integrally welded steel strap anchors for embedding in concrete.

2.19 FINISHES, GENERAL

- A. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
- B. Finish metal fabrications after assembly.
- C. Finish exposed surfaces to remove tool and die marks and stretch lines, and to blend into surrounding surface.

2.20 STEEL AND IRON FINISHES

- A. Galvanizing: Hot-dip galvanize items as indicated to comply with ASTM A153 for steel and iron hardware and with ASTM A123 for other steel and iron products.
 - 1. Do not quench or apply post galvanizing treatments that might interfere with paint adhesion.
- B. Shop prime iron and steel items not indicated to be galvanized unless they are to be embedded in concrete, sprayed-on fireproofing, or masonry, or unless otherwise indicated.
 - 1. Shop prime with primers specified in Section 09 90 00 "Painting and Protective Coatings."

- C. Preparation for Shop Priming: Prepare surfaces to comply with requirements indicated below:
 - 1. Exterior Items: SSPC-SP 6/NACE No. 3, "Commercial Blast Cleaning."
 - 2. Items Indicated to Receive Zinc-Rich Primer: SSPC-SP 6/NACE No. 3, "Commercial Blast Cleaning."
 - 3. Items Indicated to Receive Primers Specified in Section 09 96 00 "High-Performance Coatings": SSPC-SP 6/NACE No. 3, "Commercial Blast Cleaning."
 - 4. Other Items: SSPC-SP 3, "Power Tool Cleaning."
- D. Shop Priming: Apply shop primer to comply with SSPC-PA 1, "Paint Application Specification No. 1: Shop, Field, and Maintenance Painting of Steel," for shop painting.
 - 1. Stripe paint corners, crevices, bolts, welds, and sharp edges.

2.21 STAINLESS-STEEL FINISHES

- A. Remove tool and die marks and stretch lines or blend into finish.
- B. Grind and polish surfaces to produce uniform, directionally textured, polished finish indicated, free of cross scratches. Run grain with long dimension of each piece.
- C. Dull Satin Finish: No. 6.
- D. When polishing is completed, passivate and rinse surfaces. Remove embedded foreign matter and leave surfaces chemically clean.

2.22 ALUMINUM FINISHES

- A. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.
- B. As-Fabricated Finish: AA-M10 (Mechanical Finish: as fabricated, unspecified).
- C. Class I, Clear Anodic Finish: AA-M12C22A41 (Mechanical Finish: non-specular as fabricated; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class I, clear coating 0.018 mm or thicker) complying with AAMA 611.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

- A. Cutting, Fitting, and Placement: Perform cutting, drilling, and fitting required for installing metal fabrications. Set metal fabrications accurately in location, alignment, and elevation; with edges and surfaces level, plumb, true, and free of rack; and measured from established lines and levels.
- B. Fit exposed connections accurately together to form hairline joints. Weld connections that are not to be left as exposed joints but cannot be shop welded because of shipping size limitations. Do not weld, cut, or abrade surfaces of exterior units that have been hot-dip galvanized after fabrication and are for bolted or screwed field connections.
- C. Field Welding: Comply with the following requirements:
 - 1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
 - 2. Obtain fusion without undercut or overlap.

3. Remove welding flux immediately.
 4. At exposed connections, finish exposed welds and surfaces smooth and blended so no roughness shows after finishing and contour of welded surface matches that of adjacent surface.
- D. Fastening to In-Place Construction: Provide anchorage devices and fasteners where metal fabrications are required to be fastened to in-place construction. Provide threaded fasteners for use with concrete and masonry inserts, toggle bolts, through bolts, lag screws, wood screws, and other connectors.
- E. Provide temporary bracing or anchors in formwork for items that are to be built into concrete, masonry, or similar construction.
- F. Corrosion Protection: Coat concealed surfaces of aluminum that will come into contact with grout, concrete, masonry, wood, or dissimilar metals with the following:
1. Cast Aluminum: Heavy coat of bituminous paint.
 2. Extruded Aluminum: Two coats of clear lacquer.
- G. Anti-Seize Lubricant: Where stainless steel nuts and bolts will be installed, apply anti-seize lubricant to threads as recommended by lubricant manufacturer to prevent seizure of nut and bolt during installation or upon removal at a future date.

3.2 INSTALLING MISCELLANEOUS FRAMING AND SUPPORTS

- A. General: Install framing and supports to comply with requirements of items being supported, including manufacturers' written instructions and requirements indicated on Shop Drawings.

3.3 INSTALLING METAL BOLLARDS

- A. Anchor bollards to existing construction with chemical anchors. Provide four 3/4-inch bolts at each bollard unless otherwise indicated.
1. Embed anchor bolts at least 6 inches in concrete unless indicated otherwise.
- B. Anchor bollards in place with concrete footings. Center and align bollards in holes three inches above bottom of excavation. Place concrete and vibrate or tamp for consolidation. Support and brace bollards in position until concrete has cured.
- C. Fill bollards solidly with concrete, mounding top surface to shed water.
1. Do not fill removable bollards with concrete.

3.4 INSTALLING NOSINGS, TREADS, AND THRESHOLDS

- A. Center nosings on tread widths unless otherwise indicated.
- B. For nosings embedded in concrete steps or curbs, align nosings flush with riser faces and level with tread surfaces.
- C. Seal thresholds exposed to exterior with elastomeric sealant complying with Section 07 92 00 "Joint Sealants" to provide a watertight installation.

3.5 INSTALLING BEARING AND LEVELING PLATES

- A. Clean concrete and masonry bearing surfaces of bond-reducing materials and roughen to improve bond to surfaces. Clean bottom surface of plates.

- B. Set bearing and leveling plates on wedges, shims, or leveling nuts. After bearing members have been positioned and plumbed, tighten anchor bolts. Do not remove wedges or shims but, if protruding, cut off flush with edge of bearing plate before packing with grout.
 - 1. Use non shrink grout, nonmetallic grout unless otherwise indicated.
 - 2. Pack grout solidly between bearing surfaces and plates to ensure that no voids remain.

3.6 FIELD QUALITY CONTROL

- A. Testing Agency: OWNER will engage a qualified independent testing and inspecting agency to inspect field welds and high-strength bolted connections.
- B. Bolted Connections: Field-bolted connections will be tested and inspected according to RCSC's "Specification for Structural Joints Using ASTM A325 or A490 Bolts."
- C. Welded Connections: Field welds will be 100 percent visually inspected according to AWS D1.1.
 - 1. Full penetration welds and other welds as specified: In addition to 100 percent visual inspection, 10 percent of connections will be tested and inspected according to AWS D1.1 and the following inspection procedures, at testing agency's option:
 - a. Liquid Penetrant Inspection: ASTM E165.
 - b. Magnetic Particle Inspection: ASTM E709; performed on root pass and on finished weld. Cracks or zones of incomplete fusion or penetration will not be accepted.
 - c. Ultrasonic Inspection: ASTM E164.
 - d. Radiographic Inspection: ASTM E94.
- D. Correct deficiencies in Work that test reports and inspections indicate does not comply with the Contract Documents.
 - 1. Corrective measures shall be taken when welding is unsatisfactory or indicates inferior workmanship. Chip and grind if the removal of part of the weld or a portion of the base metal is required. Where deposition of additional weld material is necessary, the sides of the area to be welded shall have no less than one to one (1:1) slope to allow room for depositing new material. Correct defective or unsound welds by the removal and replacement of the entire weld using the following procedures:
 - a. Excessive Convexity: Reduce to size by removal of excess weld metal by grinding.
 - b. Shrinkage Cracks, Cracks in Base Metal, Craters and Excessive Porosity: Remove defective portions of base and weld material down to sound metal, and deposit additional sound material.
 - c. Undercutting, Undersize, and Excessive Concavity: Clean and deposit additional weld metal.
 - d. Overlapping and Incomplete Fusion: Remove and replace the defective portion of the weld.
 - e. Slag Inclusion: Remove those parts of the welds containing slag. Fill with sound weld metal.
 - f. Removal of Adjacent Base Metal during Welding: Clean and form full size by depositing weld material.

2. Remove cracked welds throughout their length.
3. Where work performed subsequently to the making of the deficient weld has rendered the weld inaccessible or has caused new conditions which make connection of the deficiency dangerous or ineffectual, restore the original conditions by removing welds or members, or both before making the necessary corrections. Another option is to compensate for the deficiency with additional work according to the revised design, approved by the ENGINEER.
4. Cut apart and reweld improperly fitted and misaligned parts.
5. Straighten members distorted by heat of welding using mechanical means or by carefully supervised application of a limited amount of localized heat. Heated areas shall not exceed 1200 degrees Fahrenheit as measured by Tempilsticks. Parts to be heated for straightening shall be free from external stress forces, except when mechanical means are used in conjunction with heat application.
6. If faulty welding or its removal for rewelding damages the base metal so that, in the ENGINEER 's judgment, it is not in accordance with the intent of the Contract Documents, remove and replace the damaged material and compensate for the deficiency in a manner acceptable to the ENGINEER.
7. Maximum space between pieces or members for fillet welds shall be 1/16 inch. Only effective portion shall be considered in measuring fillet welds.

3.7 ADJUSTING AND CLEANING

- A. Touchup Painting: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint are specified in Division 09.
- B. Galvanized Surfaces: Clean field welds, bolted connections, and abraded areas and repair galvanizing in accordance with Division 05.

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**SECTION 05 51 00
METAL STAIRS**

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Pre-Engineered, Prefabricated, Industrial aluminum stairs with aluminum bar grating treads.
- B. Related Sections:
 - 1. Section 05 50 00 "Metal Fabrications"
 - 2. Section 05 52 13 "Pipe and Tube Railings"

1.3 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Design metal stairs, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
- B. Structural Performance of Stairs: Metal stairs shall withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated.
 - 1. Uniform Load: 100 lbf/sq. ft.
 - 2. Concentrated Load: 300 lbf applied on an area of 4 sq. in.
 - 3. Uniform and concentrated loads need not be assumed to act concurrently.
 - 4. Stair Framing: Capable of withstanding stresses resulting from railing loads in addition to loads specified above.
 - 5. Limit deflection of treads, platforms, and framing members to L/240 or 1/4 inch, whichever is less.
- C. Structural Performance of Railings: Railings shall withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated.
 - 1. Handrails and Top Rails of Guards:
 - a. Uniform load of 50 lbf/ ft. applied in any direction.
 - b. Concentrated load of 200 lbf applied in any direction.
 - c. Uniform and concentrated loads need not be assumed to act concurrently.
 - 2. Infill of Guards:
 - a. Concentrated load of 50 lbf applied horizontally on an area of 1 sq. ft.
 - b. Infill load and other loads need not be assumed to act concurrently.

1.4 ACTION SUBMITTALS

- A. Product Data: For metal stairs and the following:
 - 1. Abrasive nosings.
 - 2. Paint products.
 - 3. Grout.
- B. Shop Drawings: Include plans, elevations, sections, details, and attachments to otherwork.

- C. Delegated-Design Submittal: For installed products indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified professional engineer,
- B. Welding certificates.
- C. Paint Compatibility Certificates: From manufacturers of topcoats applied over shop primers certifying that shop primers are compatible with topcoats.
- D. Product Test Reports: Based on evaluation of comprehensive tests performed by a qualified testing agency, for stairs and railings.
 - 1. Test railings according ASTM E894 and ASTM E935.

1.6 QUALITY ASSURANCE

- A. Installer Qualifications: Fabricator of products.
- B. NAAMM Stair Standard: Comply with "Recommended Voluntary Minimum Standards for Fixed Metal Stairs" in NAAMM AMP 510, "Metal Stairs Manual," for class of stair designated, unless more stringent requirements are indicated.
 - 1. Industrial-Type Stairs: Industrial class.
- C. Welding Qualifications: Qualify procedures and personnel.
 - 1. Perform welding of structural metals with welders who have current AWS certificate for the type of welding to be performed.

1.7 COORDINATION

- A. Coordinate selection of shop primers with topcoats to be applied over them. Comply with paint and coating manufacturers' written recommendations to ensure that shop primers and topcoats are compatible with one another.
- B. Coordinate installation of anchorages for metal stairs. Furnish setting drawings, templates, and directions for installing anchorages, including sleeves, concrete inserts, anchor bolts, and items with integral anchors, that are to be embedded in concrete or masonry. Deliver such items to Project site in time for installation.
- C. Coordinate locations of hanger rods and struts with other work so that they will not encroach on required stair width and will be within the fire-resistance-rated stair enclosure.

PART 2 - PRODUCTS

2.1 METALS, GENERAL

- A. Metal Surfaces, General: Provide materials with smooth, flat surfaces unless otherwise indicated. For components exposed to view in the completed Work, provide materials without seam marks, roller marks, rolled trade names, or blemishes.

2.2 NONFERROUS METALS

- A. Stair treads, stringers, risers, landings, and legs shall be constructed using aluminum alloy with 6061-T6 for primary structural components.
- B. All landing rails and stair rails shall be aluminum construction alloy 6061-T6 & 6063-T5.
- C. All bolt hardware shall be stainless steel grade 304.

2.3 ABRASIVE NOSINGS

- A. Cast-Metal Units: Cast aluminum, with an integral abrasive, as-cast finish consisting of aluminum oxide, silicon carbide, or a combination of both. Fabricate units in lengths necessary

to accurately fit openings or conditions.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. American Safety Tread Co., Inc.
 - b. Balco Inc.
 - c. Barry Pattern & Foundry Co., Inc.
 - d. Granite State Casting Co.
 - e. Safe-T-Metal Company, Inc.
 - f. Wooster Products Inc.
 - g. Approved Equal
 2. Configuration: Cross-hatched units, 4 inches wide without lip.
 3. Configuration: Cross-hatched angle-shaped units, same depth as bar-grating treads and 1 to 1-1/2 inches wide.
- B. Provide anchors for embedding units in concrete, either integral or applied to units, as standard with manufacturer.
- C. Apply bituminous paint to concealed surfaces of cast-metal units set into concrete.

2.1 ALUMINUM STAIRS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. ACL Industries, Inc.
 2. American Safety Tread Company, Inc.
 3. McNichols Company
 4. Ohio Gratings, Inc.
 5. Precision Ladders, LLC
 6. REDD Team Manufacturing
 7. Thompson Fabricating, LLC
 8. Tuttle Railing Systems
 9. The Wagner Companies
 10. Or approved equal
- B. Provide complete stair assemblies, including framing, hangers, struts, posts, railings, clips, brackets, bearing plates, and other components necessary to support and anchor stairs and platforms on supporting structure.
1. Join components by welding, unless otherwise indicated. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals. Obtain fusion without undercut or overlap. Remove welding flux immediately. At exposed connections, finish exposed welds smooth and blended.
 2. Use connections that maintain structural value of joined pieces.
 3. Cut, drill, and punch metals cleanly and accurately. Remove burrs and ease edges, unless otherwise indicated. Remove sharp or rough areas on exposed surfaces.
 4. Form bent-metal corners to smallest radius possible without impairing work.
 5. Form exposed connections with hairline joints, flush and smooth, using concealed fasteners where possible. Locate joints where least conspicuous.
- C. Stair Framing: Fabricate stringers of aluminum plates or channels. Construct platforms of aluminum plate or channel headers and miscellaneous framing members.
1. If using bolts, fabricate and join so bolts are not exposed on finished surfaces.
- D. Aluminum Stair Treads & Platforms: Fabricate treads and platforms to configurations shown in drawings from aluminum bar grating; fabricate to comply with NAAMM MBG 531, "Metal Bar Grating Manual."

1. Fabricate all stair treads and head-of-stair landing edges with aluminum abrasive safety nosings.
- E. Aluminum Tube Railings: Fabricate railings to comply with requirements indicated for design, dimensions, details, finish, and member sizes, including wall thickness of tube, post spacings, and anchorage, but not less than that needed to withstand indicated loads.
 1. Configuration: 1-1/2 outside-diameter round top and bottom rails, 1-1/2-inch outside-diameter round posts, and 1/2-inch round pickets spaced less than 4 inches clear.
 2. Fabricate railings with welded connections. Cope components at connections to provide close fit, or use fittings designed for this purpose.
 3. Form changes in direction of railings by bending or by inserting prefabricated fittings.
 4. Form curves by bending members in jigs to produce uniform curvature without buckling.
 5. Close exposed ends of railing members with prefabricated end fittings.
 6. Provide wall returns at ends of wall-mounted handrails.
 7. Provide wall brackets, end closures, flanges, miscellaneous fittings, and anchors for interconnecting components and for attaching to other work.
 8. Connect posts to stair framing by direct welding.
 9. Make welded joints flush.
 10. Dress weld fillets to uniform radius, remove excess metal, and grind smooth.
 11. Smooth with all protecting joints and sharp corners ground smooth.

2.2 FASTENERS

- A. General: Provide type 304 stainless steel fasteners.
 1. Select fasteners for type, grade and class required.
- B. Fasteners for Anchoring Railings and Guards to Other Construction: Select fasteners of type, grade, and class required to produce connections suitable for anchoring railings and guards to other types of construction indicated and capable of withstanding design loads.
- C. Post-installed Anchors: Torque-controlled expansion anchors capable of sustaining, without failure, a load equal to six times the load imposed when installed in unit masonry and four times the load imposed when installed in concrete, as determined by testing according to ASTM E488/E488M, conducted by a qualified independent testing agency.

2.3 MISCELLANEOUS MATERIALS

- A. Welding Rods and Bare Electrodes: Select according to AWS specifications for metal alloy welded.
- B. Shop Primers: Provide primers that comply with Division 09.
- C. Galvanizing Repair Paint: High-zinc-dust-content paint complying with SSPC-Paint 20 and compatible with paints specified to be used over it.
- D. Bituminous Paint: Cold-applied asphalt emulsion complying with ASTM D1187.
- E. Nonshrink, Nonmetallic Grout: Factory-packaged, non-staining, noncorrosive, nongaseous grout complying with ASTM C1107. Provide grout specifically recommended by manufacturer for interior and exterior applications.

2.4 FABRICATION, GENERAL

- A. Provide complete stair assemblies, including metal framing, hangers, struts, railings, clips, brackets, bearing plates, and other components necessary to support and anchor stairs and platforms on supporting structure.
 1. Join components by welding unless otherwise indicated.
 2. Use connections that maintain structural value of joined pieces.
 3. Fabricate treads and platforms of exterior stairs so finished walking surfaces slope to drain.
- B. Preassembled Stairs: Assemble stairs in shop to greatest extent possible. Disassemble units only as necessary for shipping and handling limitations. Clearly mark units for reassembly and coordinated

- installation.
- C. Cut, drill, and punch metals cleanly and accurately. Remove burrs and ease edges to a radius of approximately 1/32 inch unless otherwise indicated. Remove sharp or rough areas on exposed surfaces.
 - D. Form bent-metal corners to smallest radius possible without causing grain separation or otherwise impairing work.
 - E. Form exposed work with accurate angles and surfaces and straight edges.
 - F. Weld connections to comply with the following:
 - 1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
 - 2. Obtain fusion without undercut or overlap.
 - 3. Remove welding flux immediately.
 - 4. At exposed connections, finish exposed welds to comply with NOMMA's "Voluntary Joint Finish Standards" for Type 2 welds: completely sanded joint, some undercutting and pinholes okay.
 - G. Form exposed connections with hairline joints, flush and smooth, using concealed fasteners where possible. Where exposed fasteners are required, use Phillips flat-head (countersunk) screws or bolts unless otherwise indicated. Locate joints where least conspicuous.
 - H. Fabricate joints that will be exposed to weather in a manner to exclude water. Provide weep holes where water may accumulate.

2.5 STAIR RAILINGS

- A. Comply with applicable requirements in Section 05 52 13 "Pipe and Tube Railings."

2.6 FINISHES

- A. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
- B. Factory Finish: Clear Satin Anodized - AA M10 C22 A31.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

- A. Perform cutting, drilling, and fitting required for installing aluminum stairs. Set units accurately in location, alignment, and elevation, measured from established lines and levels and free of rack.
- B. Aluminum welding shall be in accordance with the ANSI/AWS D1.2-97 GMAW process and shall be performed by experienced operators.
- C. All exposed surfaces shall be smooth and free of sharp or jagged edges.
- D. Fit exposed connections accurately together to form hairline joints. Weld connections that are not to be left as exposed joints.
- E. Adjusting and Cleaning:
 - 1. Immediately after erection, clean field welds, bolted connections, and abraded areas of shop paint, and paint exposed areas with the same material as used for shop painting.
- F. Fastening to In-Place Construction: Provide anchorage devices and fasteners where necessary for securing metal stairs to in-place construction. Include threaded fasteners for concrete and masonry inserts, through-bolts, lag bolts, and other connectors.
- G. Cutting, Fitting, and Placement: Perform cutting, drilling, and fitting required for installing metal stairs. Set units accurately in location, alignment, and elevation, measured from established lines and levels and free of rack.

- H. Provide temporary bracing or anchors in formwork for items that are to be built into concrete, masonry, or similar construction.
- I. Fit exposed connections accurately together to form hairline joints. Weld connections that are not to be left as exposed joints but cannot be shop welded because of shipping size limitations. Do not weld, cut, or abrade surfaces of exterior units that have been hot-dip galvanized after fabrication and are for bolted or screwed field connections.
- J. Field Welding: Comply with requirements for welding in "Fabrication, General" Article.

3.2 INSTALLING METAL STAIRS WITH GROUTED BASEPLATES

- A. Clean concrete and masonry bearing surfaces of bond-reducing materials and roughen to improve bond to surfaces. Clean bottom surface of baseplates.
- B. Set stair baseplates on wedges, shims, or leveling nuts. After stairs have been positioned and aligned, tighten anchor bolts. Do not remove wedges or shims but, if protruding, cut off flush with edge of bearing plate before packing with grout.
 - 1. Use nonmetallic, nonshrink grout unless otherwise indicated.
 - 2. Pack grout solidly between bearing surfaces and plates to ensure that no voids remain.

3.3 INSTALLING RAILINGS

- A. Adjust railing systems before anchoring to ensure matching alignment at abutting joints. Space posts at spacing indicated or, if not indicated, as required by design loads. Plumb posts in each direction. Secure posts and rail ends to building construction as follows:
 - 1. Anchor posts by welding directly to supporting members.
 - 2. Anchor handrail ends to concrete and masonry with round flanges welded to rail ends and anchored with post-installed anchors and bolts.
- B. Attach handrails to wall with wall brackets. Use type of bracket with predrilled hole for exposed bolt anchorage. Provide bracket with 1-1/2-inch (38-mm) clearance from inside face of handrail and finished wall surface. Locate brackets as indicated or, if not indicated, at spacing required to support structural loads. Secure wall brackets to building construction as required to comply with performance requirements.

END OF SECTION

SECTION 05 52 13
PIPE AND TUBE RAILINGS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Aluminum pipe and tube railings.
- B. Related Requirements:
 - 1. Section 05 50 00 "Metal Fabrications"
 - 2. Section 05 51 00 "Metal Stairs"

1.3 COORDINATION

- A. Coordinate selection of shop primers with topcoats to be applied over them. Comply with paint and coating manufacturers' written recommendations to ensure that shop primers and topcoats are compatible with one another.
- B. Coordinate installation of anchorages for railings. Furnish setting drawings, templates, and directions for installing anchorages, including sleeves, concrete inserts, anchor bolts, and items with integral anchors, that are to be embedded in concrete or masonry. Deliver such items to Project Site in time for installation.
- C. Schedule installation so wall attachments are made only to completed walls. Do not support railings temporarily by any means that do not satisfy structural performance requirements.

1.4 ACTION SUBMITTALS

- A. Product Data: For the following:
 - 1. Manufacturer's product lines of mechanically connected railings.
 - 2. Railing brackets.
 - 3. Grout, anchoring cement, and paint products.
- B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
- C. Delegated-Design Submittal: For railings, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For testing agency.
- B. Welding certificates.
- C. Paint Compatibility Certificates: From manufacturers of topcoats applied over shop primers certifying that shop primers are compatible with topcoats.
- D. Product Test Reports: For pipe and tube railings, for tests performed by a qualified testing agency, according to ASTM E894 and ASTM E935.
- E. Evaluation Reports: For post-installed anchors, from ICC-ES.

1.6 QUALITY ASSURANCE

- A. Welding Qualifications: Qualify procedures and personnel according to the following:
 - 1. AWS D1.1/D1.1M, "Structural Welding Code - Steel."
 - 2. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum."

3. AWS D1.6/D1.6M, "Structural Welding Code - Stainless Steel."

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Protect mechanical finishes on exposed surfaces from damage by applying astrippable, temporary protective covering before shipping.

1.8 FIELD CONDITIONS

- A. Field Measurements: Verify actual locations of walls and other construction contiguous with metal fabrications by field measurements before fabrication.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Aluminum Pipe and Tube Railings:
 - 1. ATR Technologies, Inc
 - 2. Blum, Julius & Co., Inc
 - 3. Sterling Dula Architectural Products, Inc
 - 4. Superior Aluminum Products
 - 5. Tri tech, Inc
 - 6. Tuttle Railing Systems
 - 7. Wagner, R & B, Inc
- B. Source Limitations: Obtain each type of railing from single source from single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional engineer, as defined in Section 01 4000 "Quality Requirements," to design railings, including attachment to building construction.
- B. Structural Performance: Railings, including attachment to building construction, shall withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated:
 - 1. Handrails and Top Rails of Guards:
 - a. Uniform load of 50 lbf/ ft. (0.73 kN/m) applied in any direction.
 - b. Concentrated load of 200 lbf (0.89 kN) applied in any direction.
 - c. Uniform and concentrated loads need not be assumed to act concurrently.
 - 2. Infill of Guards:
 - a. Concentrated load of 50 lbf (0.22 kN) applied horizontally on an area of 1 sq. ft. (0.093 sq. m).
 - b. Infill load and other loads need not be assumed to act concurrently.
- C. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.
 - 1. Temperature Change: 120 deg F (67 deg C), ambient; 180 deg F (100 deg C, material surfaces) .

2.3 METALS, GENERAL

- A. Metal Surfaces, General: Provide materials with smooth surfaces, without seam marks, roller marks, rolled trade names, stains, discolorations, or blemishes.
- B. Brackets, Flanges, and Anchors: Cast or formed metal of same type of material and finish as supported rails unless otherwise indicated.
 - 1. Provide type of bracket with predrilled hole for exposed bolt anchorage and that provides 1-1/2-inch (38-mm) clearance from inside face of handrail to finished wall

surface.

2.4 ALUMINUM

- A. Aluminum, General: Provide alloy and temper recommended by aluminum producer and finisher for type of use and finish indicated, and with not less than the strength and durability properties of alloy and temper designated below for each aluminum form required.
- B. Extruded Bars and Tubing: ASTM B221 (ASTM B221M), Alloy 6063-T5/T52.
- C. Extruded Structural Pipe and Round Tubing: ASTM B429/B429M, Alloy 6063-T6.
 - 1. Provide Standard Weight (Schedule 40) pipe unless otherwise indicated.
- D. Drawn Seamless Tubing: ASTM B210 (ASTM B210M), Alloy 6063-T832.
- E. Plate and Sheet: ASTM B209 (ASTM B209M), Alloy 6061-T6.
- F. Die and Hand Forgings: ASTM B247 (ASTM B247M), Alloy 6061-T6.
- G. Castings: ASTM B26/B26M, Alloy A356.0-T6.

2.5 FASTENERS

- A. General: Provide the following:
 - 1. Aluminum Railings: Type 316 stainless-steel fasteners.
 - 2. Provide exposed fasteners with finish matching appearance, including color and texture, of railings.
- B. Fasteners for Anchoring Railings to Other Construction: Select fasteners of type, grade, and class required to produce connections suitable for anchoring railings to other types of construction indicated and capable of withstanding design loads.
- C. Fasteners for Interconnecting Railing Components:
 - 1. Provide concealed fasteners for interconnecting railing components and for attaching them to other work, unless otherwise indicated.
- D. Post-Installed Anchors: Torque-controlled expansion anchors or chemical anchors capable of sustaining, without failure, a load equal to 6 times the load imposed when installed in unit masonry and 4 times the load imposed when installed in concrete, as determined by testing according to ASTM E488/E488M, conducted by a qualified independent testing agency.
 - 1. Material for Exterior Locations and Where Stainless Steel Is Indicated: Alloy Group 1 (A1) Group 2 (A4) stainless-steel bolts, ASTM F593 (ASTM F738M), and nuts, ASTM F594 (ASTM F836M).

2.6 MISCELLANEOUS MATERIALS

- A. Welding Rods and Bare Electrodes: Select according to AWS specifications for metal alloy welded.
 - 1. For aluminum railings, provide type and alloy as recommended by producer of metal to be welded and as required for color match, strength, and compatibility in fabricated items.
- B. Non-shrink, Nonmetallic Grout: Factory-packaged, nonstaining, noncorrosive, nongaseous grout complying with ASTM C1107/C1107M. Provide grout specifically recommended by manufacturer for interior and exterior applications.
- C. Anchoring Cement: Factory-packaged, non-shrink, nonstaining, hydraulic-controlled expansion cement formulation for mixing with water at Project Site to create pourable anchoring, patching, and grouting compound.
 - 1. Water-Resistant Product: At exterior locations and where indicated provide formulation that is resistant to erosion from water exposure without needing protection by a sealer or waterproof coating and that is recommended by manufacturer for exterior use.

2.7 FABRICATION

- A. General: Fabricate railings to comply with requirements indicated for design, dimensions,

- member sizes and spacing, details, finish, and anchorage, but not less than that required to support structural loads.
- B. Shop assemble railings to greatest extent possible to minimize field splicing and assembly. Disassemble units only as necessary for shipping and handling limitations. Clearly mark units for reassembly and coordinated installation. Use connections that maintain structural value of joined pieces.
 - C. Cut, drill, and punch metals cleanly and accurately. Remove burrs and ease edges to a radius of approximately 1/32 inch (1 mm) unless otherwise indicated. Remove sharp or rough areas on exposed surfaces.
 - D. Form work true to line and level with accurate angles and surfaces.
 - E. Fabricate connections that are exposed to weather in a manner that excludes water. Provide weep holes where water may accumulate.
 - F. Cut, reinforce, drill, and tap as indicated to receive finish hardware, screws, and similar items.
 - G. Connections: Fabricate railings with welded connections unless otherwise indicated.
 - H. Welded Connections for Aluminum Pipe: Fabricate railings to interconnect members with concealed internal welds that eliminate surface grinding, using manufacturer's standard system of sleeve and socket fittings.
 - I. Form Changes in Direction as Follows:
 - 1. As detailed.
 - J. Close exposed ends of railing members with prefabricated end fittings.
 - K. Provide wall returns at ends of wall-mounted handrails unless otherwise indicated. Close ends of returns unless clearance between end of rail and wall is 1/4 inch (6 mm) or less.
 - L. Brackets, Flanges, Fittings, and Anchors: Provide wall brackets, flanges, miscellaneous fittings, and anchors to interconnect railing members to other work unless otherwise indicated.
 - 1. At brackets and fittings fastened to plaster or gypsum board partitions, provide crush-resistant fillers or other means to transfer loads through wall finishes to structural supports and prevent bracket or fitting rotation and crushing of substrate.
 - M. Provide inserts and other anchorage devices for connecting railings to concrete or masonry work. Fabricate anchorage devices capable of withstanding loads imposed by railings. Coordinate anchorage devices with supporting structure.
 - N. For removable railing posts, fabricate slip-fit sockets from stainless-steel tube or pipe whose ID is sized for a close fit with posts; limit movement of post without lateral load, measured at top, to not more than one-fortieth of post height. Provide socket covers designed and fabricated to resist being dislodged.
 - 1. Provide chain with eye, snap hook, and staple across gaps formed by removable railing sections at locations indicated. Fabricate from same metal as railings.
 - O. Toe Boards: Where indicated, provide toe boards at railings around openings and at edge of open-sided floors and platforms. Fabricate to dimensions and details indicated.

2.8 ALUMINUM FINISHES

- A. Appearance of Finished Work: Variations in appearance of abutting or adjacent pieces are acceptable if they are within one-half of the range of approved Samples. Noticeable variations in the same piece are unacceptable. Variations in appearance of other components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.
- B. Clear Anodic Finish: AAMA 611.

PART 3 - EXECUTION

3.1 EXAMINATION – NOT USED

3.2 INSTALLATION, GENERAL

- A. Fit exposed connections together to form tight, hairline joints.
- B. Perform cutting, drilling, and fitting required for installing railings. Set railings accurately in location, alignment, and elevation; measured from established lines and levels and free of rack.
 - 1. Do not weld, cut, or abrade surfaces of railing components that are coated or finished after fabrication and that are intended for field connection by mechanical or other means without further cutting or fitting.
 - 2. Set posts plumb within a tolerance of 1/16 inch in 3 feet (2 mm in 1 m).
 - 3. Align rails so variations from level for horizontal members and variations from parallel with rake of steps and ramps for sloping members do not exceed 1/4 inch in 12 feet (6 mm in 3.5 m).
- C. Control of Corrosion: Prevent galvanic action and other forms of corrosion by insulating metals and other materials from direct contact with incompatible materials.
 - 1. Coat, with a heavy coat of bituminous paint, concealed surfaces of aluminum that are in contact with grout, concrete, masonry, wood, or dissimilar metals.
- D. Adjust railings before anchoring to ensure matching alignment at abutting joints.
- E. Fastening to In-Place Construction: Use anchorage devices and fasteners where necessary for securing railings and for properly transferring loads to in-place construction.

3.3 RAILING CONNECTIONS

- A. Welded Connections: Use fully welded joints for permanently connecting railing components. Comply with requirements for welded connections in "Fabrication" Article whether welding is performed in the shop or in the field.
- B. Expansion Joints: Install expansion joints at locations indicated but not farther apart than required to accommodate thermal movement. Provide slip-joint internal sleeve extending 2 inches (50 mm) beyond joint on either side, fasten internal sleeve securely to one side, and locate joint within 6 inches (150 mm) of post.

3.4 ANCHORING POSTS

- A. Use metal sleeves preset and anchored into concrete for installing posts. After posts are inserted into sleeves, fill annular space between post and sleeve with nonshrink, nonmetallic grout, mixed and placed to comply with anchoring material manufacturer's written instructions.
- B. Form or core-drill holes not less than 5 inches (125 mm) deep and 3/4 inch (20 mm) larger than OD of post for installing posts in concrete. Clean holes of loose material, insert posts, and fill annular space between post and concrete with nonshrink, nonmetallic grout, mixed and placed to comply with anchoring material manufacturer's written instructions.
- C. Cover anchorage joint with flange of same metal as post, welded to post after placing anchoring material.
- D. Leave anchorage joint exposed with [1/8-inch (3-mm) buildup, sloped away from post
- E. Anchor posts to metal surfaces with oval flanges, angle type, or floor type as required by conditions, connected to posts and to metal supporting members as follows:
 - 1. For aluminum pipe railings, attach posts using fittings designed and engineered for this purpose.
- F. Install removable railing sections, where indicated, in slip-fit metal sockets cast in concrete.

3.5 ATTACHING RAILINGS

- A. Anchor railing ends at walls with round flanges anchored to wall construction and connected to railing ends using nonwelded connections.
- B. Anchor railing ends to metal surfaces with flanges bolted to metal surfaces and connected to railing ends using nonwelded connections.
- C. Attach railings to wall with wall brackets , except where end flanges are used. Locate brackets as indicated or, if not indicated, at spacing required to support structural loads.
- D. Secure wall brackets and railing end flanges to building construction as follows:
 - 1. For concrete and solid masonry anchorage, use drilled-in expansion shields and hanger or lag bolts.
 - 2. For hollow masonry anchorage, use toggle bolts.
 - 3. For wood stud partitions, use hanger or lag bolts set into studs or wood backing between studs. Coordinate with carpentry work to locate backing members.

3.6 ADJUSTING AND CLEANING

- A. Clean aluminum by washing thoroughly with clean water and soap and rinsing with clean water.

3.7 PROTECTION

- A. Protect finishes of railings from damage during construction period with temporary protective coverings approved by railing manufacturer. Remove protective coverings at time of Substantial Completion.

END OF SECTION

**SECTION 06 10 00
ROUGH CARPENTRY**

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1.Framing with dimension lumber.
 - 2.Framing with timber.
 - 3.Framing with engineered wood products.
 - 4.Shear wall panels.
 - 5.Rooftop equipment bases and support curbs.
 - 6.Wood blocking, cants, and nailers.
 - 7.Wood furring and grounds.
 - 8.Wood sleepers.
 - 9.Utility shelving.
 - 10. Plywood backing panels.
- B. Related Requirements:
 - 1.Section 061600 "Sheathing."
 - 2.Section 061760 "Metal-Plate-Connected Wood Trusses" for wood trusses made from dimension lumber.

1.3 DEFINITIONS

- A. Exposed Framing: Framing not concealed by other construction.
- B. Dimension Lumber: Lumber of 2 inches nominal or greater but less than 5 inches nominal in least dimension.
- C. Lumber grading agencies, and the abbreviations used to reference them, include the following:
 - 1.NeLMA: Northeastern Lumber Manufacturers' Association.
 - 2.NLGA: National Lumber Grades Authority.
 - 3.RIS: Redwood Inspection Service.
 - 4.SPIB: The Southern Pine Inspection Bureau.
 - 5.WCLIB: West Coast Lumber Inspection Bureau.
 - 6.WWPA: Western Wood Products Association.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of process and factory-fabricated product. Indicate component materials and dimensions and include construction and application details.
 - 1.Include data for wood-preservative treatment from chemical treatment manufacturer and certification by treating plant that treated materials comply with requirements. Indicate type of preservative used and net amount of preservative retained.

2. Include data for fire-retardant treatment from chemical treatment manufacturer and certification by treating plant that treated materials comply with requirements. Include physical properties of treated materials based on testing by a qualified independent testing agency.
3. For fire-retardant treatments, include physical properties of treated lumber both before and after exposure to elevated temperatures, based on testing by a qualified independent testing agency according to ASTM D 5664.
4. For products receiving a waterborne treatment, include statement that moisture content of treated materials was reduced to levels specified before shipment to Project site.
5. Include copies of warranties from chemical treatment manufacturers for each type of treatment.

- B. Fastener Patterns: Full-size templates for fasteners in exposed framing.

1.5 INFORMATIONAL SUBMITTALS

- A. Material Certificates: For dimension lumber specified to comply with minimum allowable unit stresses. Indicate species and grade selected for each use and design values approved by the ALSC Board of Review.
- B. Evaluation Reports: For the following, from ICC-ES:
1. Wood-preservative-treated wood.
 2. Fire-retardant-treated wood.
 3. Engineered wood products.
 4. Shear panels.
 5. Power-driven fasteners.
 6. Powder-actuated fasteners.
 7. Expansion anchors.
 8. Metal framing anchors.

1.6 QUALITY ASSURANCE

- A. Testing Agency Qualifications: For testing agency providing classification marking for fire-retardant treated material, an inspection agency acceptable to authorities having jurisdiction that periodically performs inspections to verify that the material bearing the classification marking is representative of the material tested.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Stack lumber flat with spacers beneath and between each bundle to provide air circulation. Protect lumber from weather by covering with waterproof sheeting, securely anchored. Provide for air circulation around stacks and under coverings.

PART 2 - PRODUCTS

2.1 WOOD PRODUCTS, GENERAL

- A. Lumber: DOC PS 20 and applicable rules of grading agencies indicated. If no grading agency is indicated, provide lumber that complies with the applicable rules of any rules-writing agency

certified by the ALSC Board of Review. Provide lumber graded by an agency certified by the ALSC Board of Review to inspect and grade lumber under the rules indicated.

1.Factory mark each piece of lumber with grade stamp of grading agency.

2.For exposed lumber indicated to receive a stained or natural finish, mark grade stamp on end or back of each piece or omit grade stamp and provide certificates of grade compliance issued by grading agency.

3.Where nominal sizes are indicated, provide actual sizes required by DOC PS 20 for moisture content specified. Where actual sizes are indicated, they are minimum dressed sizes for dry lumber.

4.Provide dressed lumber, S4S, unless otherwise indicated.

B. Maximum Moisture Content of Lumber: 15 percent for 2-inch nominal thickness or less, 19 percent for more than 2-inch nominal thickness unless otherwise indicated.

C. Engineered Wood Products: Provide engineered wood products acceptable to authorities having jurisdiction and for which current model code research or evaluation reports exist that show compliance with building code in effect for Project.

1.Allowable Design Stresses: Provide engineered wood products with allowable design stresses, as published by manufacturer, that meet or exceed those indicated. Manufacturer's published values shall be determined from empirical data or by rational engineering analysis and demonstrated by comprehensive testing performed by a qualified independent testing agency.

2.2 WOOD-PRESERVATIVE-TREATED LUMBER

A. Preservative Treatment by Pressure Process: AWPAC U1; Use Category UC2 for interior construction not in contact with the ground, Use Category UC3b for exterior construction not in contact with the ground, and Use Category UC4a for items in contact with the ground.

1.Preservative Chemicals: Acceptable to authorities having jurisdiction and containing no arsenic or chromium.

2.For exposed items indicated to receive a stained or natural finish, use chemical formulations that do not require incising, contain colorants, bleed through, or otherwise adversely affect finishes.

B. Kiln-dry lumber after treatment to a maximum moisture content of 19 percent. Do not use material that is warped or that does not comply with requirements for untreated material.

C. Mark lumber with treatment quality mark of an inspection agency approved by the ALSC Board of Review.

1.For exposed lumber indicated to receive a stained or natural finish, mark end or back of each piece or omit marking and provide certificates of treatment compliance issued by inspection agency.

D. Application: Treat items indicated on Drawings, and the following:

1.Wood cants, nailers, curbs, equipment support bases, blocking, stripping, and similar members in connection with roofing, flashing, vapor barriers, and waterproofing.

2.Wood sills, sleepers, blocking, furring, stripping, and similar concealed members in contact with masonry or concrete.

3.Wood framing and furring attached directly to the interior of below-grade exterior masonry or concrete walls.

4. Wood framing members that are less than 18 inches above the ground in crawlspaces or unexcavated areas.
5. Wood floor plates that are installed over concrete slabs-on-grade.
6. Exposed wood ceiling or deck intended as finish material.

2.3 FIRE-RETARDANT-TREATED MATERIALS

- A. General: Where fire-retardant-treated materials are indicated, use materials complying with requirements in this article, that are acceptable to authorities having jurisdiction, and with fire-test-response characteristics specified as determined by testing identical products per test method indicated by a qualified testing agency.
- B. Fire-Retardant-Treated Lumber and Plywood by Pressure Process: Products with a flame spread index of 25 or less when tested according to ASTM E 84, and with no evidence of significant progressive combustion when the test is extended an additional 20 minutes, and with the flame front not extending more than 10.5 feet beyond the centerline of the burners at any time during the test.
 1. Use treatment that does not promote corrosion of metal fasteners.
 2. Exterior Type: Treated materials shall comply with requirements specified above for fire-retardant-treated lumber and plywood by pressure process after being subjected to accelerated weathering according to ASTM D 2898. Use for exterior locations and where indicated.
 3. Interior Type A: Treated materials shall have a moisture content of 28 percent or less when tested according to ASTM D 3201 at 92 percent relative humidity. Use where exterior type is not indicated.
 4. Design Value Adjustment Factors: Treated lumber shall be tested according ASTM D 5664 and design value adjustment factors shall be calculated according to ASTM D 6841.
- C. Kiln-dry lumber after treatment to a maximum moisture content of 19 percent.
- D. Identify fire-retardant-treated wood with appropriate classification marking of qualified testing agency.
 1. For exposed lumber indicated to receive a stained or natural finish, mark end or back of each piece or omit marking and provide certificates of treatment compliance issued by testing agency.
- E. For exposed items indicated to receive a stained or natural finish, use chemical formulations that do not bleed through, contain colorants, or otherwise adversely affect finishes.
- F. Application: Treat items indicated on Drawings, and the following:
 1. Framing for raised platforms.
 2. Framing for stages.
 3. Concealed blocking.
 4. Framing for non-load-bearing partitions.
 5. Framing for non-load-bearing exterior walls.
 6. Roof construction.
 7. Plywood backing panels.

2.4 DIMENSION LUMBER FRAMING

- A. Non-Load-Bearing Interior Partitions: Construction or No. 2 grade.
 - 1.Application: Interior partitions not indicated as load-bearing.
 - 2.Species: Per structural drawings.
- B. Load-Bearing Partitions: Grade per structural drawings.
 - 1.Application: Exterior walls and interior load-bearing partitions.
 - 2.Species: Per structural drawings.
- C. Ceiling Joists: Construction or No. 2 grade.
 - 1.Species: Per structural drawings.
- D. Joists, Rafters, and Other Framing Not Listed Above: Grade per structural drawings.
 - 1.Species: Per structural drawings.
- E. Exposed Framing: Provide material hand-selected for uniformity of appearance and freedom from characteristics, on exposed surfaces and edges, that would impair finish appearance, including decay, honeycomb, knot-holes, shake, splits, torn grain, and wane.
 - 1.Application: Exposed exterior and interior framing indicated to receive a stained or natural finish.
 - 2.Species and Grade: Per structural drawings.

2.5 TIMBER FRAMING

- A. Provide timber framing complying with the following requirements, according to grading rules of grading agency indicated:
 - 1.Species and Grade: Per structural drawings.
 - 2.Maximum Moisture Content: 20 percent.
 - 3.Additional Restriction: Free of heart centers.

2.6 ENGINEERED WOOD PRODUCTS

- A. Engineered Wood Products, General: Products shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."
- B. Source Limitations: Obtain each type of engineered wood product from single source from a single manufacturer.
- C. Laminated-Veneer Lumber: Structural composite lumber made from wood veneers with grain primarily parallel to member lengths, evaluated and monitored according to ASTM D 5456 and manufactured with an exterior-type adhesive complying with ASTM D 2559.
 - 1.Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Boise Cascade Corporation.
 - b. Finnforest USA.
 - c. Georgia-Pacific.
 - d. Jager Building Systems Inc.
 - e. Louisiana-Pacific Corporation.

- f. Pacific Woodtech Corporation.
- g. Roseburg Forest Products Co.
- h. Standard Structures Inc.
- i. Stark Truss Company, Inc.
- j. West Fraser Timber Co., Ltd.
- k. Weyerhaeuser Company.

2. Extreme Fiber Stress in Bending, Edgewise: Per structural drawings.

3. Modulus of Elasticity, Edgewise: Per structural drawings.

- D. Parallel-Strand Lumber: Structural composite lumber made from wood strand elements with grain primarily parallel to member lengths, evaluated and monitored according to ASTM D 5456 and manufactured with an exterior-type adhesive complying with ASTM D 2559.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

- a. Louisiana-Pacific Corporation.
- b. Weyerhaeuser Company.

2. Extreme Fiber Stress in Bending, Edgewise: Per structural drawings.

3. Modulus of Elasticity, Edgewise: Per structural drawings.

2.7 SHEAR WALL PANELS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
- B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - 1. Shear Transfer Systems.
 - 2. Simpson Strong-Tie Co., Inc.
 - 3. Weyerhaeuser Company.
- C. Wood-Framed Shear Wall Panels: Prefabricated assembly consisting of wood perimeter framing, tie downs, and Exposure I, Structural I plywood or OSB sheathing.
 - 1. Products shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."
- D. Steel-Framed Shear Wall Panels: Prefabricated assembly consisting of cold-formed galvanized steel panel, steel top and bottom plates, and wood studs.
- E. Allowable Design Loads: Provide products with allowable design loads, as published by manufacturer, that meet or exceed those of products of manufacturers listed. Manufacturer's published values shall be determined from empirical data or by rational engineering analysis and demonstrated by comprehensive testing performed by a qualified independent testing agency.

2.8 MISCELLANEOUS LUMBER

- A. General: Provide miscellaneous lumber indicated and lumber for support or attachment of other construction, including the following:
 - 1. Blocking.

- 2.Nailers.
 - 3.Rooftop equipment bases and support curbs.
 - 4.Cants.
 - 5.Furring.
 - 6.Grounds.
 - 7.Utility shelving.
- B. For items of dimension lumber size, provide Construction or No. 2 grade lumber and any of the following species unless specifically noted otherwise on the drawings:
- 1.Hem-fir (north); NLGA.
 - 2.Mixed southern pine; SPIB.
 - 3.Spruce-pine-fir; NLGA.
 - 4.Hem-fir; WCLIB or WWPA.
 - 5.Spruce-pine-fir (south); NeLMA, WCLIB, or WWPA.
 - 6.Western woods; WCLIB or WWPA.
 - 7.Northern species; NLGA.
 - 8.Eastern softwoods; NeLMA.
- C. For utility shelving, provide lumber with 19 percent maximum moisture content and any of the following species and grades:
- 1.Eastern white pine, Idaho white, lodgepole, ponderosa, or sugar pine; Premium or No. 2 Common (Sterling) grade; NeLMA, NLGA, WCLIB, or WWPA.
 - 2.Mixed southern pine; No. 1 grade; SPIB.
 - 3.Hem-fir or hem-fir (north); Select Merchantable or No. 1 Common grade; NLGA, WCLIB, or WWPA.
 - 4.Spruce-pine-fir (south) or spruce-pine-fir; Select Merchantable or No. 1 Common grade; NeLMA, NLGA, WCLIB, or WWPA.
- D. For concealed boards, provide lumber with 19 percent maximum moisture content and any of the following species and grades:
- 1.Mixed southern pine; No. 2 grade; SPIB.
 - 2.Hem-fir or hem-fir (north); Construction or No. 2 Common grade; NLGA, WCLIB, or WWPA.
 - 3.Spruce-pine-fir (south) or spruce-pine-fir; Construction or No. 2 Common grade; NeLMA, NLGA, WCLIB, or WWPA.
 - 4.Eastern softwoods; No. 2 Common grade; NeLMA.
 - 5.Northern species; No. 2 Common grade; NLGA.
 - 6.Western woods; Construction or No. 2 Common grade; WCLIB or WWPA.
- E. For blocking not used for attachment of other construction, Utility, Stud, or No. 3 grade lumber of any species may be used provided that it is cut and selected to eliminate defects that will interfere with its attachment and purpose.
- F. For blocking and nailers used for attachment of other construction, select and cut lumber to eliminate knots and other defects that will interfere with attachment of other work.
- G. For furring strips for installing plywood or hardboard paneling, select boards with no knots capable of producing bent-over nails and damage to paneling.

2.9 PLYWOOD BACKING PANELS

- A. Equipment Backing Panels: DOC PS 1, Exterior, AC, in thickness indicated or, if not indicated, not less than 1/2-inch nominal thickness.
 - 1. Plywood shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.10 FASTENERS

- A. General: Provide fasteners of size and type indicated that comply with requirements specified in this article for material and manufacture.
 - 1. Where rough carpentry is exposed to weather, in ground contact, pressure-preservative treated, or in area of high relative humidity, provide fasteners with hot-dip zinc coating complying with ASTM A 153/A 153M.
- B. Nails, Brads, and Staples: ASTM F 1667.
- C. Power-Driven Fasteners: NES NER-272.
- D. Wood Screws: ASME B18.6.1.
- E. Lag Bolts: ASME B18.2.1.
- F. Bolts: Steel bolts complying with ASTM A 307, Grade A; with ASTM A 563 hex nuts and, where indicated, flat washers.
- G. Expansion Anchors: Anchor bolt and sleeve assembly of material indicated below with capability to sustain, without failure, a load equal to six times the load imposed when installed in unit masonry assemblies and equal to four times the load imposed when installed in concrete as determined by testing per ASTM E 488 conducted by a qualified independent testing and inspecting agency.
 - 1. Material: Carbon-steel components, zinc plated to comply with ASTM B 633, Class Fe/Zn 5.
 - 2. Material: Stainless steel with bolts and nuts complying with ASTM F 593 and ASTM F 594, Alloy Group 1 or 2.

2.11 METAL FRAMING ANCHORS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
- B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - 1. Cleveland Steel Specialty Co.
 - 2. KC Metals Products, Inc.
 - 3. Phoenix Metal Products, Inc.
 - 4. Simpson Strong-Tie Co., Inc.
 - 5. USP Structural Connectors.
- C. Allowable Design Loads: Provide products with allowable design loads, as published by manufacturer, that meet or exceed those of products of manufacturers listed. Manufacturer's published values shall be determined from empirical data or by rational engineering analysis

and demonstrated by comprehensive testing performed by a qualified independent testing agency.

2.12 MISCELLANEOUS MATERIALS

- A. Sill-Sealer Gaskets: Glass-fiber-resilient insulation, fabricated in strip form, for use as a sill sealer; 1-inch nominal thickness, compressible to 1/32 inch; selected from manufacturer's standard widths to suit width of sill members indicated.
- B. Sill-Sealer Gaskets: Closed-cell neoprene foam, 1/4 inch thick, selected from manufacturer's standard widths to suit width of sill members indicated.
- C. Flexible Flashing: Composite, self-adhesive, flashing product consisting of a pliable, butyl rubber or rubberized-asphalt compound, bonded to a high-density polyethylene film, aluminum foil, or spunbonded polyolefin to produce an overall thickness of not less than 0.025 inch.
- D. Adhesives for Gluing Furring and Sleepers to Concrete or Masonry: Formulation complying with ASTM D 3498 that is approved for use indicated by adhesive manufacturer.
 - 1. Adhesives shall have a VOC content of 70 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 - 2. Adhesives shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."
- E. Water-Repellent Preservative: NWWDA-tested and -accepted formulation containing 3-iodo-2-propynyl butyl carbamate, combined with an insecticide containing chlorpyrifos as its active ingredient.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

- A. Set rough carpentry to required levels and lines, with members plumb, true to line, cut, and fitted. Fit rough carpentry to other construction; scribe and cope as needed for accurate fit. Locate furring, nailers, blocking, grounds, and similar supports to comply with requirements for attaching other construction.
- B. Framing Standard: Comply with AF&PA's WCD 1, "Details for Conventional Wood Frame Construction," unless otherwise indicated.
- C. Framing with Engineered Wood Products: Install engineered wood products to comply with manufacturer's written instructions.
- D. Install plywood backing panels by fastening to studs; coordinate locations with utilities requiring backing panels. Install fire-retardant treated plywood backing panels with classification marking of testing agency exposed to view.
- E. Shear Wall Panels: Install shear wall panels to comply with manufacturer's written instructions.
- F. Metal Framing Anchors: Install metal framing anchors to comply with manufacturer's written instructions. Install fasteners through each fastener hole.

- G. Install sill sealer gasket to form continuous seal between sill plates and foundation walls.
- H. Do not splice structural members between supports unless otherwise indicated.
- I. Provide blocking and framing as indicated and as required to support facing materials, fixtures, specialty items, and trim.
 - 1. Provide metal clips for fastening gypsum board or lath at corners and intersections where framing or blocking does not provide a surface for fastening edges of panels. Space clips not more than 16 inches o.c.
- J. Provide fire blocking in furred spaces, stud spaces, and other concealed cavities as indicated and as follows:
 - 1. Fire block furred spaces of walls, at each floor level, at ceiling, and at not more than 96 inches o.c. with solid wood blocking or noncombustible materials accurately fitted to close furred spaces.
 - 2. Fire block concealed spaces of wood-framed walls and partitions at each floor level, at ceiling line of top story, and at not more than 96 inches o.c. Where fire blocking is not inherent in framing system used, provide closely fitted solid wood blocks of same width as framing members and 2-inch nominal thickness.
 - 3. Fire block concealed spaces between floor sleepers with same material as sleepers to limit concealed spaces to not more than 100 sq. ft. and to solidly fill space below partitions.
 - 4. Fire block concealed spaces behind combustible cornices and exterior trim at not more than 20 feet o.c.
- K. Sort and select lumber so that natural characteristics will not interfere with installation or with fastening other materials to lumber. Do not use materials with defects that interfere with function of member or pieces that are too small to use with minimum number of joints or optimum joint arrangement.
- L. Comply with AWPA M4 for applying field treatment to cut surfaces of preservative-treated lumber.
 - 1. Use inorganic boron for items that are continuously protected from liquid water.
 - 2. Use copper naphthenate for items not continuously protected from liquid water.
- M. Securely attach rough carpentry work to substrate by anchoring and fastening as indicated, complying with the following:
 - 1. NES NER-272 for power-driven fasteners.
 - 2. Table 2304.9.1, "Fastening Schedule," in ICC's International Building Code.
- N. Use steel common nails unless otherwise indicated. Select fasteners of size that will not fully penetrate members where opposite side will be exposed to view or will receive finish materials. Make tight connections between members. Install fasteners without splitting wood. Drive nails snug but do not countersink nail heads unless otherwise indicated.
- O. For exposed work, arrange fasteners in straight rows parallel with edges of members, with fasteners evenly spaced, and with adjacent rows staggered.
 - 1. Comply with approved fastener patterns where applicable. Before fastening, mark fastener locations, using a template made of sheet metal, plastic, or cardboard.

2. Use finishing nails unless otherwise indicated. Countersink nail heads and fill holes with wood filler.
3. Use common nails unless otherwise indicated. Drive nails snug but do not countersink nail heads.

3.2 WOOD GROUND, SLEEPER, BLOCKING, AND NAILER INSTALLATION

- A. Install where indicated and where required for screeding or attaching other work. Form to shapes indicated and cut as required for true line and level of attached work. Coordinate locations with other work involved.
- B. Attach items to substrates to support applied loading. Recess bolts and nuts flush with surfaces unless otherwise indicated.
- C. Where wood-preserved-treated lumber is installed adjacent to metal decking, install continuous flexible flashing separator between wood and metal decking.
- D. Provide permanent grounds of dressed, pressure-preserved-treated, key-beveled lumber not less than 1-1/2 inches wide and of thickness required to bring face of ground to exact thickness of finish material. Remove temporary grounds when no longer required.

3.3 WOOD FURRING INSTALLATION

- A. Install level and plumb with closure strips at edges and openings. Shim with wood as required for tolerance of finish work.
- B. Furring to Receive Plywood or Hardboard Paneling: Install 1-by-3-inch nominal- size furring horizontally and vertically at 24 inches o.c.
- C. Furring to Receive Gypsum Board or Plaster Lath: Install 1-by-2-inch nominal- size furring vertically at 16 inches o.c.

3.4 WALL AND PARTITION FRAMING INSTALLATION

- A. General: Provide single bottom plate and double top plates using members of 2-inch nominal thickness whose widths equal that of studs, except single top plate may be used for non-load-bearing partitions. Fasten plates to supporting construction unless otherwise indicated.
 1. For exterior walls, provide stud framing per Drawings.
 2. For interior partitions and walls, provide stud framing per Drawings.
 3. Provide continuous horizontal blocking at midheight of partitions more than 96 inches high, using members of 2-inch nominal thickness and of same width as wall or partitions.
- B. Construct corners and intersections with three or more studs, except that two studs may be used for interior non-load-bearing partitions.

3.5 CEILING JOIST AND RAFTER FRAMING INSTALLATION

- A. Ceiling Joists: Install ceiling joists with crown edge up and complying with requirements specified above for floor joists. Face nail to ends of parallel rafters.
 1. Where ceiling joists are at right angles to rafters, provide additional short joists parallel to rafters from wall plate to first joist; nail to ends of rafters and to top plate and nail to first joist or anchor with framing anchors or metal straps. Provide 1-by-8-inch nominal-

size or 2-by-4-inch nominal- size stringers spaced 48 inches o.c. crosswise over main ceiling joists.

- B. Rafters: Notch to fit exterior wall plates and use metal framing anchors. Double rafters to form headers and trimmers at openings in roof framing, if any, and support with metal hangers. Where rafters abut at ridge, place directly opposite each other and nail to ridge member or use metal ridge hangers.
 - 1. At valleys, provide double-valley rafters of size indicated or, if not indicated, of same thickness as regular rafters and 2 inches deeper. Bevel ends of jack rafters for full bearing against valley rafters.
 - 2. At hips, provide hip rafter of size indicated or, if not indicated, of same thickness as regular rafters and 2 inches deeper. Bevel ends of jack rafters for full bearing against hip rafter.
- C. Provide special framing as indicated for eaves, overhangs, dormers, and similar conditions if any.

3.6 TIMBER FRAMING INSTALLATION

- A. Install timber with crown edge up and provide not less than 4 inches of bearing on supports. Provide continuous members unless otherwise indicated; tie together over supports as indicated if not continuous.
- B. Where beams or girders are framed into pockets of exterior concrete or masonry walls, provide 1/2-inch air space at sides and ends of wood members.
- C. Install wood posts using metal anchors indicated.
- D. Treat ends of timber beams and posts exposed to weather by dipping in water-repellent preservative for 15 minutes.

3.7 PROTECTION

- A. Protect wood that has been treated with inorganic boron (SBX) from weather. If, despite protection, inorganic boron-treated wood becomes wet, apply EPA-registered borate treatment. Apply borate solution by spraying to comply with EPA-registered label.
- B. Protect rough carpentry from weather. If, despite protection, rough carpentry becomes wet, apply EPA-registered borate treatment. Apply borate solution by spraying to comply with EPA-registered label.

END OF SECTION

SECTION 06 16 00
SHEATHING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Wall sheathing.
 - 2. Roof sheathing.
 - 3. Composite nail base insulated roof sheathing.
 - 4. Subflooring.
 - 5. Underlayment.
 - 6. Sheathing joint and penetration treatment.
- B. Related Requirements:
 - 1. Section 061000 "Rough Carpentry" for plywood backing panels.
 - 2. Section 072500 "Weather Barriers" for water-resistive barrier applied over wall sheathing.
 - 3. Division 9 Sections for interior finishes applied over subflooring.
 - 4. Division 9 Sections for exterior finish systems applied over wall sheathing.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of process and factory-fabricated product. Indicate component materials and dimensions and include construction and application details.
 - 1. Include data for wood-preservative treatment from chemical treatment manufacturer and certification by treating plant that treated plywood complies with requirements. Indicate type of preservative used and net amount of preservative retained.
 - 2. Include data for fire-retardant treatment from chemical treatment manufacturer and certification by treating plant that treated plywood complies with requirements. Include physical properties of treated materials.
 - 3. For fire-retardant treatments, include physical properties of treated plywood both before and after exposure to elevated temperatures, based on testing by a qualified independent testing agency according to ASTM D 5516.
 - 4. For products receiving a waterborne treatment, include statement that moisture content of treated materials was reduced to levels specified before shipment to Project site.
 - 5. Include copies of warranties from chemical treatment manufacturers for each type of treatment.

1.4 INFORMATIONAL SUBMITTALS

- A. Evaluation Reports: For following products, from ICC-ES:
 - 1. Preservative-treated plywood.
 - 2. Fire-retardant-treated plywood.
 - 3. Foam-plastic sheathing.

1.5 QUALITY ASSURANCE

- A. Testing Agency Qualifications: For testing agency providing classification marking for fire-retardant-treated material, an inspection agency acceptable to authorities having jurisdiction that periodically performs inspections to verify that the material bearing the classification marking is representative of the material tested.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Stack panels flat with spacers beneath and between each bundle to provide air circulation. Protect sheathing from weather by covering with waterproof sheeting, securely anchored. Provide for air circulation around stacks and under coverings.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Fire-Test-Response Characteristics: For assemblies with fire-resistance ratings, provide materials and construction identical to those of assemblies tested for fire resistance per ASTM E 119 by a testing and inspecting agency acceptable to authorities having jurisdiction.
 - 1. Fire-Resistance Ratings: Indicated by design designations from UL's "Fire Resistance Directory." and/or GA-600, "Fire Resistance Design Manual."

2.2 WOOD PANEL PRODUCTS

- A. Emissions: Products shall meet the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."
- B. Plywood: Either DOC PS 1 or DOC PS 2 unless otherwise indicated.
- C. Oriented Strand Board: DOC PS 2.
- D. Thickness: As needed to comply with requirements specified, but not less than thickness indicated.
- E. Factory mark panels to indicate compliance with applicable standard.

2.3 PRESERVATIVE-TREATED PLYWOOD

- A. Preservative Treatment by Pressure Process: AWPAC U1; Use Category UC2 for interior construction not in contact with the ground, Use Category UC3b for exterior construction not in contact with the ground, and Use Category UC4a for items in contact with the ground.
 - 1. Preservative Chemicals: Acceptable to authorities having jurisdiction and containing no arsenic or chromium.
- B. Mark plywood with appropriate classification marking of an inspection agency acceptable to authorities having jurisdiction.
- C. Application: Treat items indicated on Drawings and plywood in contact with masonry or concrete or used with roofing, flashing, vapor barriers, and waterproofing.

2.4 FIRE-RETARDANT-TREATED PLYWOOD

- A. General: Where fire-retardant-treated materials are indicated, use materials complying with requirements in this article that are acceptable to authorities having jurisdiction and with fire-

test-response characteristics specified as determined by testing identical products per test method indicated by a qualified testing agency.

- B. Fire-Retardant-Treated Plywood by Pressure Process: Products with a flame-spread index of 25 or less when tested according to ASTM E 84, and with no evidence of significant progressive combustion when the test is extended an additional 20 minutes, and with the flame front not extending more than 10.5 feet beyond the centerline of the burners at any time during the test.
 - 1. Use treatment that does not promote corrosion of metal fasteners.
 - 2. Exterior Type: Treated materials shall comply with requirements specified above for fire-retardant-treated plywood by pressure process after being subjected to accelerated weathering according to ASTM D 2898. Use for exterior locations and where indicated.
 - 3. Interior Type A: Treated materials shall have a moisture content of 28 percent or less when tested according to ASTM D 3201 at 92 percent relative humidity. Use where exterior type is not indicated.
 - 4. Design Value Adjustment Factors: Treated lumber plywood shall be tested according ASTM D 5516 and design value adjustment factors shall be calculated according to ASTM D 6305. Span ratings after treatment shall be not less than span ratings specified.
- C. Kiln-dry material after treatment to a maximum moisture content of 15 percent. Do not use material that is warped or does not comply with requirements for untreated material.
- D. Identify fire-retardant-treated plywood with appropriate classification marking of qualified testing agency.
- E. Application: Treat plywood indicated on Drawings, and the following:
 - 1. Roof and wall sheathing within 48 inches of fire walls.
 - 2. Roof sheathing and subfloors where required by Code or referenced rated assembly.

2.5 WALL SHEATHING

- A. Plywood Wall Sheathing: Per structural drawings.
 - 1. Span Rating: Per structural drawings.
 - 2. Nominal Thickness: Per structural drawings.
- B. Oriented-Strand-Board Wall Sheathing: Per structural drawings.
 - 1. Span Rating: Per structural drawings.
 - 2. Nominal Thickness: Per structural drawings.
- C. Cementitious Backer Units: ASTM C 1325, Type A.
 - 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. C-Cure; C-Cure Board 990.
 - b. Custom Building Products; Wonderboard.
 - c. FinPan, Inc.; Util-A-Crete Concrete Backer Board.
 - d. USG Corporation; DUROCK Cement Board.
 - 2. Thickness: As indicated.
- D. Fiberboard Wall Sheathing: ASTM C 208, Type IV, Grade 2 (Structural) cellulosic fiberboard sheathing with square edges, 1/2 inch thick.

2.6 ROOF SHEATHING

- A. Plywood Roof Sheathing: Per structural drawings.
 - 1. Span Rating: Per structural drawings.
 - 2. Nominal Thickness: Per structural drawings.
- B. Oriented-Strand-Board Roof Sheathing: Per structural drawings.
 - 1. Span Rating: Per structural drawings.
 - 2. Nominal Thickness: Per structural drawings.

2.7 FASTENERS

- A. General: Provide fasteners of size and type indicated that comply with requirements specified in this article for material and manufacture.
 - 1. For roof and wall sheathing, provide fasteners with hot-dip zinc coating complying with ASTM A 153/A 153M.
- B. Nails, Brads, and Staples: ASTM F 1667.
- C. Power-Driven Fasteners: NES NER-272.
- D. Wood Screws: ASME B18.6.1.

2.8 MISCELLANEOUS MATERIALS

- A. Adhesives for Field Gluing Panels to Framing: Formulation complying with APA AFG-01 that is approved for use with type of construction panel indicated by manufacturers of both adhesives and panels.
 - 1. Adhesives shall have a VOC content of 70 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 - 2. Adhesives shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

- A. Do not use materials with defects that impair quality of sheathing or pieces that are too small to use with minimum number of joints or optimum joint arrangement. Arrange joints so that pieces do not span between fewer than three support members.
- B. Cut panels at penetrations, edges, and other obstructions of work; fit tightly against abutting construction unless otherwise indicated.
- C. Securely attach to substrate by fastening as indicated, complying with the following:
 - 1. NES NER-272 for power-driven fasteners.
 - 2. Table 2304.9.1, "Fastening Schedule," in ICC's "International Building Code."
- D. Use common wire nails unless otherwise indicated. Select fasteners of size that will not fully penetrate members where opposite side will be exposed to view or will receive finish materials. Make tight connections. Install fasteners without splitting wood.

- E. Coordinate wall and roof sheathing installation with flashing and joint-sealant installation so these materials are installed in sequence and manner that prevent exterior moisture from passing through completed assembly.
- F. Coordinate sheathing installation with installation of materials installed over sheathing so sheathing is not exposed to precipitation or left exposed at end of the workday when rain is forecast.

3.2 WOOD STRUCTURAL PANEL INSTALLATION

- A. General: Comply with applicable recommendations in APA Form No. E30, "Engineered Wood Construction Guide," for types of structural-use panels and applications indicated.
- B. Fastening Methods: Fasten panels as indicated below:
 - 1. Wall and Roof Sheathing:
 - a. Nail to wood framing.
 - b. Space panels 1/8 inch apart at edges and ends.

END OF SECTION

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SECTION 07 11 13
BITUMINOUS DAMPPROOFING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Cold-applied, emulsified-asphalt dampproofing.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. VOC Content: Products are to comply with VOC content limits of authorities having jurisdiction unless otherwise indicated.

2.2 COLD-APPLIED, EMULSIFIED-ASPHALT DAMPPROOFING

- A. Provide products by one of the following manufacturers:
 - 1. Euclid Chemical – Dehydratone 75
 - 2. Sika USA – Sikalastic -310
 - 3. Tremco - MULSEAL
 - 4. Approved Equal
- B. Spray Coats: ASTM D1227, Type III, Class 1.

2.3 AUXILIARY MATERIALS

- A. Furnish auxiliary materials recommended in writing by dampproofing manufacturer for intended use and compatible with bituminous dampproofing.
- B. Emulsified-Asphalt Primer: ASTM D1227, Type III, Class 1, except diluted with water as recommended in writing by manufacturer.

PART 3 - EXECUTION

3.1 APPLICATION, GENERAL

- A. Comply with manufacturer's written instructions for dampproofing application, cure time between coats, and drying time before backfilling unless otherwise indicated.
 - 1. Apply dampproofing to provide continuous plane of protection.
 - 2. Apply additional coats if recommended in writing by manufacturer or to achieve a smooth surface and uninterrupted coverage.
- B. Where dampproofing footings and foundation walls, apply from finished-grade line to top of footing; extend over top of footing and down a minimum of 6 inches (150 mm) over outside face of footing.
 - 1. Extend dampproofing 12 inches (300 mm) onto intersecting walls and footings, but do not extend onto surfaces exposed to view when Project is completed.
 - 2. Install flashings and corner protection stripping at internal and external corners, changes in plane, construction joints, cracks, and where indicated as "reinforced," by embedding an 8-inch- (200-mm-) wide strip of asphalt-coated glass fabric in a heavy coat of dampproofing. Dampproofing coat for embedding fabric is in addition to other coats required.

3.2 COLD-APPLIED, EMULSIFIED-ASPHALT DAMPPROOFING

- A. Concrete Foundations: Apply two spray coats at not less than 1.5 gal./100 sq. ft. (0.6 L/sq. m) for first coat and 1 gal./100 sq. ft. (0.4 L/sq. m) for second coat.

3.3 PROTECTION COURSE INSTALLATION

- A. Install protection course over completed-and-cured dampproofing. Comply with dampproofing-material and protection-course manufacturers' written instructions for attaching protection course.

END OF SECTION

**SECTION 07 21 00
THERMAL INSULATION**

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Extruded Polystyrene Foam Plastic Board Insulation (Foundation)
2. Polyisocyanurate foam-plastic board insulation (Roof)

PART 2 - PRODUCTS

2.1 FOAM-PLASTIC BOARD INSULATION

A. General: Products shall meet Colorado Greenhouse Gas Regulations 5 CCR 1001-26 regulating prohibited blowing agents for foam insulation products.

1. Prohibited blowing agents (refer to full regulation for specific product requirements)
 - a. HFC-134a
 - b. HFC-143a
 - c. HFC-245fa
 - d. HFC-365mfc
 - e. Formacel B
 - f. Formacel TI
 - g. Formacel Z-6

B. Extruded-Polystyrene Board Insulation: ASTM C 578, with maximum flame-spread and smoke-developed indexes of 75 and 450, respectively, per ASTM E 84.

1. Type IV, 25 PSI

C. Polyisocyanurate Board Insulation: ASTM C 1289, Type II, Class 1, Grade 2 felt or glass-fiber mat facer on both major surfaces.

2.2 INSULATION FASTENERS

A. Adhesively Attached, Spindle Type Anchors: Plate and angle formed from perforated galvanized carbon steel sheet, 0.030 inch thick by 2 inches square, welded to projecting copper coated steel spindle 0.105 inch in diameter and enough length capable of holding insulation of thickness indicated securely in position with 1-1/2" square or diameter self-locking washers complying with the following requirements.

1. Installation Retaining Washers: Self-locking washers formed from 0.016 inch thick galvanized steel sheet, with beveled edge for increased stiffness.
 2. Where anchors are located in ceiling plenums or attic spaces, protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap.
- B. Installation Standoff: Spacer fabricated from galvanized mild steel sheet for fitting over spindle of insulation anchor to maintain air space of two inches between face of insulation and substrate to which anchor is attached.
- C. Anchor Adhesive: Product with demonstrate capability to bond insulation anchors securely to substrates indicated without damaging insulation fasteners and substrates.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

- A. Comply with insulation manufacturer's written instructions applicable to products and applications indicated.
- B. Install insulation that is undamaged, dry, and unsoiled and that has not been left exposed to ice, rain, or snow at any time.
- C. Extend insulation to envelop entire area to be insulated. Cut and fit tightly around obstructions and fill voids with insulation. Remove projections that interfere with placement.
- D. Provide sizes to fit applications indicated and selected from manufacturer's standard thicknesses, widths, and lengths. Apply single layer of insulation units to produce thickness indicated unless multiple layers are otherwise shown or required to make up total thickness.

3.2 INSTALLATION OF BELOW-GRADE INSULATION

- A. On vertical footing and foundation wall surfaces, set insulation units using manufacturer's recommended adhesive according to manufacturer's written instructions.

3.3 INSTALLATION OF INSULATION FOR FRAMED CONSTRUCTION

- A. Apply insulation units to substrates by method indicated, complying with manufacturer's written instructions. If no specific method is indicated, bond units to substrate with adhesive or use mechanical anchorage to provide permanent placement and support of units.
- B. Foam Plastic Board Insulation: Seal joints between units by applying adhesive, mastic or sealant to edges of each unit to form a tight seal as units are shoved into place. Fill voids in completed insulation with adhesive, mastic or sealant as recommended by the insulation manufacturer.

- C. Miscellaneous Voids: Install insulation in miscellaneous voids and cavity spaces where required to prevent gaps in insulation.

END OF SECTION

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SECTION 07 27 26
FLUID-APPLIED MEMBRANE AIR BARRIERS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Vapor-permeable, fluid-applied air barriers.

1.2 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: For air-barrier assemblies.
 - 1. Include details for substrate joints and cracks, counterflashing strips, penetrations, inside and outside corners, terminations, and tie-ins with adjoining construction.

1.4 INFORMATIONAL SUBMITTALS

- A. Product certificates.
- B. Product test reports.
- C. Field quality-control reports.

1.5 QUALITY ASSURANCE

- A. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by manufacturer.
- B. Mockups: Build mockups to set quality standards for materials and execution.
 - 1. Build integrated mockups of exterior wall assembly, 100 sq. ft. incorporating backup wall construction, external cladding, window, storefront, door frame and sill, insulation, ties and other penetrations, and flashing to demonstrate surface preparation, crack and joint treatment, application of air barriers, and sealing of gaps, terminations, and penetrations of air-barrier assembly.
 - a. Coordinate construction of mockups to permit inspection and testing of air barrier before external insulation and cladding are installed.
 - b. Include junction with roofing membrane, building corner condition and foundation wall intersection.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Air-Barrier Performance: Air-barrier assembly and seals with adjacent construction shall be capable of performing as a continuous air barrier and as a liquid-water drainage plane flashed to discharge to the exterior incidental condensation or water penetration. Air-barrier assemblies shall be capable of accommodating substrate movement and of sealing substrate expansion and control joints, construction material changes, penetrations, and transitions at perimeter conditions without deterioration and air leakage exceeding specified limits.
- B. Air-Barrier Assembly Air Leakage: Maximum 0.04 cfm/sq. ft. of surface area at 1.57 lbf/sq. ft., when tested according to ASTM E2357.

2.2 HIGH-BUILD AIR BARRIERS, VAPOR PERMEABLE

- A. High-Build, Vapor-Permeable Air Barrier: Synthetic polymer membrane with an installed dry film thickness, according to manufacturer's written instructions, of 35 mils (0.9 mm) or thicker over smooth, void-free substrates.
 - 1. Synthetic Polymer Type, provide products by one of the following manufacturers:
 - a. DuPont de Nemours, Inc.
 - b. Henry Company
 - c. Prosoco, Inc.
 - d. Tremco, Inc.
 - e. W.R. Meadows, Inc.
 - 2. Physical and Performance Properties:
 - a. Air Permeance: Maximum 0.004 cfm/sq. ft. of surface area at 1.57-lbf/sq. ft. pressure difference; ASTM E2178.
 - b. Vapor Permeance: Minimum 10 perms; ASTM E96/E96M, Desiccant Method, Procedure A.
 - c. Ultimate Elongation: Minimum 200 percent; ASTM D412, Die C.
 - d. Adhesion to Substrate: Minimum 16 lbf/sq. in. when tested according to ASTM D4541.
 - e. UV Resistance: Can be exposed to sunlight for 30 days according to manufacturer's written instructions.

2.3 ACCESSORY MATERIALS

- A. Requirement: Provide primers, transition strips, termination strips, joint reinforcing fabric and strips, joint sealants, counterflashing strips, flashing sheets and metal termination bars, termination mastic, substrate patching materials, adhesives, tapes, foam sealants, lap sealants, and other accessory materials that are recommended in writing by air-barrier manufacturer to produce a complete air-barrier assembly and that are compatible with primary air-barrier material and adjacent construction to which they may seal.

PART 3 - EXECUTION

3.1 SURFACE PREPARATION

- A. Clean, prepare, treat, fill, and seal substrate and joints and cracks in substrate according to manufacturer's written instructions and details. Provide clean, dust-free, and dry substrate for air-barrier application.
- B. Mask off adjoining surfaces not covered by air barrier to prevent spillage and overspray affecting other construction.
- C. Remove fins, ridges, mortar, and other projections and fill honeycomb, aggregate pockets, holes, and other voids in concrete with substrate-patching material.
- D. Remove excess mortar from masonry ties, shelf angles, and other obstructions.
- E. At changes in substrate plane, apply sealant or termination mastic beads at sharp corners and edges to form a smooth transition from one plane to another.
- F. Bridge expansion joints and discontinuous wall-to-wall, deck-to-wall, and deck-to-deck joints with air-barrier accessory material that accommodates joint movement according to manufacturer's written instructions and details.

3.2 INSTALLATION

- A. Install materials according to air-barrier manufacturer's written instructions and details to form a seal with adjacent construction and ensure continuity of air and water barrier.
 - 1. Coordinate the installation of air barrier with installation of roofing membrane and base flashing to ensure continuity of air barrier with roofing membrane.
 - 2. Install transition strip on roofing membrane or base flashing so that a minimum of 3 inches (75 mm) of coverage is achieved over each substrate.
 - 3. Unless manufacturer recommends in writing against priming, apply primer to substrates at required rate and allow it to dry.
 - 4. Apply primer to substrates at required rate and allow it to dry. Limit priming to areas that will be covered by air-barrier material on same day. Reprime areas exposed for more than 24 hours.
- B. Connect and seal exterior wall air-barrier material continuously to roofing-membrane air barrier, concrete below-grade structures, floor-to-floor construction, exterior glazing and window systems, glazed curtain-wall systems, storefront systems, exterior louvers, exterior door framing, and other construction used in exterior wall openings, using accessory materials.
- C. Wall Openings: Prime concealed, perimeter frame surfaces of windows, curtain walls, storefronts, and doors. Apply transition strip so that a minimum of 3 inches (75 mm) of coverage is achieved over each substrate. Maintain 3 inches (75 mm) of full contact over firm bearing to perimeter frames, with not less than 1 inch (25 mm) of full contact.

- D. Repair punctures, voids, and deficient lapped seams in strips and transition strips. Slit and flatten fishmouths and blisters. Patch with transition strips extending 6 inches (150 mm) beyond repaired areas in strip direction.
 - E. High-Build Air Barriers: Apply continuous unbroken air-barrier material to substrates according to the following thickness. Apply air-barrier material in full contact around protrusions such as masonry ties.
 - 1. Vapor-Permeable, High-Build Air Barrier: Total dry film thickness as recommended in writing by manufacturer to comply with performance requirements, but not less than 35 mils applied in or more equal coats.
 - F. Do not cover air barrier until it has been tested and inspected by testing agency.
 - G. Correct deficiencies in or remove air barrier that does not comply with requirements; repair substrates and reapply air-barrier components.
- 3.3 FIELD QUALITY CONTROL
- A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.
 - B. Tests: As determined by testing agency from among the following tests:
 - 1. Air-barrier dry film thickness.
 - C. Air barriers will be considered defective if they do not pass tests and inspections.
 - 1. Apply additional air-barrier material, according to manufacturer's written instructions, where inspection results indicate insufficient thickness.
 - 2. Remove and replace deficient air-barrier components for retesting as specified above.
 - D. Repair damage to air barriers caused by testing; follow manufacturer's written instructions.
 - E. Prepare test and inspection reports.
- 3.4 CLEANING AND PROTECTION
- A. Protect air-barrier system from damage during application and remainder of construction period, according to manufacturer's written instructions.
 - B. Remove masking materials after installation.

END OF SECTION

SECTION 07 41 13
STANDING-SEAM METAL ROOF PANELS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes standing-seam metal roof panels.

1.2 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.

1.3 SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: Include fabrication and installation layouts of metal panels; details of edge conditions, joints, panel profiles, corners, anchorages, attachment system, trim, flashings, closures, and accessories; and special details.
- C. Samples: For each type of metal panel indicated.
- D. Product test reports.
- E. Warranties: Sample of special warranties.

1.4 QUALITY ASSURANCE

- A. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by manufacturer.
- B. UL-Certified, Portable Roll-Forming Equipment: UL-certified, portable roll-forming equipment capable of producing metal panels warranted by manufacturer to be the same as factory-formed products. Maintain UL certification of portable roll-forming equipment for duration of work.

1.5 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of metal panel systems that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period: Two years from date of Substantial Completion.

- B. Special Warranty on Panel Finishes: Manufacturer's standard form in which manufacturer agrees to repair finish or replace metal panels that show evidence of deterioration of factory-applied finishes within specified warranty period.
 - 1. Finish Warranty Period: 30 years from date of Substantial Completion.
- C. Special Weathertightness Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace standing-seam metal roof panel assemblies that fail to remain weathertight, including leaks, within specified warranty period.
 - 1. Warranty Period: 20 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Structural Performance: Provide metal panel systems capable of withstanding the effects of the following loads, based on testing according to ASTM E 1592:
 - 1. Wind Loads: As indicated on Drawings.
 - 2. Other Design Loads: As indicated on Drawings.
 - 3. Deflection Limits: For wind loads, no greater than 1/240 of the span.
- B. Air Infiltration: Air leakage of not more than 0.06 cfm/sq. ft. (0.3 L/s per sq. m) when tested according to ASTM E 1680 at the following test-pressure difference:
 - 1. Test-Pressure Difference: 6.24 lbf/sq. ft. (300 Pa).
- C. Water Penetration under Static Pressure: No water penetration when tested according to ASTM E 1646 at the following test-pressure difference:
 - 1. Test-Pressure Difference: 6.24 lbf/sq. ft. (300 Pa).
- D. Hydrostatic-Head Resistance: No water penetration when tested according to ASTM E 2140.
- E. Wind-Uplift Resistance: Provide metal roof panel assemblies that comply with UL 580 for wind-uplift-resistance class indicated.
 - 1. Uplift Rating: UL 90.
- F. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes by preventing buckling, opening of joints, overstressing of components, failure of joint sealants, failure of connections, and other detrimental effects. Base calculations on surface temperatures of materials due to both solar heat gain and nighttime-sky heat loss.
 - 1. Temperature Change (Range): 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces.

2.2 STANDING-SEAM METAL ROOF PANELS

- A. General: Provide factory-formed metal roof panels designed to be installed by lapping and interconnecting raised side edges of adjacent panels with joint type indicated and mechanically attaching panels to supports using concealed clips in side laps. Include clips, cleats, pressure plates, and accessories required for weathertight installation.
 - 1. Steel Panel Systems: Unless more stringent requirements are indicated, comply with ASTM E 1514.
 - 2. Aluminum Panel Systems: Unless more stringent requirements are indicated, comply with ASTM E 1637.
- B. Vertical-Rib, Seamed-Joint, Standing-Seam, Curved Metal Roof Panels: Formed with vertical ribs at panel edges and intermediate stiffening ribs symmetrically spaced between ribs; designed for sequential installation by mechanically attaching panels to supports using concealed clips located under one side of panels, engaging opposite edge of adjacent panels, and snapping seamed panels together.
 - 1. Basis-of-Design Product: Subject to compliance with requirements, provide Horizon Loc Panel manufactured by Central States Manufacturing or comparable product by one of the following:
 - a. AEP Span
 - b. Berridge
 - c. Drexel Metals, Inc.
 - d. Firestone Metal Products, LLC.
 - e. Petersen Aluminum Corporation.
 - 2. Metallic-Coated Steel Sheet: Zinc-coated (galvanized) steel sheet complying with ASTM A 653/A 653M, G90 coating designation, or aluminum-zinc alloy-coated steel sheet complying with ASTM A 792/A 792M, Class AZ50 coating designation; structural quality. Prepainted by the coil-coating process to comply with ASTM A 755/A 755M.
 - a. Nominal Thickness: 26 gage.
 - b. Exterior Finish: Galvalume with clear acrylic coating.
 - c. Color: Galvalume
 - 3. Clips: One-piece or two-piece fixed to accommodate thermal movement.
 - a. Material: 0.064-inch- (1.63-mm-) nominal thickness, zinc-coated (galvanized) or aluminum-zinc alloy-coated steel sheet.
 - 4. Joint Type: As standard with manufacturer.
 - 5. Panel Coverage: 16 inches with intermediate pencil rib panel striations.
 - 6. Panel Height: 1 inch.

2.3 UNDERLAYMENT MATERIALS

- A. Self-Adhering, High-Temperature Underlayment: Provide self-adhering, cold-applied, sheet underlayment, a minimum of 30 mils thick, consisting of slip-resistant, polyethylene-film top surface laminated to a layer of butyl or SBS-modified asphalt adhesive, with release-paper backing. Provide primer when recommended by underlayment manufacturer.
1. Thermal Stability: Stable after testing at 240 deg F (116 deg C); ASTM D 1970.
 2. Low-Temperature Flexibility: Passes after testing at minus 20 deg F (29 deg C); ASTM D 1970.
 3. Products: Subject to compliance with requirements, provide one of the following:
 - a. Carlisle Construction Materials; WIP 300HT.
 - b. Drexel Metals, Inc.; MetShield.
 - c. Grace Construction Products, a unit of W. R. Grace & Co.; Grace Ultra.
 - d. Metal-Fab Manufacturing, LLC; MetShield.
 - e. Owens Corning; WeatherLock Metal High Temperature Underlayment.
 - f. Tamko; TW Metal & Tile Underlayment.
 - g. Approved Equal
- B. Slip Sheet: Manufacturer's recommended slip sheet, if required, of type required for application.

2.4 MISCELLANEOUS MATERIALS

- A. Panel Accessories: Provide components required for a complete, weathertight panel system including trim, copings, fasciae, mullions, sills, corner units, clips, flashings, sealants, gaskets, fillers, closure strips, and similar items. Match material and finish of metal panels unless otherwise indicated.
1. Closures: Provide closures at eaves and ridges, fabricated of same metal as metal panels.
 2. Backing Plates: Provide metal backing plates at panel end splices, fabricated from material recommended by manufacturer.
 3. Closure Strips: Closed-cell, expanded, cellular, rubber or crosslinked, polyolefin-foam or closed-cell laminated polyethylene; minimum 1-inch thick, flexible closure strips; cut or premolded to match metal panel profile. Provide closure strips where indicated or necessary to ensure weathertight construction.
- B. Flashing and Trim: Provide flashing and trim formed from same material as metal panels as required to seal against weather and to provide finished appearance. Locations include, but are not limited to, eaves, rakes, corners, bases, framed openings, ridges, fasciae, and fillers. Finish flashing and trim with same finish system as adjacent metal panels.
- C. Gutters and Downspouts: Formed from same material as roof panels according to SMACNA's "Architectural Sheet Metal Manual." Finish shall match metal roof panels.

- D. Seamless Gutters: Formed from 0.0179-inch- (0.45-mm-) thick, metallic-coated steel sheet. Match profile of gable trim, complete with end pieces, outlet tubes, and other special pieces as required. Fabricate in minimum 96-inch- (2400-mm-) long sections, sized according to SMACNA's "Architectural Sheet Metal Manual." Furnish gutter supports spaced 36 inches (900 mm) o.c., fabricated from same metal as gutters. Provide bronze, copper, or aluminum wire ball strainers at outlets. Finish gutters to match color of metal fascia panels.
- E. Downspouts: Formed from 0.0179-inch- (0.45-mm-) thick, metallic-coated steel sheet; in 10-foot- (3-m-) long sections, complete with formed elbows and offsets. Finish downspouts to match color of metal roof panels.
- F. Panel Fasteners: Self-tapping screws designed to withstand design loads.
- G. Panel Sealants: Provide sealant type recommended by manufacturer that are compatible with panel materials, are nonstaining, and do not damage panel finish.
 - 1. Sealant Tape: Pressure-sensitive, 100 percent solids, gray polyisobutylene compound sealant tape with release-paper backing; 1/2 inch (13 mm) wide and 1/8 inch (3 mm) thick.
 - 2. Joint Sealant: ASTM C 920; as recommended in writing by metal panel manufacturer.
 - 3. Butyl-Rubber-Based, Solvent-Release Sealant: ASTM C 1311.

2.5 FABRICATION

- A. General: Fabricate and finish metal panels and accessories at the factory, by manufacturer's standard procedures and processes, as necessary to fulfill indicated performance requirements demonstrated by laboratory testing. Comply with indicated profiles and with dimensional and structural requirements.
- B. On-Site Fabrication: Subject to compliance with requirements of this Section, metal panels may be fabricated on-site using UL-certified, portable roll-forming equipment if panels are of same profile and warranted by manufacturer to be equal to factory-formed panels. Fabricate according to equipment manufacturer's written instructions and to comply with details shown.
- C. Provide panel profile, including major ribs and intermediate stiffening ribs, if any, for full length of panel.
- D. Fabricate metal panel joints with factory-installed captive gaskets or separator strips that provide a weathertight seal and prevent metal-to-metal contact, and that minimize noise from movements.
- E. Sheet Metal Flashing and Trim: Fabricate flashing and trim to comply with manufacturer's recommendations and recommendations in SMACNA's "Architectural Sheet Metal Manual" that apply to design, dimensions, metal, and other characteristics of item indicated.

2.6 FINISHES

A. Panels and Accessories:

1. Two-Coat Fluoropolymer: AAMA 621 Fluoropolymer finish containing not less than 70 percent PVDF resin by weight in color coat.
2. Concealed Finish: White or light-colored acrylic or polyester backer finish.

PART 3 - EXECUTION

3.1 PREPARATION

- #### A. Miscellaneous Supports:
- Install subframing, furring, and other miscellaneous panel support members and anchorages according to ASTM C 754 and metal panel manufacturer's written recommendations.

3.2 UNDERLAYMENT INSTALLATION

- #### A. Self-Adhering Sheet Underlayment:
- Apply primer if required by manufacturer. Comply with temperature restrictions of underlayment manufacturer for installation. Apply at locations indicated below, wrinkle free, in shingle fashion to shed water, and with end laps of not less than 6 inches (152 mm) staggered 24 inches (610 mm) between courses. Overlap side edges not less than 3-1/2 inches (90 mm). Extend underlayment into gutter trough. Roll laps with roller. Cover underlayment within 14 days.
1. Apply over the entire roof surface.
- #### B. Slip Sheet:
- Apply slip sheet over underlayment before installing metal roof panels.
- #### C. Flashings:
- Install flashings to cover underlayment to comply with requirements specified in Section 076200 "Sheet Metal Flashing and Trim."

3.3 METAL PANEL INSTALLATION

- #### A. Standing-Seam Metal Roof Panel Installation:
- Fasten metal roof panels to supports with concealed clips at each standing-seam joint at location, spacing, and with fasteners recommended in writing by manufacturer.
1. Install clips to supports with self-tapping fasteners.
 2. Install pressure plates at locations indicated in manufacturer's written installation instructions.
 3. Seamed Joint: Crimp standing seams with manufacturer-approved, motorized seamer tool so clip, metal roof panel, and factory-applied sealant are completely engaged.

4. Watertight Installation:

- a. Apply a continuous ribbon of sealant or tape to seal joints of metal panels, using sealant or tape as recommend in writing by manufacturer as needed to make panels watertight.
 - b. Provide sealant or tape between panels and protruding equipment, vents, and accessories.
 - c. At panel splices, nest panels with minimum 6-inch (152-mm) end lap, sealed with sealant and fastened together by interlocking clamping plates.
- B. Accessory Installation: Install accessories with positive anchorage to building and weathertight mounting, and provide for thermal expansion. Coordinate installation with flashings and other components.
- C. Flashing and Trim: Comply with performance requirements, manufacturer's written installation instructions, and SMACNA's "Architectural Sheet Metal Manual." Provide concealed fasteners where possible, and set units true to line and level as indicated. Install work with laps, joints, and seams that will be permanently watertight and weather resistant.

3.4 CLEANING AND PROTECTION

- A. Remove temporary protective coverings and strippable films, if any, as metal panels are installed, unless otherwise indicated in manufacturer's written installation instructions. On completion of metal panel installation, clean finished surfaces as recommended by metal panel manufacturer. Maintain in a clean condition during construction.

END OF SECTION

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SECTION 07 46 46
FIBER-CEMENT SIDING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes fiber-cement siding and trim.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Samples: For fiber-cement siding and soffit including related accessories.

1.3 INFORMATIONAL SUBMITTALS

- A. Product certificates.
- B. Product test reports.
- C. Research/evaluation reports.
- D. Sample warranty.

1.4 CLOSEOUT SUBMITTALS

- A. Maintenance data.

1.5 QUALITY ASSURANCE

- A. Mockups: Build mockups to verify selections made under Sample submittals and to demonstrate aesthetic effects and to set quality standards for fabrication and installation.
 - 1. Build mockup of typical wall area as shown on Drawings.
 - 2. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.6 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace products that fail in materials or workmanship within specified warranty period.

1. Warranty Period: 30 years from date of Substantial Completion.
2. Pre-Finished Coated Paint Finish Warranty: 15 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 FIBER-CEMENT SIDING

- A. General: ASTM C 1186, Type A, Grade II, fiber-cement board, noncombustible when tested according to ASTM E 136; with a flame-spread index of 25 or less when tested according to ASTM E 84.
 1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. James Hardie Building Products, Inc.
 - b. Or approved equal.
- B. Labeling: Provide fiber-cement siding that is tested and labeled according to ASTM C 1186 by a qualified testing agency acceptable to authorities having jurisdiction.
- C. Nominal Thickness: Not less than 5/16 inch (8 mm).
- D. Horizontal Pattern: Boards size and exposure to match existing building.
 1. Texture: Wood grain; Select Cedarmill
- E. Factory Finish: Manufacturer's standard acrylic primer.
 1. Primer
 2. Colored UV finish coats ('Color Plus' technology)

2.2 FIBER-CEMENT SOFFIT

- A. General: ASTM C 1186, Type A, Grade II, fiber-cement board, noncombustible when tested according to ASTM E 136; with a flame-spread index of 25 or less when tested according to ASTM E 84.
 1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. James Hardie Building Products, Inc.
 - b. Or approved equal.
- B. Nominal Thickness: Not less than 1/4 inch.
- C. Pattern: 24-inch-wide sheets with Cedarmill texture and 1x hardie-board batten trim at seams.

D. Factory Finish: Manufacturer's standard acrylic primer.

1. Primer
2. Colored UV finish coats ('Color Plus' technology)

2.3 FIBER CEMENT TRIM

A. General: ASTM C 1186, Type A, Grade II, fiber-cement board, noncombustible when tested according to ASTM E 136; with a flame-spread index of 25 or less when tested according to ASTM E 84.

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. James Hardie Building Products, Inc.
 - b. Or approved equal.

B. Nominal Thickness: Not less than 3/4 inch.

C. Pattern: 5-1/2" wide smooth face trim boards.

D. Factory Finish: Manufacturer's standard acrylic primer.

1. Primer
2. Colored UV finish coats - 'ColorPlus' Technology.

2.4 ACCESSORIES

A. Siding Accessories, General: Provide starter strips, edge trim, outside and inside corner caps, and other items as recommended by siding manufacturer for building configuration.

1. Provide accessories made from same material as and matching color and texture of adjacent siding unless otherwise indicated.

B. Flashing: Provide aluminum metal flashing complying with Section 076200 "Sheet Metal Flashing and Trim" at window and door heads and where indicated.

1. Special Metal Trim and Reveals: Utilize special trim and reveals as indicated on the construction drawings for the project.

C. Fasteners:

1. For fastening to wood, use siding nails or ribbed bugle-head screws of sufficient length to penetrate a minimum of 1 inch (25 mm) into substrate.
2. For fastening fiber cement, use hot-dip galvanized fasteners.
3. Screw heads at the flat panel system shall be painted to match the panel colors.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. General: Comply with manufacturer's written installation instructions applicable to products and applications indicated unless more stringent requirements apply.
 - 1. Install fasteners no more than 24 inches o.c.
- B. Install joint sealants as specified in Section 079200 "Joint Sealants" and to produce a weathertight installation.
- C. Touch up coat all cut ends and exposed surfaces and fasteners with same UV coating as siding and soffit panel.

3.2 ADJUSTING AND CLEANING

- A. Remove damaged, improperly installed, or otherwise defective materials and replace with new materials complying with specified requirements.
- B. Clean finished surfaces according to manufacturer's written instructions and maintain in a clean condition during construction.

END OF SECTION

SECTION 07 62 00
SHEET METAL FLASHING AND TRIM

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Manufactured reglets and counterflashing.
2. Formed roof drainage sheet metal fabrications.
3. Formed low-slope roof sheet metal fabrications.
4. Formed steep-slope roof sheet metal fabrications.
5. Formed wall sheet metal fabrications.

1.2 SUBMITTALS

A. Shop Drawings: Show installation layouts of sheet metal flashing and trim, including plans, elevations, expansion-joint locations, and keyed details. Distinguish between shop- and field-assembled work.

1. Include details for forming, joining, supporting, and securing sheet metal flashing and trim, including pattern of seams, termination points, fixed points, expansion joints, expansion-joint covers, edge conditions, special conditions, and connections to adjoining work.

B. Samples: For each exposed product and for each finish specified.

C. Warranty: Sample of special warranty.

1.3 QUALITY ASSURANCE

A. Sheet Metal Flashing and Trim Standard: Comply with SMACNA's "Architectural Sheet Metal Manual" unless more stringent requirements are specified or shown on Drawings.

1.4 WARRANTY

A. Special Warranty on Finishes: Manufacturer's standard form in which manufacturer agrees to repair finish or replace sheet metal flashing and trim that shows evidence of deterioration of factory-applied finishes within 10 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SHEET METALS

- A. General: Protect mechanical and other finishes on exposed surfaces from damage by applying a strippable, temporary protective film before shipping.
- B. Metallic-Coated Steel Sheet: Restricted flatness steel sheet, metallic coated by the hot-dip process and prepainted by the coil-coating process to comply with ASTM A 755/A 755M.
 - 1. Zinc-Coated (Galvanized) Steel Sheet: ASTM A 653/A 653M, G90 (Z275) coating designation; structural quality.
 - 2. Aluminum-Zinc Alloy-Coated Steel Sheet: ASTM A 792/A 792M, Class AZ50 coating designation, Grade 40 (Class AZM150 coating designation, Grade 275); structural quality.
 - 3. Exposed Coil-Coated Finish:
 - a. Two-Coat Fluoropolymer: AAMA 621. Fluoropolymer finish containing not less than 70 percent PVDF resin by weight in color coat.
 - 4. Color: As selected by Architect from manufacturer's full range

2.2 UNDERLAYMENT MATERIALS

- A. Self-Adhering, High-Temperature Sheet: Minimum 30 to 40 mils (0.76 to 1.0 mm) thick, consisting of slip-resisting polyethylene-film top surface laminated to layer of butyl or SBS-modified asphalt adhesive, with release-paper backing; cold applied. Provide primer when recommended by underlayment manufacturer.
 - 1. Thermal Stability: ASTM D 1970; stable after testing at 240 deg F (116 deg C).
 - 2. Low-Temperature Flexibility: ASTM D 1970; passes after testing at minus 20 deg F (29 deg C).

2.3 MISCELLANEOUS MATERIALS

- A. General: Provide materials and types of fasteners, solder, welding rods, protective coatings, separators, sealants, and other miscellaneous items as required for complete sheet metal flashing and trim installation and recommended by manufacturer of primary sheet metal or manufactured item unless otherwise indicated.

- B. Fasteners: Wood screws, annular threaded nails, self-tapping screws, self-locking rivets and bolts, and other suitable fasteners designed to withstand design loads and recommended by manufacturer of primary sheet metal or manufactured item.
 - 1. General: Blind fasteners or self-drilling screws, gasketed, with hex-washer head.
 - a. Exposed Fasteners: Heads matching color of sheet metal using plastic caps or factory-applied coating.
 - b. Blind Fasteners: High-strength aluminum or stainless-steel rivets suitable for metal being fastened.
 - c. Spikes and Ferrules: Same material as gutter; with spike with ferrule matching internal gutter width.
 - 2. Fasteners for Zinc-Coated (Galvanized) or Aluminum Zinc Alloy Coated Steel Sheet: Hot-dip galvanized steel according to ASTM A 153/A 153M or ASTM F 2329 or Series 300 stainless steel.
- C. Solder:
 - 1. For Zinc-Coated (Galvanized) Steel: ASTM B 32, Grade Sn50, 50 percent tin and 50 percent lead or Grade Sn60, 60 percent tin and 40 percent lead.
- D. Sealant Tape: Pressure-sensitive, 100 percent solids, gray polyisobutylene compound sealant tape with release-paper backing. Provide permanently elastic, nonsag, nontoxic, nonstaining tape 1/2 inch (13 mm) wide and 1/8 inch (3 mm) thick.
- E. Elastomeric Sealant: ASTM C 920, elastomeric polymer sealant; low modulus; of type, grade, class, and use classifications required to seal joints in sheet metal flashing and trim and remain watertight.
- F. Bituminous Coating: Cold-applied asphalt emulsion complying with ASTM D 1187.

2.4 REGLETS

- A. Reglets: Units of type, material, and profile indicated, formed to provide secure interlocking of separate reglet and counterflashing pieces, and compatible with flashing indicated with factory-mitered and -welded corners and junctions.
 - 1. Material: Galvanized steel, 0.022 inch (0.56 mm) thick.
 - 2. Finish: With manufacturer's standard color coating

2.5 FABRICATION, GENERAL

- A. General: Custom fabricate sheet metal flashing and trim to comply with recommendations in SMACNA's "Architectural Sheet Metal Manual" that apply to design, dimensions, geometry, metal thickness, and other characteristics of item indicated. Fabricate items at the shop to greatest extent possible.
 - 1. Obtain field measurements for accurate fit before shop fabrication.
 - 2. Form sheet metal flashing and trim without excessive oil canning, buckling, and tool marks and true to line and levels indicated, with exposed edges folded back to form hems.
 - 3. Conceal fasteners and expansion provisions where possible. Exposed fasteners are not allowed on faces exposed to view.
- B. Sealed Joints: Form nonexpansion but movable joints in metal to accommodate elastomeric sealant.
- C. Expansion Provisions: Where lapped or bayonet type expansion provisions cannot be used, form expansion joints of intermeshing hooked flanges, not less than 1 inch (25 mm) deep, filled with elastomeric sealant concealed within joints.
- D. Fabricate cleats and attachment devices from same material as accessory being anchored or from compatible, noncorrosive metal.
- E. Seams: Fabricate nonmoving seams with flat-lock seams. Form seams and seal with elastomeric sealant unless otherwise recommended by sealant manufacturer for intended use.

2.6 ROOF DRAINAGE SHEET METAL FABRICATIONS

- A. Through-Wall Overflow Scuppers: Fabricate overflow through-wall scuppers to the cross sections indicated on the drawings complete with mitered corners, flashings and drip edges.
- B. Finish: All of the through-wall scuppers on the project shall be prefinished utilizing fluoropolymer coatings.

2.7 LOW-SLOPE ROOF SHEET METAL FABRICATIONS

- A. Apron, Step, Cricket, and Backer Flashing: Fabricate from the following materials:
 - 1. Aluminum-Zinc Alloy-Coated Steel: 0.022 inch (0.56 mm) thick.
- B. Drip Edges: Fabricate from the following materials:
 - 1. Aluminum-Zinc Alloy-Coated Steel: 0.022 inch (0.56 mm) thick.

- C. Ridge and Edge Flashings: Fabricate from the following materials:
 - 1. Aluminum-Zinc Alloy-Coated Steel: 0.022 inch (0.56 mm) thick.
- D. Finish: All of the gutters and downspouts on the project shall be prefinished utilizing fluoropolymer coatings.

2.8 WALL SHEET METAL FABRICATIONS

- A. Opening Flashings in Frame Construction: Fabricate head, sill, and similar flashings to extend 4 inches (100 mm)] beyond wall openings. Form head and sill flashing with 2-inch- (50-mm-) high, end dams. Fabricate from the following materials:
 - 1. Aluminum-Zinc Alloy-Coated Steel: 0.022 inch (0.56 mm) thick.
- B. Wall Expansion Joint Cover: Fabricate from the following materials:
 - 1. Aluminum-Zinc Alloy-Coated Steel: 0.028 inch thick.

PART 3 - EXECUTION

3.1 UNDERLAYMENT INSTALLATION

- A. Self-Adhering Sheet Underlayment: Install self-adhering sheet underlayment, wrinkle free. Comply with temperature restrictions of underlayment manufacturer for installation; use primer rather than nails for installing underlayment at low temperatures. Apply in shingle fashion to shed water, with end laps of not less than 6 inches (150 mm) staggered 24 inches (600 mm) between courses. Overlap side edges not less than 3-1/2 inches (90 mm). Roll laps with roller. Cover underlayment within 14 days.

3.2 INSTALLATION, GENERAL

- A. General: Anchor sheet metal flashing and trim and other components of the Work securely in place, with provisions for thermal and structural movement so that completed sheet metal flashing and trim shall not rattle, leak, or loosen, and shall remain watertight. Use fasteners, solder, welding rods, protective coatings, separators, sealants, and other miscellaneous items as required to complete sheet metal flashing and trim system.
 - 1. Install sheet metal flashing and trim true to line and levels indicated. Provide uniform, neat seams with minimum exposure of solder, welds, and sealant.
 - 2. Install sheet metal flashing and trim to fit substrates and to result in watertight performance. Verify shapes and dimensions of surfaces to be covered before fabricating sheet metal.
 - 3. Space cleats not more than 12 inches (300 mm) apart. Anchor each cleat with two fasteners. Bend tabs over fasteners.

4. Install exposed sheet metal flashing and trim without excessive oil canning, buckling, and tool marks.
 5. Install sealant tape where indicated.
 6. Torch cutting of sheet metal flashing and trim is not permitted.
- B. Metal Protection: Where dissimilar metals will contact each other or corrosive substrates, protect against galvanic action by painting contact surfaces with bituminous coating or by other permanent separation as recommended by SMACNA.
1. Underlayment: Where installing metal flashing directly on cementitious or wood substrates, install a course of felt underlayment and cover with a slip sheet or install a course of polyethylene sheet.
- C. Expansion Provisions: Provide for thermal expansion of exposed flashing and trim. Space movement joints at a maximum of 10 feet (3 m) with no joints allowed within 24 inches (600 mm) of corner or intersection. Where lapped expansion provisions cannot be used or would not be sufficiently watertight, form expansion joints of intermeshing hooked flanges, not less than 1 inch (25 mm) deep, filled with sealant concealed within joints.
- D. Fastener Sizes: Use fasteners of sizes that will penetrate wood sheathing not less than 1-1/4 inches (32 mm) for nails and not less than 3/4 inch (19 mm) for wood screws.
- E. Seal joints as shown and as required for watertight construction.

3.3 ROOF FLASHING INSTALLATION

- A. General: Install sheet metal flashing and trim to comply with performance requirements, sheet metal manufacturer's written installation instructions, and SMACNA's "Architectural Sheet Metal Manual." Provide concealed fasteners where possible, set units true to line, and level as indicated. Install work with laps, joints, and seams that will be permanently watertight and weather resistant.
- B. Roof Edge Flashing: Anchor to resist uplift and outward forces according to recommendations in SMACNA's "Architectural Sheet Metal Manual" and as indicated. Interlock bottom edge of roof edge flashing with continuous cleat anchored to substrate at staggered 3-inch (75-mm) centers.
- C. Pipe or Post Counterflashing: Install counterflashing umbrella with close-fitting collar with top edge flared for elastomeric sealant, extending a minimum of 4 inches (100 mm) over base flashing. Install stainless-steel draw band and tighten.
- D. Counterflashing: Coordinate installation of counterflashing with installation of base flashing. Insert counterflashing in reglets or receivers and fit tightly to base flashing. Extend counterflashing 4 inches (100 mm) over base flashing. Lap counterflashing joints a minimum of 4 inches (100 mm) and bed with sealant.

- E. Roof-Penetration Flashing: Coordinate installation of roof-penetration flashing with installation of roofing and other items penetrating roof. Seal with elastomeric sealant and clamp flashing to pipes that penetrate roof.

3.4 WALL FLASHING INSTALLATION

- A. General: Install sheet metal wall flashing to intercept and exclude penetrating moisture according to SMACNA recommendations and as indicated. Coordinate installation of wall flashing with installation of wall-opening components such as windows, doors, and louvers.
- B. Opening Flashings in Frame Construction: Install continuous head, sill, and similar flashings to extend 4 inches (100 mm) beyond wall openings.

3.5 CLEANING AND PROTECTION

- A. Clean and neutralize flux materials. Clean off excess solder and sealants.
- B. Remove temporary protective coverings and strippable films as sheet metal flashing and trim are installed unless otherwise indicated in manufacturer's written installation instructions.

END OF SECTION

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SECTION 07 72 53
SNOW GUARDS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Rail-type, seam-mounted snow guards.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: Include roof plans showing layouts and attachment details of snow guards.

1. Include calculation of number and location of snow guards based on snow load, roof slope, roof type, components, spacings, and finish.

C. Product test reports.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Performance Requirements: Provide snow guards that withstand exposure to weather and resist thermally induced movement without failure, rattling, or fastener disengagement due to defective manufacture, fabrication, installation, or other defects in construction.

1. Temperature Change: 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces.

B. Structural Performance:

1. Snow Loads: Refer to Drawings.

2.2 RAIL-TYPE SNOW GUARDS

A. Seam-Mounted, Rail-Type Snow Guards:

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following
 - a. Alpine Snow Guards; ASG4025 System
 - b. S-5! Solutions; SnoFence System
 - c. Approved equivalent.

2. Description: Snow guard rails fabricated from metal pipes, bars, or extrusions, anchored to brackets and equipped with two rails.
3. Material and Finish: Aluminum; clear anodized finish.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions, with Installer present, for compliance with requirements for installation tolerances, snow guard attachment, and other conditions affecting performance of the Work.

3.2 INSTALLATION

- A. Install snow guards according to manufacturer's written instructions. Space rows as recommended by manufacturer.
- B. Attachment for Standing-Seam Metal Roofing:
 1. Do not use fasteners that will penetrate metal roofing, or fastening methods that void metal roofing finish warranty.
 2. Seam-Mounted, Rail-Type Snow Guards: Stainless-steel clamps attached to vertical ribs of standing-seam metal roof panels.

END OF SECTION

**SECTION 07 92 00
JOINT SEALANTS**

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes joint sealants for the following applications, including those specified by reference to this Section:
 - 1. Exterior joints in vertical surfaces and horizontal nontraffic surfaces.
 - 2. Exterior joints in horizontal traffic surfaces.
 - 3. Interior joints in vertical surfaces and horizontal nontraffic surfaces.
 - 4. Interior joints in horizontal traffic surfaces.
- B. See Division 8 Section "Glazing" for glazing sealants.

1.2 PERFORMANCE REQUIREMENTS

- A. Provide elastomeric joint sealants that establish and maintain watertight and airtight continuous joint seals without staining or deteriorating joint substrates.
- B. Provide joint sealants for interior applications that establish and maintain airtight and water-resistant continuous joint seals without staining or deteriorating joint substrates.

1.3 SUBMITTALS

- A. Product Data: For each joint-sealant product indicated.
- B. Color Card: For sealant color selections for each product indicated.
- C. Product certificates.

1.4 WARRANTY

- A. Special Installer's Warranty: Installer's standard form in which Installer agrees to repair or replace elastomeric joint sealants that do not comply with performance and other requirements specified in this Section within specified warranty period.
 - 1. Warranty Period: Two (2) years from date of Substantial Completion.

- B. Special Manufacturer's Warranty: Manufacturer's standard form in which elastomeric sealant manufacturer agrees to furnish elastomeric joint sealants to repair or replace those that do not comply with performance and other requirements specified in this Section within specified warranty period.

- 1. Warranty Period: Two (2) years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, products listed in other Part 2 articles.

2.2 MATERIALS, GENERAL

- A. Compatibility: Provide joint sealants, backings, and other related materials that are compatible with one another and with joint substrates under conditions of service and application, as demonstrated by sealant manufacturer, based on testing and field experience.
- B. Colors of Exposed Joint Sealants: As selected by Architect from manufacturer's full range.

2.3 ELASTOMERIC JOINT SEALANTS

- A. Elastomeric Sealants: Comply with ASTM C 920 and other requirements indicated for each liquid-applied chemically curing sealant specified, including those referencing ASTM C 920 classifications for type, grade, class, and uses related to exposure and joint substrates.
- B. Stain-Test-Response Characteristics: Where elastomeric sealants are specified to be nonstaining to porous substrates, provide products that have undergone testing according to ASTM C 1248 and have not stained porous joint substrates indicated for Project.
- C. Suitability for Contact with Food: Where elastomeric sealants are indicated for joints that will come in repeated contact with food, provide products that comply with 21 CFR 177.2600.
- D. Single-Component Mildew-Resistant Neutral-Curing Silicone Sealant ES-1:
 - 1. Available Products:
 - a. Pecora Corporation; 898.
 - b. Tremco; Tremsil 600 White.
 - 2. Type and Grade: S (single component) and NS (nonsag).
 - 3. Class: 25.

4. Use Related to Exposure: NT (nontraffic).
5. Uses Related to Joint Substrates: M, G, A, and, as applicable to joint substrates indicated, O.

E. Multicomponent Nonsag Urethane Sealant ES-2:

1. Available Products:
 - a. Schnee-Morehead, Inc.; Permthane SM 7200.
 - b. Sika Corporation, Inc.; Sikaflex - 2c NS TG.
 - c. Sonneborn, Division of ChemRex Inc.; NP 2.
 - d. Tremco; Vulkem 227.
 - e. Tremco; Vulkem 322 DS.
2. Type and Grade: M (multicomponent) and NS (nonsag).
3. Class: 25.
4. Uses Related to Exposure: T (traffic) and NT (nontraffic).
5. Uses Related to Joint Substrates: M, G, A, and, as applicable to joint substrates indicated, O.

F. Multicomponent Pourable Urethane Sealant ES-3:

1. Available Products:
 - a. Bostik Findley; Chem-Calk 550.
 - b. Meadows, W. R., Inc.; POURTHANE.
 - c. Pacific Polymers, Inc.; Elasto-Thane 227 High Shore Type I (Self Leveling).
 - d. Pacific Polymers, Inc.; Elasto-Thane 227 Type I (Self Leveling).
 - e. Pecora Corporation; Urexpam NR-200.
 - f. Polymeric Systems Inc.; PSI-270SL.
 - g. Schnee-Morehead, Inc.; Permthane SM 7201.
 - h. Tremco; THC-901.
 - i. Tremco; THC-900.
 - j. Tremco; Vulkem 245.
 - k. Pecora Corporation; Urexpam NR 300, Type H.
 - l. Pecora Corporation; Urexpam NR 300, Type M.
2. Type and Grade: M (multicomponent) and P (pourable).
3. Class: 25.
4. Use Related to Exposure: T (traffic).
5. Uses Related to Joint Substrates: M, A, and, as applicable to joint substrates indicated, O.

2.4 SILICONE JOINT SEALANTS

A. Mildew-Resistant Silicone Joint Sealant: ASTM C 920.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. BASF Building Systems.
 - b. Dow Corning Corporation.
 - c. GE Advanced Materials - Silicones.
 - d. Pecora Corporation.
 - e. Polymeric Systems, Inc.
 - f. Sika Corporation; Construction Products Division.
2. Type: Single component (S)
3. Grade: Nonsag (NS)
4. Class: 50
5. Uses Related to Exposure: Nontraffic (NT).

2.5 LATEX JOINT SEALANTS

A. Latex Sealant LS-1: Comply with ASTM C 834, Type O P, Grade NF.

B. Available Products:

1. Bostik Findley; Chem-Calk 600.
2. Pecora Corporation; AC-20+.
3. Schnee-Morehead, Inc.; SM 8200.
4. Sonneborn, Division of ChemRex Inc.; Sonolac.
5. Tremco; Tremflex 834.

2.6 JOINT-SEALANT BACKING

- A. General: Provide sealant backings of material and type that are nonstaining; are compatible with joint substrates, sealants, primers, and other joint fillers; and are approved for applications indicated by sealant manufacturer based on field experience and laboratory testing.
- B. Cylindrical Sealant Backings: ASTM C 1330, Type C (closed-cell material with a surface skin), O (open-cell material), B (bicellular material with a surface skin), or any of the preceding types, as approved in writing by joint-sealant manufacturer for joint application indicated, and of size and density to control sealant depth and otherwise contribute to producing optimum sealant performance:

- C. Bond-Breaker Tape: Polyethylene tape or other plastic tape recommended by sealant manufacturer for preventing sealant from adhering to rigid, inflexible joint-filler materials or joint surfaces at back of joint where such adhesion would result in sealant failure. Provide self-adhesive tape where applicable.

2.7 MISCELLANEOUS MATERIALS

- A. Primer: Material recommended by joint-sealant manufacturer where required for adhesion of sealant to joint substrates indicated, as determined from preconstruction joint-sealant-substrate tests and field tests.
- B. Cleaners for Nonporous Surfaces: Chemical cleaners acceptable to manufacturers of sealants and sealant backing materials, free of oily residues or other substances capable of staining or harming joint substrates and adjacent nonporous surfaces in any way, and formulated to promote optimum adhesion of sealants to joint substrates.
- C. Masking Tape: Nonstaining, nonabsorbent material compatible with joint sealants and surfaces adjacent to joints.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Surface Cleaning of Joints: Clean out joints immediately before installing joint sealants.
 - 1. Remove all foreign material from joint substrates that could interfere with adhesion of joint sealant.
 - a. Clean porous joint substrate surfaces by brushing, grinding, blast cleaning, mechanical abrading, or a combination of these methods to produce a clean, sound substrate capable of developing optimum bond with joint sealants. Remove loose particles remaining after cleaning operations above by vacuuming or blowing out joints with oil-free compressed air.
 - 2. Remove laitance and form-release agents from concrete.
 - a. Clean nonporous surfaces with chemical cleaners or other means that do not stain, harm substrates, or leave residues capable of interfering with adhesion of joint sealants.
- B. Joint Priming: Prime joint substrates, where recommended in writing by joint-sealant manufacturer, based on preconstruction joint-sealant-substrate tests or prior experience. Apply primer to comply with joint-sealant manufacturer's written instructions. Confine primers to areas of joint-sealant bond; do not allow spillage or migration onto adjoining surfaces.

- C. Masking Tape: Use masking tape where required to prevent contact of sealant with adjoining surfaces that otherwise would be permanently stained or damaged by such contact or by cleaning methods required to remove sealant smears. Remove tape immediately after tooling without disturbing joint seal.

3.2 INSTALLATION

- A. Sealant Installation Standard: Comply with recommendations in ASTM C 1193 for use of joint sealants as applicable to materials, applications, and conditions indicated.
- B. Acoustical Sealant Application Standard: Comply with recommendations in ASTM C 919 for use of joint sealants in acoustical applications as applicable to materials, applications, and conditions indicated.
- C. Install sealant backings of type indicated to support sealants during application and at position required to produce cross-sectional shapes and depths of installed sealants relative to joint widths that allow optimum sealant movement capability.
 - 1. Do not leave gaps between ends of sealant backings.
 - 2. Do not stretch, twist, puncture, or tear sealant backings.
 - 3. Remove absorbent sealant backings that have become wet before sealant application and replace them with dry materials.
- D. Install bond-breaker tape behind sealants where sealant backings are not used between sealants and backs of joints.
- E. Install sealants using proven techniques that comply with the following and at the same time backings are installed:
 - 1. Place sealants so they directly contact and fully wet joint substrates.
 - 2. Completely fill recesses in each joint configuration.
 - 3. Produce uniform, cross-sectional shapes and depths relative to joint widths that allow optimum sealant movement capability.
- F. Tooling of Nonsag Sealants: Immediately after sealant application and before skinning or curing begins, tool sealants according to requirements specified below to form smooth, uniform beads of configuration indicated; to eliminate air pockets; and to ensure contact and adhesion of sealant with sides of joint.
 - 1. Remove excess sealant from surfaces adjacent to joints.
 - 2. Use tooling agents that are approved in writing by sealant manufacturer and that do not discolor sealants or adjacent surfaces.
 - 3. Provide concave joint configuration per Figure 5A in ASTM C 1193, unless otherwise indicated.
- G. Clean off excess sealant or sealant smears adjacent to joints as the Work progresses by methods and with cleaning materials approved in writing by manufacturers of joint sealants and of products in which joints occur.

3.3 JOINT-SEALANT SCHEDULE

- A. Joint-Sealant Application JS-1: Exterior horizontal traffic, isolation, and contraction joints in cast-in-place concrete slabs.
 - 1. Joint Sealant: Multicomponent pourable polysulfide sealant ES-3.
- B. Joint-Sealant Application JS-2: Exterior perimeter joints between the cementitious siding and the frames of doors, windows, and louvers.
 - 1. Joint Sealant: Multicomponent nonsag urethane sealant ES-2.
- C. Joint-Sealant Application JS-3: Exterior control and expansion joints in overhead surfaces.
 - 1. Joint Sealant: Multicomponent nonsag urethane sealant ES-2.
- D. Joint-Sealant Application JS-4: Vertical control and expansion joints on exposed interior surfaces of exterior walls.
 - 1. Joint Sealant: Multicomponent nonsag urethane sealant ES-2.
- E. Joint-Sealant Application JS-5: Interior perimeter joints of exterior openings.
 - 1. Joint Sealant: Multicomponent nonsag urethane sealant ES-2.
- F. Joint-Sealant Application JS-6: Interior ceramic tile expansion, control, contraction, and isolation joints in horizontal traffic surfaces.
 - 1. Joint Sealant: Multicomponent nonsag urethane sealant ES-2.
- G. Joint-Sealant Application JS-7: Interior joints between plumbing fixtures and adjoining walls, floors, and counters.
 - 1. Joint Sealant: Single-component mildew-resistant neutral-curing silicone sealant ES-1.
 - 2. Joint-Sealant Color: White or clear.
- H. Joint-Sealant Application JS-8: Perimeter joints between interior wall surfaces and frames of interior doors and windows.
 - 1. Joint Sealant: Latex sealant.
- I. Joint-Sealant Application JS-9: Interior control, expansion, and isolation joints in horizontal traffic surfaces of concrete slabs-on-grade.
 - 1. Joint Sealant: Multicomponent nonsag urethane sealant ES-2.

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SECTION 08 11 13
HOLLOW METAL DOORS AND FRAMES

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Standard hollow metal doors and frames.

1.2 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: Include elevations, door edge details, frame profiles, metal thicknesses, preparations for hardware, and other details.
- C. Schedule: Prepared by or under the supervision of supplier, using same reference numbers for details and openings as those on Drawings.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Amweld Building Products, LLC.
 - a. Ceco Door Products; an Assa Abloy Group company.
 - b. Curries Company; an Assa Abloy Group company.
 - c. Kewanee Corporation (The).
 - d. Steelcraft; an Ingersoll-Rand company.

2.2 MATERIALS

- A. Cold-Rolled Steel Sheet: ASTM A 1008/A 1008M, CS, Type B; suitable for exposed applications.
- B. Metallic-Coated Steel Sheet: ASTM A 653/A 653M, Commercial Steel (CS), Type B; with minimum G60 (Z180) or A60 (ZF180) metallic coating.
- C. Frame Anchors: ASTM A 591/A 591M, Commercial Steel (CS), 40Z (12G) coating designation; mill phosphatized.
 - 1. For anchors built into exterior walls, steel sheet complying with ASTM A 1008/A 1008M or ASTM A 1011/A 1011M, hot-dip galvanized according to ASTM A 153/A 153M, Class B.
- D. Inserts, Bolts, and Fasteners: Hot-dip galvanized according to ASTM A 153/A 153M.
- E. Grout: ASTM C 476, except with a maximum slump of 4 inches (102 mm), as measured according to ASTM C 143/C 143M.
- F. Bituminous Coating: Cold-applied asphalt mastic, SSPC-Paint 12, compounded for 15-mil (0.4-mm) dry film thickness per coat.

2.3 HEAVY DUTY SECURITY GRADE HOLLOW METAL DOORS

- A. General: Comply with ANSI/SDI A250.8.
 - 1. Design: Flush panel
 - a. Core Construction: Manufacturer's standard steel stiffened, polyurethane core.
 - 2. Vertical Edges for Single-Acting Doors: Manufacturer's standard.
 - a. Top and Bottom Edges: Closed with flush or inverted 0.042-inch- (1.0-mm-) thick, end closures or channels of same material as face sheets.
 - b. Tolerances: SDI 117, "Manufacturing Tolerances for Standard Steel Doors and Frames."
- B. Exterior Doors: Face sheets fabricated from metallic-coated steel sheet. Comply with ANSI/SDI A250.8 for level and model and ANSI/SDI A250.4 for physical performance level:
 - 1. Basis-of-Design: Curries 847 Series Steel Stiffened Door with polyurethane core. Minimum U-Value of installed door & frame assembly: U-0.45.
 - a. Door Face Gauge: 14 gauge
 - b. Level 2 and Physical Performance Level B (Heavy Duty), Model 1 (Full Flush)
- C. Hardware Reinforcement: ANSI/SDI A250.6.

2.4 STANDARD HOLLOW METAL FRAMES

- A. General: Comply with ANSI/SDI A250.8.
- B. Exterior Frames: Fabricated from metallic-coated steel sheet.
 - 1. Fabricate frames with mitered or coped corners.
 - a. Fabricate frames as full profile welded unless otherwise indicated.
 - b. Frames for Level 2 Steel Doors: 0.053-inch- (1.3-mm-) thick steel sheet.
 - c. Frame Gauge: 14 gauge
- C. Hardware Reinforcement: ANSI/SDI A250.6.

2.5 FRAME ANCHORS

- A. Jamb Anchors:
 - 1. Masonry Type: Adjustable strap-and-stirrup or T-shaped anchors to suit frame size, not less than 0.042 inch (1.0 mm) thick, with corrugated or perforated straps not less than 2 inches (50 mm) wide by 10 inches (250 mm) long; or wire anchors not less than 0.177 inch (4.5 mm) thick.
 - 2. Post-installed Expansion Type for In-Place Concrete or Masonry: Minimum 3/8-inch- (9.5-mm-) diameter bolts with expansion shields or inserts. Provide pipe spacer from frame to wall, with throat reinforcement plate, welded to frame at each anchor location.
- B. Floor Anchors: Formed from same material as frames, not less than 0.042 inch (1.0 mm) thick, and as follows:
 - 1. Monolithic Concrete Slabs: Clip-type anchors, with two holes to receive fasteners.
 - a. Separate Topping Concrete Slabs: Adjustable-type anchors with extension clips, allowing not less than 2-inch (50-mm) height adjustment. Terminate bottom of

frames at finish floor surface.

2.6 HOLLOW METAL PANELS

- A. Provide hollow metal panels of same materials, construction, and finish as specified for adjoining hollow metal work.

2.7 STOPS AND MOLDINGS

- A. Fixed Frame Moldings: Formed integral with hollow metal frames, a minimum of five-eighths inch (16 mm) high unless otherwise indicated.

2.8 ACCESSORIES

- A. Ceiling Struts: Minimum one-quarter-inch-thick by 1-inch- (6.4-mm-thick by 25.4-mm-) wide steel.
- B. Grout Guards: Formed from same material as frames, not less than 0.016 inch (0.4 mm) thick.

2.9 FABRICATION

- A. Tolerances: Fabricate hollow metal work to tolerances indicated in SDI 117.
- B. Hollow Metal Doors:
 - 1. Exterior Doors: Provide weep-hole openings in bottom of exterior doors. Seal joints in top edges of doors against water penetration.
- C. Hollow Metal Frames: Where frames are fabricated in sections, provide alignment plates or angles at each joint, fabricated of same thickness metal as frames.
 - 1. Welded Frames: Weld flush face joints continuously; grind, fill, dress, and make smooth, flush, and invisible.
 - a. Provide countersunk, flat- or oval-head exposed screws and bolts for exposed fasteners unless otherwise indicated.
 - b. Grout Guards: Weld guards to frame at back of hardware mortises in frames to be grouted.
 - c. Floor Anchors: Weld anchors to bottom of jambs and mullions with at least four spot welds per anchor.
 - d. Jamb Anchors: Provide number and spacing of anchors as follows:
 - 1) Masonry Type: Locate anchors not more than 18 inches (457 mm) from top and bottom of frame. Space anchors not more than 32 inches (813 mm) o.c. and as follows:
 - a) Two anchors per jamb up to 60 inches (1524 mm) high.
 - b) Three anchors per jamb from 60 to 90 inches (1524 to 2286 mm) high.
 - c) Four anchors per jamb from 90 to 120 inches (2286 to 3048 mm) high.
 - d) Four anchors per jamb plus 1 additional anchor per jamb for each 24 inches (610 mm) or fraction thereof above 120 inches (3048 mm) high.

- 2) Postinstalled Expansion Type: Locate anchors not more than 6 inches (152 mm) from top and bottom of frame. Space anchors not more than 26 inches (660 mm) o.c.
- D. Hardware Preparation: Factory prepare hollow metal work to receive templated mortised hardware according to the Door Hardware Schedule and templates furnished as specified in Division 08 Section "Door Hardware."
1. Locate hardware as indicated, or if not indicated, according to ANSI/SDI A250.8.
 - a. Reinforce doors and frames to receive nontemplated, mortised and surface-mounted door hardware.
 - b. Comply with applicable requirements in ANSI/SDI A250.6 and ANSI/DHI A115 Series specifications for preparation of hollow metal work for hardware.
 - c. Coordinate locations of conduit and wiring boxes for electrical connections with Division 26 electrical Sections.
- E. Stops and Moldings: Provide stops and moldings around glazed lites where indicated. Form corners of stops and moldings with butted or mitered hairline joints.
1. Single Glazed Lites: Provide fixed stops and moldings welded on secure side of hollow metal work.
 - a. Multiple Glazed Lites: Provide fixed and removable stops and moldings so that each glazed lite are capable of being removed independently.
 - b. Provide fixed frame moldings on outside of exterior and on secure side of interior doors and frames.
 - c. Provide loose stops and moldings on inside of hollow metal work.
 - d. Coordinate rabbet width between fixed and removable stops with type of glazing and type of installation indicated.

2.10 STEEL FINISHES

- A. Prime Finish: Apply manufacturer's standard primer immediately after cleaning and pretreating.
1. Shop Primer: ANSI/SDI A250.10.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Hollow Metal Frames: Comply with ANSI/SDI A250.11.
1. Set frames accurately in position, plumbed, aligned, and braced securely until permanent anchors are set. After wall construction is complete, remove temporary braces, leaving surfaces smooth and undamaged.
 - a. Where frames are fabricated in sections because of shipping or handling limitations, field splice at approved locations by welding face joint continuously; grind, fill, dress, and make splice smooth, flush, and invisible on exposed faces.
 - 1) Install frames with removable glazing stops located on secure side of

- opening.
 - 2) Install door silencers in frames before grouting.
 - 3) Remove temporary braces necessary for installation only after frames have been properly set and secured.
 - 4) Check plumbness, squareness, and twist of frames as walls are constructed. Shim as necessary to comply with installation tolerances.
 - 5) Field apply bituminous coating to backs of frames that are filled with grout containing antifreezing agents.
2. Floor Anchors: Provide floor anchors for each jamb and mullion that extends to floor, and secure with postinstalled expansion anchors.
- a. Floor anchors may be set with powder-actuated fasteners instead of postinstalled expansion anchors if so indicated and approved on Shop Drawings.
3. Masonry Walls: Coordinate installation of frames to allow for solidly filling space between frames and masonry with grout.
- a. Concrete Walls: Solidly fill space between frames and concrete with grout. Take precautions, including bracing frames, to ensure that frames are not deformed or damaged by grout forces.
 - b. In-Place Concrete or Masonry Construction: Secure frames in place with postinstalled expansion anchors. Countersink anchors, and fill and make smooth, flush, and invisible on exposed faces.
 - c. Ceiling Struts: Extend struts vertically from top of frame at each jamb to overhead structural supports or substrates above frame unless frame is anchored to masonry or to other structural support at each jamb. Bend top of struts to provide flush contact for securing to supporting construction. Provide adjustable wedged or bolted anchorage to frame jamb members.
 - d. Installation Tolerances: Adjust hollow metal door frames for squareness, alignment, twist, and plumb to the following tolerances:
 - 1) Squareness: Plus or minus 1/16 inch (1.6 mm), measured at door rabbet on a line 90 degrees from jamb perpendicular to frame head.
 - a) Alignment: Plus or minus 1/16 inch (1.6 mm), measured at jambs on a horizontal line parallel to plane of wall.
 - b) Twist: Plus or minus 1/16 inch (1.6 mm), measured at opposite face corners of jambs on parallel lines, and perpendicular to plane of wall.
 - c) Plumbness: Plus or minus 1/16 inch (1.6 mm), measured at jambs at floor.
- B. Hollow Metal Doors: Fit hollow metal doors accurately in frames, within clearances specified below. Shim as necessary.
1. Non-Fire-Rated Standard Steel Doors:
- a. Jambs and Head: 1/8 inch (3 mm) plus or minus 1/16 inch (1.6 mm).
 - 1) Between Edges of Pairs of Doors: 1/8 inch (3 mm) plus or minus 1/16 inch (1.6 mm).
 - 2) Between Bottom of Door and Top of Threshold: Maximum 3/8 inch (9.5

mm).

3.2 ADJUSTING AND CLEANING

- A. Final Adjustments: Check and readjust operating hardware items immediately before final inspection. Leave work in complete and proper operating condition. Remove and replace defective work, including hollow metal work that is warped, bowed, or otherwise unacceptable.
- B. Prime-Coat Touchup: Immediately after erection, sand smooth rusted or damaged areas of prime coat and apply touchup of compatible air-drying, rust-inhibitive primer.
- C. Metallic-Coated Surfaces: Clean abraded areas and repair with galvanizing repair paint according to manufacturer's written instructions.

END OF SECTION

SECTION 08 33 23
OVERHEAD COILING DOORS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Manually operated insulated service doors.

B. Related Requirements:

1. Section 055000 "Metal Fabrications" for miscellaneous steel supports, door-opening framing, corner guards, and bollards.

1.2 ACTION SUBMITTALS

A. Product Data: For each type and size of overhead coiling door and accessory.

B. Shop Drawings: For each installation and for special components not dimensioned or detailed in manufacturer's product data.

1. Include points of attachment and their corresponding static and dynamic loads imposed on structure.
2. Show locations of any operation chains or other accessories.

C. Samples: For each exposed product and for each color and texture specified.

1.3 INFORMATIONAL SUBMITTALS

A. Sample warranty.

1.4 CLOSEOUT SUBMITTALS

A. Special warranty.

B. Maintenance data.

1.5 QUALITY ASSURANCE

- A. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by manufacturer for both installation and maintenance of units required for this Project.

1.6 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of doors that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period: Three years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Accessibility Standard: Comply with applicable provisions in ICC A117.1
- B. Structural Performance, Exterior Doors: Capable of withstanding the following design wind loads:
 - 1. Design Wind Load: Uniform pressure (velocity pressure) of 20 lbf/sq. ft. (960 Pa), acting inward and outward.
 - 2. Testing: According to ASTM E330/E330M
 - 3. Deflection Limits: Design overhead coiling doors to withstand design wind load without evidencing permanent deformation or disengagement of door components.

2.2 DOOR ASSEMBLY

- A. Insulated Service Door: Overhead coiling door formed with curtain of interlocking metal slats.
 - 1. Manufacturers: Subject to compliance with requirements, provide one of the following, or a comparable approved equivalent:
 - a. Cornell Iron Works, Inc. – Thermiser Model ESD20
 - b. Overhead Door Corporation – Stormtite Model 625
 - c. Raynor Manufacturing Company – Duracoil Optima IF
 - d. Wayne Dalton – Thermotite Model 800C
- B. Operation Cycles: Door components and operators capable of operating for not less than 100,000
- C. Insulated Door Curtain R-Value: 7.7
- D. Insulated Door Assembly U-Factor: 0.13

- E. Door Curtain Material: Galvanized steel.
- F. Door Curtain Slats: Flat profile slats of 3-inch center-to-center height.
 - 1. Insulated-Slat Interior Facing: Galvanized steel.
- G. Bottom Bar: Two angles, each not less than .12 inch minimum thickness; fabricated from stainless steel and finished to match door.
- H. Curtain Jamb Guides: Three-piece structural angle guide assembly forming a slot to retain curtains and guides with exposed finish matching curtain slats.
 - 1. Provide with integral windlock bars when required by size or wind loading.
 - 2. Removable bottom bar stops.
- I. Hood: Match curtain material and finish.
 - 1. Mounting: As indicated on Drawings.
- J. Locking Devices: Equip door with chain lock keeper and manual slide bolt.
- K. Manual Door Operator: Chain-hoist operator.
- L. Curtain Accessories: Equip door with weather seals push/pull handles.
- M. Door Finish:
 - 1. Powder-Coated Finish: Custom RAL Color as selected by Architect from manufacturer's full range.
 - 2. Interior Curtain-Slat Facing: Finish as selected by Architect from manufacturer's full range of RAL powder-coat finish colors.

2.3 DOOR CURTAIN MATERIALS AND CONSTRUCTION

- A. Door Curtains: Fabricate overhead coiling-door curtain of interlocking metal slats, designed to withstand wind loading indicated, in a continuous length for width of door without splices. Unless otherwise indicated, provide slats of thickness and mechanical properties recommended by door manufacturer for performance, size, and type of door indicated, and as follows:
 - 1. Insulation: Fill slats for insulated doors with manufacturer's standard thermal insulation complying with maximum flame-spread and smoke-developed indexes of 75 and 450, respectively, according to ASTM E84 or UL 723. Enclose insulation completely within slat faces.
 - 2. Metal Interior Curtain-Slat Facing: Match metal of exterior curtain-slat face, with minimum steel thickness of 0.010 inch.
- B. Curtain Jamb Guides: Manufacturer's standard angles or channels and angles of same material and finish as curtain slats unless otherwise indicated, with sufficient depth and strength to

retain curtain, to allow curtain to operate smoothly, and to withstand loading. Slot bolt holes for guide adjustment. Provide removable stops on guides to prevent overtravel of curtain.

2.4 HOODS

- A. General: Form sheet metal hood to entirely enclose coiled curtain and operating mechanism at opening head. Contour to fit end brackets to which hood is attached. Roll and reinforce top and bottom edges for stiffness. Form closed ends for surface-mounted hoods and fascia for any portion of between-jamb mounting that projects beyond wall face. Equip hood with intermediate support brackets as required to prevent sagging.

2.5 CURTAIN ACCESSORIES

- A. Weatherseals for Exterior Doors: Equip each exterior door with weather-stripping gaskets fitted to entire exterior perimeter of door for a weather-resistant installation unless otherwise indicated.

2.6 LOCKING DEVICES

- A. Slide Bolt: Fabricate with side-locking bolts to engage through slots in tracks for locking by padlock, located on both left and right jamb sides, operable from coil side.
- B. Chain Lock Keeper: Suitable for padlock.

2.7 MANUAL DOOR OPERATORS

- A. General: Equip door with manual door operator by door manufacturer.
- B. Chain-Hoist Operator: Consisting of endless steel hand chain, chain-pocket wheel and guard, and gear-reduction unit with a maximum 25-lbf force for door operation. Provide alloy-steel hand chain with chain holder secured to operator guide.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

- A. Install overhead coiling doors and operating equipment complete with necessary hardware, anchors, inserts, hangers, and equipment supports; according to manufacturer's written instructions and as specified.

3.2 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
 - 1. Test door release, closing, and manual operation of door.
- B. Repair or remove and replace installations where inspections indicate that they do not comply with specified requirements.
- C. Reinspect repaired or replaced installations to determine if replaced or repaired door assembly installations comply with specified requirements.

3.3 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain overhead coiling doors.

END OF SECTION

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SECTION 08 45 23
INSULATED TRANSLUCENT FIBERGLASS SKYLIGHT

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes the insulated, translucent sandwich panel system and accessories as shown and specified. Work includes providing and installing:
 - 1. Flat, insulated, translucent sandwich panels
 - 2. Aluminum clampite installation system
 - 3. Aluminum flashing attached to skylights

1.2 SUBMITTALS

- A. Submit manufacturer's product data. Include construction details, material descriptions, profiles, and finishes of components.
- B. Submit shop drawings. Include plans, elevations, and details.
- C. Submit manufacturer's color charts showing the full range of colors available for factory finished exposed aluminum.
- D. Submit Installer Certificate, signed by installer, certifying compliance with project qualification requirements.
- E. Submit product reports from a qualified independent testing agency indicating each type and class of panel system complies with the project performance requirements, based on comprehensive testing of current products. Previously completed reports will be acceptable if for current manufacturer and indicative of products used on this project.
 - 1. Reports required (if applicable) are:
 - a. Flame Spread and Smoke Developed (UL 723) – Submit UL Card
 - b. Burn Extent (ASTM D 635)
 - c. Color Difference (ASTM D 2244)
 - d. Impact Strength (UL 972)
 - e. Bond Tensile Strength (ASTM C 297 after aging by ASTM D 1037)
 - f. Bond Shear Strength (ASTM D 1002)
 - g. Beam Bending Strength (ASTM E 72)
 - h. Insulation U-Factor (NFRC 100)
 - i. NFRC System U-Factor Certification (NFRC 700)
 - j. NFRC Visible Light Transmittance (NFRC 202)
 - k. Solar Heat Gain Coefficient (NFRC or Calculations)
 - l. Condensation Resistance Factor (AAMA 1503) (Thermally Broken, insulated panels only)
 - m. Air Leakage (ASTM E 283)
 - n. Structural Performance (ASTM E 330)

- o. Water Penetration (ASTM E 331)
- p. Fire Penetration of Exterior Wall Assemblies Using a Direct Flame Impingement Exposure (ASTM E2707)
- q. Fall Through Resistance (ASTM E 661)
- r. Class A Roof Covering Burning Brand (UL 790)
- s. UL Listed Class A Roof System (UL 790) (Optional) – Submit UL Card

1.3 CLOSEOUT SUBMITTALS

- A. Provide field maintenance manual to include in project maintenance manuals.

1.4 QUALITY ASSURANCE

- A. Manufacturer's Qualifications:
 - 1. Material and products shall be manufactured by a company continuously and regularly employed in the manufacture of specified materials for a period of at least ten consecutive years and which can show evidence of those materials being satisfactorily used on at least six projects of similar size, scope, and location. At least three of the projects shall have been in successful use for ten years or longer.
 - 2. Panel system must be listed by an ANSI accredited Evaluation Service, which requires quality control inspections and fire, structural, and water infiltration testing of sandwich panel systems by an accredited agency.
 - 3. Quality control inspections shall be conducted at least once each year and shall include manufacturing facilities, sandwich panel components, and production sandwich panels for conformance with AC177 "Translucent Fiberglass Reinforced Plastic (FRP) Faced Panel Wall, Roof and Skylight Systems" as issued by the ICC-ES.
- B. Installer's Qualifications: Installation shall be by an experienced installer, which has been in the business of installing manufacturer's panel systems for at least two consecutive years and can show evidence of satisfactory completion of projects of similar size, scope, and type.

1.5 PERFORMANCE REQUIREMENTS

- A. The manufacturer shall be responsible for the configuration and fabrication of the complete panel system.
 - 1. When requested, include span analysis data.
 - 2. Standard panel system shall have less than 0.01 cfm/ft² air leakage by ASTM E 283 at 6.24 PSF (50 mph) and no water penetration by ASTM E 331 at 15 PSF; and structural testing by ASTM E 330.
 - 3. Structural Loads. Provide skylight system capable of handling the following loads:
 - a. Live Load (PSF): Refer to structural drawings.
 - b. Snow Load (PSF): Refer to structural drawings.
 - c. Drift Load (PSF): Refer to structural drawings.
 - d. Wind Load (PSF): Refer to structural drawings.
- B. Deflection Limits:

1. Unit Skylight: Limited to L/60 of clear span for each assembly component.
- C. Thermal Movements: Allow for thermal movements from ambient- and surface-temperature changes. Base calculations on surface temperatures of materials due to both solar heat gain and nighttime-sky heat loss.
 1. Temperature Change (Range): 110 deg F (43 deg C), ambient; 150 deg F (66 deg C), material surfaces.

1.6 DELIVERY, STORAGE AND HANDLING

- A. Deliver panel system, components, and materials in manufacturer's standard protective packaging.
- B. Store panels on the long edge; several inches above the ground, blocked and under cover in accordance with manufacturer's storage and handling instructions.

1.7 WARRANTY

- A. Provide manufacturer's and installer's written warranties agreeing to repair or replace panel system work, which fails in material or workmanship, within one year from the date of delivery. Failure of material or workmanship shall include deterioration of finish on metal in excess of normal weathering; and defects in accessories; insulated, translucent sandwich panels; and other components of the work.
- B. Extended Panel Warranty: 10 years from date of delivery.
- C. Extended Manufacturer's factory applied Finish Warranty: 10 years from date of delivery.

PART 2 - PRODUCTS

2.1 MANUFACTURER

- A. The basis for this specification is for products manufactured by Kalwall Corporation. Other manufacturers may bid this project subject to compliance with the performance requirements of this specification and submission of evidence thereof. Listing other manufacturers' names in this specification does not constitute approval of their products or relieve them of compliance with all the performance requirements contained herein.
- B. Kalwall Corporation: Contact Todd Bryant with Powers Products. Telephone: 303-226-1599. Email: toddb@powersproducts.com

2.2 PANEL COMPONENTS

A. Face Sheets:

1. Translucent faces: Manufactured from glass fiber reinforced thermoset resins, formulated specifically for architectural use.
 - a. Thermoplastic (e.g. polycarbonate, acrylic) faces are not acceptable.
 - b. Face sheets shall not deform, deflect, or drip when subjected to fire or flame.
2. Interior face sheets:
 - a. Flame spread: Underwriters Laboratories (UL) listed, which requires periodic unannounced retesting, with flame spread rating no greater than 25 and smoke developed no greater than 450 when tested in accordance with UL 723.
 - b. Burn extent by ASTM D 635 shall be no greater than 1".
3. Exterior face sheets:
 - a. Color stability: Full thickness of the exterior face sheet shall not change color more than 3 CIE Units DELTA E by ASTM D 2244 after 5 years outdoor South Florida weathering at 5° facing south as measured on a white sample, with and without a protective film or coating to ensure long-term color stability. Color stability shall be unaffected by abrasion or scratching.
 - b. Strength: Exterior face sheet shall be uniform in strength, impenetrable by hand held pencil and repel an impact minimum of 70 ft. lbs. without fracture or tear when impacted by a 3-1/4" diameter, 5 lb. free-falling ball per UL 972.
 - c. Erosion Protection: Integral, embedded-glass erosion barrier.
4. Appearance:
 - a. Exterior face sheet: Smooth, 0.70" thick and White in color.
 - b. Interior face sheet: Smooth, 0.45" thick and Crystal in color.
 - c. Face sheets shall not vary more than $\pm 10\%$ in thickness and be uniform in color.

B. Grid Core:

1. Thermally-Broken Composite I-beam grid core shall be of 6063-T6 or 6005-T5 alloy and temper with provisions for mechanical interlocking of muntin-mullion and perimeter. Width of I-beam shall be no less than 7/16".
2. I-beam Thermal break: Minimum 1", thermoset fiberglass composite. Poured and de-bridged thermal break is not acceptable.

C. Laminate Adhesive:

1. 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".
2. Minimum tensile strength of 750 PSI when the panel assembly is tested by ASTM C 297 after two exposures to six cycles each of the aging conditions prescribed by ASTM D 1037.
3. Minimum shear strength of the panel adhesive by ASTM D 1002 after exposure to four separate conditions:
 - a. 50% Relative Humidity at 68° F: 540 PSI
 - b. 182° F: 100 PSI
 - c. Accelerated Aging by ASTM D 1037 at room temperature: 800 PSI
 - d. Accelerated Aging by ASTM D 1037 at 182° F: 250 PSI

2.3 PANEL CONSTRUCTION

- A. Provide sandwich panels of flat fiberglass reinforced translucent face sheets laminated to a grid core of mechanically interlocking I-beams. The adhesive bonding line shall be straight, cover the entire width of the I-beam and have a neat, sharp edge.
1. Thickness: 2-3/4 inches
 2. Grid Core Insulation: Fill panel cores with air.
 3. Panel U-factor by NFRC certified laboratory:
 - a. 2-3/4" thermally broken grid u-value: 0.50 maximum
 4. Visible Light Transmittance (VLT):
 - a. Visible LT (NFRC 202) by NFRC certified laboratory: 0.29
 5. Solar heat gain coefficient: 0.40 maximum
 6. Grid pattern as viewed: Nominal size 12x12
- B. Standard panels shall deflect no more than 1.9" at 30 PSF in 10'-0" span without a supporting frame by ASTM E 72.
- C. Panels shall meet the conditions of acceptance according to ASTM E2707 Fire Penetration of Exterior Wall Assemblies Using a Direct Flame Impingement Exposure:
1. Absence of flame penetration through the wall assembly at any time.
 2. Absence of evidence of glowing combustion on the interior surface of the assembly at the end of the 60-min observation period.
 3. Absence of evidence of flame, glow, and smoke if the test is terminated prior to the completion of the 60-min observation period.
- D. Thermally broken, insulated panels: Minimum Condensation Resistance Factor of 80 by AAMA 1503 measured on the bond line.
- E. Skylight System:
1. Skylight system shall pass Class A Roof Burning Brand Test by UL 790.

- F. Skylight System shall meet the fall through requirements of OSHA 1910.21 as demonstrated by testing in accordance with ASTM E 661, thereby not requiring supplemental screens or railings.

2.4 ALUMINUM CLAMPTITE INSTALLATION SYSTEM

- A. Aluminum clamptite installation system – Unit Skylight:
 - 1. Extruded aluminum 6063-T6 and 6063-T5 alloy and temper clamp-tite screw type closure system.
- B. Sealing tape: Manufacturer's standard, pre-applied to aluminum clamptite installation system at the factory under controlled conditions.
- C. Fasteners: 300 series stainless steel screws for aluminum clamptite installation system, excluding final fasteners to the building.
- D. Finish:
 - 1. Manufacturer's factory applied finish, which meets the performance requirements of AAMA 2604. Color to be selected from manufacturer's standards.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Installer shall examine substrates, supporting structure, and installation conditions.
- B. Do not proceed with panel installation until unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Metal Protection:
 - 1. Where aluminum will contact dissimilar metals, protect against galvanic action by painting contact surfaces with primer or by applying sealant or tape recommended by sealant manufacturer for this purpose.
 - 2. Where aluminum will contact concrete, masonry, or pressure treated wood, protect against corrosion by painting contact surfaces with bituminous paint or method recommended by sealant manufacturer.

3.3 INSTALLATION

- A. Install the panel system in accordance with the manufacturer's fabrication drawings and suggested installation instructions.
 - 1. Anchor component parts securely in place by permanent mechanical attachment system.
 - 2. Accommodate thermal and mechanical movements.

3. Seal aluminum clampite installation system as shown on the manufacturer's fabrication drawings and suggested installation instructions.
- B. Install joint sealants at perimeter joints and within the panel system in accordance with manufacturers fabrication drawings and suggested installation instructions.

3.5 CLEANING

- A. Clean the panel system, interior and exterior, immediately after installation.
- B. Refer to manufacturer's written recommendations.

END OF SECTION

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**SECTION 08 71 00
DOOR HARDWARE**

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes the following:
 - 1. Commercial door hardware.

1.2 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: Details of electrified door hardware, including wiring diagrams.
- C. Samples: For each exposed finish, as requested by the Architect.
- D. Other Action Submittals:
 - 1. Door Hardware Sets: Prepared by or under the supervision of an Architectural Hardware Consultant, detailing fabrication and assembly of door hardware, as well as procedures and diagrams.
 - a. Format: Scheduling sequence and format as suggested by the Door and Hardware Institute.
 - b. Content: Include the following information:
 - 1) Identification number, location, hand, fire rating, and material of each door and frame.
 - 2) Type, style, function, size, quantity, and finish of each door hardware item. Include description and function of each lockset and exit device.
 - 3) Complete designations of every item required for each door or opening including name and manufacturer.
 - 4) Description of each electrified door hardware function, including location, sequence of operation, and interface with other building control systems.
 - 2. Keying Schedule: Prepared by or under the supervision of an Architectural Hardware Consultant, detailing Owner's final keying instructions for locks.

1.3 QUALITY ASSURANCE

- A. Architectural Hardware Consultant Qualifications: A person who is currently certified by DHI as an Architectural Hardware Consultant and who is experienced in providing consulting services for door hardware installations that are comparable in material, design, and extent to that indicated for this Project.
- B. Keying Conference: Conduct conference at Project site to comply with requirements in Division 1 Section "Project Management and Coordination." Incorporate keying conference decisions into final keying schedule after reviewing door hardware keying system.
- C. Pre-installation Conference: Conduct conference at Project site.

1.4 DELIVERY, STORAGE, AND HANDLING

- A. Deliver keys and/or permanent cores to Owner by registered mail or overnight package

service.

1. Town of Frisco, Attention: Jeff Goble

1.5 COORDINATION

- A. Templates: Distribute door hardware templates for doors, frames, and other work specified to be factory prepared for installing door hardware. Check Shop Drawings of other work to confirm that adequate provisions are made for locating and installing door hardware to comply with indicated requirements.

1.6 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of door hardware that fail in materials or workmanship within specified warranty period.
 1. Warranty Period: Three years from date of Substantial Completion, except as follows:
 - a. Locksets: Five (5) years from date of Substantial Completion.
 - b. Exit Devices: Five (5) years from date of Substantial Completion.
 - c. Manual Closers: Ten (10) years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SCHEDULED DOOR HARDWARE

- A. General: Provide door hardware for each door to comply with requirements in this Section and door hardware sets indicated in Part 3 "Door Hardware Sets" Article.
 1. Door Hardware Sets: Provide quantity, item, size, finish or color indicated, and named manufacturers' products.
- B. Designations: Requirements for design, grade, function, finish, size, and other distinctive qualities of each type of door hardware are indicated in Part 3 "Door Hardware Sets" Article. Products are identified by using door hardware designations, as follows:
 1. Named Manufacturers' Products: Manufacturer and product designation are listed for each door hardware type required for the purpose of establishing minimum requirements. Manufacturers' names are abbreviated in Part 3 "Door Hardware Sets" Article.

2.2 HINGES, GENERAL

- A. Template Requirements: Except for hinges and pivots to be installed entirely (both leaves) into wood doors and frames, provide only template-produced units.
- B. Hinge Base Metal: Unless otherwise indicated, provide the following:
 1. Exterior Hinges: Steel, with steel pin.
 2. Interior Hinges: Steel, with steel pin.
 3. Hinges for Fire-Rated Assemblies: Steel, with steel pin.
- C. Non-removable Pins: Provide set screw in hinge barrel that, when tightened into a groove in hinge pin, prevents removal of pin while door is closed; for out swinging exterior doors.
- D. Fasteners: Comply with the following:

1. Machine Screws: For metal doors and frames. Install into drilled and tapped holes.
2. Wood Screws: For wood doors and frames.
3. Threaded-to-the-Head Wood Screws: For fire-rated wood doors.
4. Screws: Phillips flat-head; Finish screw heads to match surface of hinges.

2.3 HINGES

- A. Butts and Hinges: BHMA A156.1.
- B. Template Hinge Dimensions: BHMA A156.7.
- C. Manufacturers:
 1. As indicated in Part 3 "Door Hardware Sets" Article.

2.4 LOCKS AND LATCHES, GENERAL

- A. Accessibility Requirements: Provide operating devices that do not require tight grasping, pinching, or twisting of the wrist.
- B. Latches and Locks for Means of Egress Doors: Comply with NFPA 101. Latches shall not require more than 15 lbf to release the latch. Locks shall not require use of a key, tool, or special knowledge for operation.
- C. Lock Trim:
 1. Levers: As indicated in Part 3 "Door Hardware Sets" Article.
- D. Lock Throw: Comply with testing requirements for length of bolts required for labeled fire doors.
- E. Backset: 2-3/4 inches, unless otherwise indicated.
- F. Strikes: Manufacturer's standard strike with strike box for each latchbolt or lock bolt, with curved lip extended to protect frame, finished to match door hardware set.

2.5 MECHANICAL LOCKS AND LATCHES

- A. Lock Functions: Function numbers and descriptions indicated in door hardware sets comply with the following:
 1. Bored Locks: BHMA A156.2.
 2. Mortise Locks: BHMA A156.13.
 3. Interconnected Locks: BHMA A156.12.
- B. Bored Locks: BHMA A156.2; Series 4000.
 1. Manufacturers:
 - a. As indicated in Part 3 "Door Hardware Sets" Article.

2.6 LOCK CYLINDERS

- A. Standard Lock Cylinders: BHMA A156.5, Grade 1.
- B. Cylinders: Manufacturer's standard tumbler type, constructed from brass or bronze, stainless steel, or nickel silver, and complying with the following:
 1. Coordinate to match keying core requirements with Owner.

- C. Construction Keying: Comply with the following:
 - 1. Construction Master Keys: Provide cylinders with feature that permits voiding of construction keys without cylinder removal.
- D. Manufacturer: Same manufacturer as for locks and latches.

2.7 KEYING

- A. Keying System: Factory registered, complying with guidelines in BHMA A156.28, Appendix A. Incorporate decisions made in keying conference into master or grand master key system, as directed by the owner.
 - 1. Existing System: Master key or grand master key locks to Owner's existing system.
- B. Keys: Nickel silver; permanently inscribed as directed by the owner.

2.8 OPERATING TRIM

- A. Standard: BHMA A156.6.
- B. Materials: Fabricate from aluminum, brass, bronze, or stainless steel, unless otherwise indicated.
- C. Manufacturers:
 - 1. As indicated in Part 3 "Door Hardware Sets" Article.

2.9 CLOSERS

- A. Accessibility Requirements: Comply with the following maximum opening-force requirements:
 - 1. Interior, Non-Fire-Rated Hinged Doors: 5 lbf applied perpendicular to door.
 - 2. Fire Doors: Minimum opening force allowable by authorities having jurisdiction.
- B. Door Closers for Means of Egress Doors: Comply with NFPA 101. Door closers shall not require more than 30 lbf to set door in motion and not more than 15 lbf to open door to minimum required width.
- C. Size of Units: Unless otherwise indicated, comply with manufacturer's written recommendations for size of door closers depending on size of door, exposure to weather, and anticipated frequency of use. Provide factory-sized closers, adjustable to meet field conditions and requirements for opening force.
- D. Surface Closers: BHMA A156.4, Grade 1. Provide type of arm required for closer to be located on non-public side of door, unless otherwise indicated.
 - 1. Manufacturers:
 - a. As indicated in Part 3 "Door Hardware Sets" Article.

2.10 PROTECTIVE TRIM UNITS

- A. Size: 2 inches less than door width on single doors and 1 inch less than door width on pairs of doors, by height specified in door hardware sets.
- B. Metal Protective Trim Units: BHMA A156.6; beveled top and 2 sides; fabricated from the following material:
 - 1. Material: 0.050-inch- thick aluminum, brass, bronze or stainless steel, As indicated in

Part 3 "Door Hardware Sets" Article.

2. Manufacturers:
 - a. As indicated in Part 3 "Door Hardware Sets" Article.

2.11 STOPS AND HOLDERS

- A. Stops and Bumpers: BHMA A156.16, Grade 1.
 1. Provide floor stops for doors unless wall or other type stops are scheduled or indicated. Do not mount floor stops where they will impede traffic. Where floor or wall stops are not appropriate, provide overhead holders.
- B. Mechanical Door Holders: BHMA A156.16, Grade 1.
- C. Combination Floor and Wall Stops and Holders: BHMA A156.8, Grade 1.
- D. Combination Overhead Stops and Holders: BHMA A156.8, Grade 1.
- E. Silencers for Door Frames: BHMA A156.16, Grade 1; neoprene or rubber; fabricated for drilled-in application to frame.
- F. Manufacturers:
 1. As indicated in Part 3 "Door Hardware Sets" Article.

2.12 DOOR GASKETING

- A. Standard: BHMA A156.22.
- B. General: Provide continuous weather-strip gasketing on exterior doors and provide smoke, light, or sound gasketing on interior doors where indicated or scheduled. Provide noncorrosive fasteners for exterior applications and elsewhere as indicated.
 1. Perimeter Gasketing: Apply to head and jamb, forming seal between door and frame.
 2. Meeting Stile Gasketing: Fasten to meeting stiles, forming seal when doors are closed.
 3. Door Bottoms: Apply to bottom of door, forming seal with threshold when door is closed.
- C. Smoke-Labeled Gasketing: Assemblies complying with NFPA 105 that are listed and labeled by a testing and inspecting agency acceptable to authorities having jurisdiction, for smoke-control ratings indicated, based on testing according to UL 1784.
 1. Provide smoke-labeled gasketing on 20-minute-rated doors and on smoke-labeled doors.
- D. Sound-Rated Gasketing: Assemblies that are listed and labeled by a testing and inspecting agency, for sound ratings indicated, based on testing according to ASTM E 1408.
- E. Replaceable Seal Strips: Provide only those units where resilient or flexible seal strips are easily replaceable and readily available from stocks maintained by manufacturer.
- F. Gasketing Materials: ASTM D 2000 and AAMA 701/702.
- G. Manufacturers:
 1. As indicated in Part 3 "Door Hardware Sets" Article.

2.13 THRESHOLDS

- A. Standard: BHMA A156.21.
- B. Accessibility Requirements: Bevel raised thresholds with a slope of not more than 1:2. Provide thresholds not more than 1/2 inch high.
- C. Thresholds for Means of Egress Doors: Comply with NFPA 101. Maximum 1/2 inch high.
- D. Manufacturers:
 - 1. As indicated in Part 3 "Door Hardware Sets" Article.

2.14 FABRICATION

- A. Base Metals: Produce door hardware units of base metal, fabricated by forming method indicated, using manufacturer's standard metal alloy, composition, temper, and hardness. Furnish metals of a quality equal to or greater than that of specified door hardware units and BHMA A156.18. Do not furnish manufacturer's standard materials or forming methods if different from specified standard.
- B. Fasteners: Provide screws according to commercially recognized industry standards for application intended, except aluminum fasteners are not permitted. Provide Phillips flat-head screws with finished heads to match surface of door hardware, unless otherwise indicated.
 - 1. Comply with NFPA 80 for fasteners of door hardware in fire-rated applications.
- C. Finishes: BHMA A156.18, as indicated in door hardware sets.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Steel Doors and Frames: Comply with DHI A115 Series. Drill and tap doors and frames for surface-applied door hardware according to ANSI A250.6.
- B. Wood Doors: Comply with DHI A115-W Series.
- C. Mounting Heights: Mount door hardware units at heights indicated as follows unless otherwise indicated or required to comply with governing regulations.
 - 1. Standard Steel Doors and Frames: DHI's "Recommended Locations for Architectural Hardware for Standard Steel Doors and Frames."
 - 2. Custom Steel Doors and Frames: DHI's "Recommended Locations for Builders' Hardware for Custom Steel Doors and Frames."
 - 3. Wood Doors: DHI WDHS.3, "Recommended Locations for Architectural Hardware for Wood Flush Doors."
- D. Install each door hardware item to comply with manufacturer's written instructions. Where cutting and fitting are required to install door hardware onto or into surfaces that are later to be painted or finished in another way, coordinate removal, storage, and reinstallation of surface protective trim units with finishing work specified in Division 9 Sections. Do not install surface-mounted items until finishes have been completed on substrates involved.
- E. Thresholds: Set thresholds for exterior and acoustical doors in full bed of sealant complying with requirements specified in Division 7 Section "Joint Sealants."

- F. Adjustment: Adjust and check each operating item of door hardware and each door to ensure proper operation or function of every unit. Replace units that cannot be adjusted to operate as intended. Adjust door control devices to compensate for final operation of heating and ventilating equipment and to comply with referenced accessibility requirements.
1. Door Closers: Unless otherwise required by authorities having jurisdiction, adjust sweep period so that, from an open position of 70 degrees, the door will take at least 3 seconds to move to a point 3 inches from the latch, measured to the leading edge of the door.

3.2 DOOR HARDWARE SETS

- A. Manufacturers: The following manufacturers are approved subject to compliance with requirements of the Contract Documents. Approval of manufacturers other than those listed shall be in accordance with Division 1.

<u>Item:</u>	<u>Manufacturer:</u>	<u>Approved:</u>
Hinges	Stanley	Hager, McKinney, Ives
Locksets & Cylinders	Schlage	Best, Sargent (Verify with Owner)
Closers	Stanley	LCN 4041, Norton 7500
Protection Plates	Trimco	Hager, Rockwood
Threshold & Gasketing	Pemko	National Guard, Hager

- B. Manufacturer's Abbreviations:

1. PE Pemko
2. SC Schlage
3. ST Stanley
4. TR Trimco

- C. General Hardware Installation Notes:

1. Designations used in Hardware Sets and elsewhere to indicate hardware finishes are those listed in ANSI/BHMA A156.18 including coordination with traditional U.S. finishes shown by certain manufacturers for their products.
2. Powder coat door closers to match other hardware, unless otherwise noted.
3. Furnish all brackets required to mount closers, as required by frame or door details.

- D. Hardware Set #1

3	Hinges	FB191 4 1/2 X 4 1/2	630	ST
1	Lockset	LV9080P 06N 10-072	630	SC
1	Kick Plate	KO050 12" x 2" LDW B4E CSK	630	TR
1	Door Closer/Stop	D-4550 Cush-Stop	689	ST
1	Set Seals	303 CS		PE
1	Threshold	1717 A		PE
1	Door Bottom	315 D		PE
1	Rain Drip	346 D		PE

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SECTION 08 80 00
GLAZING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes glazing for the following products and applications, including those specified in other Sections where glazing requirements are specified by reference to this Section:
 - 1. Windows.
 - a. Doors.

1.2 PRECONSTRUCTION TESTING

- A. Preconstruction Adhesion and Compatibility Testing: Test each glazing material type, tape sealant, gasket, glazing accessory, and glass-framing member for adhesion to and compatibility with elastomeric glazing sealants.
 - 1. Testing will not be required if data are submitted based on previous testing of current sealant products and glazing materials matching those submitted.

1.3 SUBMITTALS

- A. Product Data: For each glass product and glazing material indicated.
- B. Glazing Schedule: List glass types and thicknesses for each size opening and location. Use same designations indicated on Drawings.
- C. Preconstruction adhesion and compatibility test report.

1.4 QUALITY ASSURANCE

- A. Glazing Publications: Comply with published recommendations of glass product manufacturers and organizations below, unless more stringent requirements are indicated. Refer to these publications for glazing terms not otherwise defined in this Section or in referenced standards.
 - 1. IGMA Publication for Insulating Glass: SIGMA TM-3000, "North American Glazing Guidelines for Sealed Insulating Glass Units for Commercial and Residential Use."
- B. Safety Glazing Labeling: Where safety glazing labeling is indicated, permanently mark glazing with certification label of the SGCC or another certification agency acceptable to authorities having jurisdiction. Label shall indicate manufacturer's name, type of glass, thickness, and safety glazing standard with which glass complies.
- C. Fire-Protection-Rated Glazing Labeling: Permanently mark fire-protection-rated glazing with certification label of a testing agency acceptable to authorities having jurisdiction. Label shall indicate manufacturer's name, test standard, whether glazing is for use in fire doors or other openings, whether or not glazing passes hose-stream test, whether or not glazing has

- a temperature rise rating of 450 deg F (250 deg C), and the fire-resistance rating in minutes.
- D. Insulating-Glass Certification Program: Permanently marked either on spacers or on at least one component lite of units with appropriate certification label of IGCC.

1.5 WARRANTY

- A. Manufacturer's Special Warranty on Insulating Glass: Manufacturer's standard form in which insulating-glass manufacturer agrees to replace insulating-glass units that deteriorate within specified warranty period. Deterioration of insulating glass is defined as failure of hermetic seal under normal use that is not attributed to glass breakage or to maintaining and cleaning insulating glass contrary to manufacturer's written instructions. Evidence of failure is the obstruction of vision by dust, moisture, or film on interior surfaces of glass.
1. Warranty Period: 10 years from date of Substantial Completion.
- B. Manufacturer's Special Warranty for Coated-Glass Products: Manufacturer's standard form in which coated-glass manufacturer agrees to replace coated-glass units that deteriorate within specified warranty period. Deterioration of coated glass is defined as defects developed from normal use that are not attributed to glass breakage or to maintaining and cleaning coated glass contrary to manufacturer's written instructions. Defects include peeling, cracking, and other indications of deterioration in coating.
1. Warranty Period: 10 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 GLASS PRODUCTS, GENERAL

- A. Thickness: Where glass thickness is indicated, it is a minimum. Provide glass lites in thicknesses as needed to comply with requirements indicated.
- B. Strength: Where float glass is indicated, provide annealed float glass, Kind HS heat-treated float glass, or Kind FT heat-treated float glass. Where heat-strengthened glass is indicated, provide Kind HS heat-treated float glass or Kind FT heat-treated float glass. Where fully tempered glass is indicated, provide Kind FT heat-treated float glass.
- C. Windborne-Debris-Impact Resistance: Provide exterior glazing that passes basic protection testing requirements in ASTM E 1996 for Wind Zone 1 when tested according to ASTM E 1886. Test specimens shall be no smaller in width and length than glazing indicated for use on the Project and shall be installed in same manner as glazing indicated for use on the Project.
1. Large-Missile Test: For glazing located within 30 feet (9.1 m) of grade.
- a. Small-Missile Test: For glazing located more than 30 feet (9.1 m) above grade.
- D. Thermal and Optical Performance Properties: Provide glass with performance properties specified, as indicated in manufacturer's published test data, based on procedures indicated below:
1. U-Factors: Center-of-glazing values, according to NFRC 100 and based on LBL's

WINDOW 5.2 computer program, expressed as Btu/sq. ft. x h x deg F (W/sq. m x K).

- a. Solar Heat-Gain Coefficient and Visible Transmittance: Center-of-glazing values, according to NFRC 200 and based on LBL's WINDOW 5.2 computer program.
- b. Visible Reflectance: Center-of-glazing values, according to NFRC 300.

2.2 GLASS PRODUCTS

- A. Float Glass: ASTM C 1036, Type I, Quality-Q3, Class I (clear) unless otherwise indicated.
- B. Heat-Treated Float Glass: ASTM C 1048; Type I; Quality-Q3; Class I (clear) unless otherwise indicated; of kind and condition indicated.
 1. Fabrication Process: By horizontal (roller-hearth) process with roll-wave distortion parallel to bottom edge of glass as installed, unless otherwise indicated.
 - a. Provide Kind HS (heat-strengthened) float glass in place of annealed float glass where needed to resist thermal stresses induced by differential shading of individual glass lites and to comply with glass design requirements specified in Part 1 "Performance Requirements" Article.
 - b. For uncoated glass, comply with requirements for Condition A.
 - c. For coated vision glass, comply with requirements for Condition C (other uncoated glass).
 - d. Provide Kind FT (fully tempered) float glass in place of annealed or Kind HS (heat-strengthened) float glass where safety glass is indicated.
- C. Pyrolytic-Coated Float Glass: ASTM C 1376, float glass with metallic-oxide coating applied by pyrolytic deposition process during initial manufacture, and complying with other requirements specified.
- D. Uncoated Tinted Float Glass: Class 2, complying with other requirements specified.
 1. Tint Color: Gray

2.3 INSULATING GLASS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 1. Viracon, Inc.; Viracon Solarscreen Low-E (VE)
 - a. PPG Industries, Inc.; Solarban 60 Solar Control Low-E
 - b. Pilkington North America; Eclipse Advantage Low-E
- B. Insulating-Glass Units: Factory-assembled units consisting of sealed lites of glass separated by a dehydrated interspace, qualified according to ASTM E 2190, and complying with other requirements specified.
 1. Sealing System: Dual seal.

- a. Spacer: Manufacturer's standard spacer material and construction

2.4 GLAZING GASKETS

- A. Dense Compression Gaskets: Molded or extruded gaskets of profile and hardness required to maintain watertight seal, made from the following:
 - 1. EPDM complying with ASTM C 864.
 - 2. Silicone complying with ASTM C 1115.
 - 3. Thermoplastic polyolefin rubber complying with ASTM C 1115.
- B. Soft Compression Gaskets: Extruded or molded, closed-cell, integral-skinned EPDM, silicone or thermoplastic polyolefin rubber gaskets complying with ASTM C 509, Type II, black; of profile and hardness required to maintain watertight seal.
 - 1. Application: Use where soft compression gaskets will be compressed by inserting dense compression gaskets on opposite side of glazing or pressure applied by means of pressure-glazing stops on opposite side of glazing.

2.5 GLAZING SEALANTS

- A. General:
 - 1. Compatibility: Provide glazing sealants that are compatible with one another and with other materials they will contact, including glass products, seals of insulating-glass units, and glazing channel substrates, under conditions of service and application, as demonstrated by sealant manufacturer based on testing and field experience.
 - a. Suitability: Comply with sealant and glass manufacturers' written instructions for selecting glazing sealants suitable for applications indicated and for conditions existing at time of installation.
 - b. Colors of Exposed Glazing Sealants: Match adjacent surface.
- B. Glazing Sealants for Fire-Rated Glazing Products: Products that are approved by testing agencies that listed and labeled fire-resistant glazing products with which they are used for applications and fire-protection ratings indicated.

2.6 GLAZING TAPES

- A. Back-Bedding Mastic Glazing Tapes: Preformed, butyl-based, 100 percent solids elastomeric tape; nonstaining and nonmigrating in contact with nonporous surfaces; with or without spacer rod as recommended in writing by tape and glass manufacturers for application indicated; and complying with ASTM C 1281 and AAMA 800 for products indicated below:
 - 1. AAMA 807.3 tape, for glazing applications in which tape is not subject to continuous pressure.

2.7 MISCELLANEOUS GLAZING MATERIALS

- A. Cleaners, Primers, and Sealers: Types recommended by sealant or gasket manufacturer.
- B. Setting Blocks: Elastomeric material with a Shore, Type A durometer hardness of 85, plus or minus 5.
- C. Spacers: Elastomeric blocks or continuous extrusions of hardness required by glass manufacturer to maintain glass lites in place for installation indicated.
- D. Edge Blocks: Elastomeric material of hardness needed to limit glass lateral movement (side walking).
- E. Cylindrical Glazing Sealant Backing: ASTM C 1330, Type O (open-cell material), of size and density to control glazing sealant depth and otherwise produce optimum glazing sealant performance.
- F. Perimeter Insulation for Fire-Resistive Glazing: Product that is approved by testing agency that listed and labeled fire-resistant glazing product with which it is used for application and fire-protection rating indicated.

2.8 MONOLITHIC-GLASS TYPES

- A. Glass Type GL-1: Fire Rated safety glazing.
 - 1. Type: Pilkington Pyrostop, 60 minute rated
 - a. Thickness: 7/8" inch

2.9 INSULATING-GLASS TYPES

- A. Glass Type GL-2: Low-e-coated, tinted insulating security glass.
 - 1. Overall Unit Thickness: 1 inch (25 mm)
 - a. Thickness of Each Glass Lite: ¼ inch (6.0 mm)
 - b. Outdoor Lite: Tinted heat-strengthened float glass or tinted fully tempered float glass as indicated in the drawings.
 - c. Interspace Content: Air
 - d. Outdoor Lite Wire: Diamond polished.
 - e. Indoor Lite: Heat-strengthened float glass or fully tempered float glass as indicated in the drawings.
 - f. Low-E Coating: Sputtered or pyrolytic on third surface.
 - g. Visible Light Transmittance: 40 percent minimum.
 - h. Winter Nighttime U-Factor: .31 maximum.
 - i. Summer Daytime U-Factor: .32 maximum.
 - j. Solar Heat Gain Coefficient: .39 maximum.
 - k. Provide safety glazing labeling at locations indicated in the drawings

PART 3 - EXECUTION

3.1 GLAZING, GENERAL

- A. Comply with combined written instructions of manufacturers of glass, sealants, gaskets, and other glazing materials, unless more stringent requirements are indicated, including those in referenced glazing publications.

- B. Adjust glazing channel dimensions as required by Project conditions during installation to provide necessary bite on glass, minimum edge and face clearances, and adequate sealant thicknesses, with reasonable tolerances.
- C. Protect glass edges from damage during handling and installation. Remove damaged glass from Project site and legally dispose of off Project site. Damaged glass is glass with edge damage or other imperfections that, when installed, could weaken glass and impair performance and appearance.
- D. Apply primers to joint surfaces where required for adhesion of sealants, as determined by preconstruction testing.
- E. Install setting blocks in sill rabbets, sized and located to comply with referenced glazing publications, unless otherwise required by glass manufacturer. Set blocks in thin course of compatible sealant suitable for heel bead.
- F. Do not exceed edge pressures stipulated by glass manufacturers for installing glass lites.
- G. Provide spacers for glass lites where length plus width is larger than 50 inches (1270 mm).
- H. Provide edge blocking where indicated or needed to prevent glass lites from moving sideways in glazing channel, as recommended in writing by glass manufacturer and according to requirements in referenced glazing publications.

3.2 TAPE GLAZING

- A. Position tapes on fixed stops so that, when compressed by glass, their exposed edges are flush with or protrude slightly above sightline of stops.
- B. Install tapes continuously, but not necessarily in one continuous length. Do not stretch tapes to make them fit opening.
- C. Cover vertical framing joints by applying tapes to heads and sills first and then to jambs. Cover horizontal framing joints by applying tapes to jambs and then to heads and sills.
- D. Place joints in tapes at corners of opening with adjoining lengths butted together, not lapped. Seal joints in tapes with compatible sealant approved by tape manufacturer.
- E. Apply heel bead of elastomeric sealant.
- F. Center glass lites in openings on setting blocks and press firmly against tape by inserting dense compression gaskets formed and installed to lock in place against faces of removable stops. Start gasket applications at corners and work toward centers of openings.
- G. Apply cap bead of elastomeric sealant over exposed edge of tape.

3.3 GASKET GLAZING (DRY)

- A. Cut compression gaskets to lengths recommended by gasket manufacturer to fit openings exactly, with allowance for stretch during installation.
- B. Insert soft compression gasket between glass and frame or fixed stop so it is securely in place with joints miter cut and bonded together at corners.
- C. Installation with Drive-in Wedge Gaskets: Center glass lites in openings on setting blocks and press firmly against soft compression gasket by inserting dense compression gaskets formed and installed to lock in place against faces of removable stops. Start gasket applications at corners and work toward centers of openings. Compress gaskets to produce a weathertight seal without developing bending stresses in glass. Seal gasket joints with sealant recommended by gasket manufacturer.
- D. Installation with Pressure-Glazing Stops: Center glass lites in openings on setting blocks and press firmly against soft compression gasket. Install dense compression gaskets and

pressure-glazing stops, applying pressure uniformly to compression gaskets. Compress gaskets to produce a weathertight seal without developing bending stresses in glass. Seal gasket joints with sealant recommended by gasket manufacturer.

- E. Install gaskets so they protrude past face of glazing stops.

3.4 SEALANT GLAZING (WET)

- A. Install continuous spacers, or spacers combined with cylindrical sealant backing, between glass lites and glazing stops to maintain glass face clearances and to prevent sealant from extruding into glass channel and blocking weep systems until sealants cure. Secure spacers or spacers and backings in place and in position to control depth of installed sealant relative to edge clearance for optimum sealant performance.
- B. Force sealants into glazing channels to eliminate voids and to ensure complete wetting or bond of sealant to glass and channel surfaces.
- C. Tool exposed surfaces of sealants to provide a substantial wash away from glass.

3.5 CLEANING AND PROTECTION

- A. Protect exterior glass from damage immediately after installation by attaching crossed streamers to framing held away from glass. Do not apply markers to glass surface. Remove nonpermanent labels and clean surfaces.
- B. Protect glass from contact with contaminating substances resulting from construction operations. If, despite such protection, contaminating substances do come into contact with glass, remove substances immediately as recommended in writing by glass manufacturer.
- C. Examine glass surfaces adjacent to or below exterior concrete and other masonry surfaces at frequent intervals during construction, but not less than once a month, for buildup of dirt, scum, alkaline deposits, or stains; remove as recommended in writing by glass manufacturer.
- D. Remove and replace glass that is broken, chipped, cracked, or abraded or that is damaged from natural causes, accidents, and vandalism, during construction period.

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SECTION 09 22 16
NON-STRUCTURAL METAL FRAMING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Non-load-bearing steel framing systems for interior gypsum board assemblies.
2. Suspension systems for interior gypsum ceilings and soffits.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Fire-Test-Response Characteristics:** Provide materials and construction identical to those tested according to ASTM E 119.
- B. STC-Rated Assemblies:** Provide materials and construction identical to those tested in assembly indicated according to ASTM E 90 and classified according to ASTM E 413.

2.2 FRAMING SYSTEMS

- A. Steel Studs and Runners:** ASTM C 645. Use either steel studs and runners or dimpled steel studs and runners of equivalent minimum base-metal thickness.
1. Minimum Base-Metal Thickness: 0.018 inch minimum.
 2. Depth: As indicated on Drawings
- B. Slip-Type Head Joints:** Where indicated, provide one of the following in thickness not less than indicated for studs and in width to accommodate depth of studs:
1. Double-Runner System: ASTM C 645 top runners, inside runner with 2-inch-deep flanges and fastened to studs, and outer runner sized to friction fit inside runner.
 2. Deflection Track: Steel sheet top runner manufactured to prevent cracking of finishes due to deflection of structure above.

- a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - 1) Dietrich Metal Framing; SLP-TRK Slotted Deflection Track.
 - 2) MBA Building Supplies; Slotted Deflecto Track.
 - 3) Steel Network Inc. (The); VertiTrack VTD Series.
 - 4) Superior Metal Trim; Superior Flex Track System (SFT).
 - 5) Telling Industries; Vertical Slip Track
- C. Firestop Tracks: Manufactured to allow partition heads to expand and contract with movement of the structure while maintaining continuity of fire-resistance-rated assembly indicated; in thickness not less than indicated for studs and in width to accommodate depth of studs.
 - 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Fire Trak Corp.; Fire Trak System attached to studs with Fire Trak Posi Klip.
 - b. Grace Construction Products; FlameSafe FlowTrak System.
 - c. Metal-Lite, Inc.; The System.
- D. Flat Strap and Backing Plate: Steel sheet for blocking and bracing in length and width indicated.
 - 1. Minimum Base-Metal Thickness: 0.018 inch
- E. Cold-Rolled Channel Bridging: Steel, 0.053-inch minimum base-metal thickness, with minimum 1/2-inch-wide flanges.
 - 1. Depth: 1-1/2 inches
 - 2. Clip Angle: Not less than 1-1/2 by 1-1/2 inches, 0.068-inch-thick, galvanized steel.
- F. Hat-Shaped, Rigid Furring Channels: ASTM C 645.
 - 1. Minimum Base-Metal Thickness: 0.033 inch.
 - 2. Depth: 7/8 inch
- G. Cold-Rolled Furring Channels: 0.053-inch uncoated-steel thickness, with minimum 1/2-inch-wide flanges.
 - 1. Depth: As indicated on Drawings
 - 2. Furring Brackets: Adjustable, corrugated-edge type of steel sheet with minimum uncoated-steel thickness of 0.033 inch.
 - 3. Tie Wire: ASTM A 641/A 641M, Class 1 zinc coating, soft temper, 0.062-inch- diameter wire, or double strand of 0.048-inch-diameter wire.

2.3 SUSPENSION SYSTEMS

- A. Tie Wire: ASTM A 641/A 641M, Class 1 zinc coating, soft temper, 0.062-inch- diameter wire, or double strand of 0.048-inch-diameter wire.
- B. Hanger Attachments to Concrete:
 - 1. Anchors: Capable of sustaining a load equal to 5 times that imposed as determined by ASTM E 488.
 - a. Type: Postinstalled, expansion anchor.
 - 2. Powder-Actuated Fasteners: Capable of sustaining, a load equal to 10 times that imposed as determined by ASTM E 1190.
- C. Wire Hangers: ASTM A 641/A 641M, Class 1 zinc coating, soft temper, 0.16 inch in diameter.
- D. Flat Hangers: Steel sheet, 1 by 3/16 inch by length indicated
- E. Carrying Channels: Cold-rolled, commercial-steel sheet with a base-metal thickness of 0.053 inch and minimum 1/2-inch-wide flanges.
 - 1. Depth: 2-1/2 inches
- F. Furring Channels (Furring Members):
 - 1. Cold-Rolled Channels: 0.053-inch uncoated-steel thickness, with minimum 1/2-inch wide flanges, 3/4 inch deep.
 - 2. Steel Studs and Runners: ASTM C 645. Use either steel studs and runners or dimpled steel studs and runners of equivalent minimum base-metal thickness.
 - a. Minimum Base-Metal Thickness: 0.018 inch
 - b. Depth: As indicated on Drawings
 - 3. Hat-Shaped, Rigid Furring Channels: ASTM C 645, 7/8 inch deep.
 - a. Minimum Base-Metal Thickness: 0.018 inch

2.4 AUXILIARY MATERIALS

- A. Fasteners for Metal Framing: Of type, material, size, corrosion resistance, holding power, and other properties required to fasten steel members to substrates.
- B. Isolation Strip at Exterior Walls: Provide asphalt saturated organic felt or foam gasket.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

- A. Installation Standard: ASTM C 754.
 - 1. Gypsum Board Assemblies: Also comply with requirements in ASTM C 840 that apply to framing installation.
- B. Install supplementary framing, and blocking to support fixtures, equipment services, heavy trim, grab bars, toilet accessories, furnishings, or similar construction.
- C. Install bracing at terminations in assemblies.
- D. Do not bridge building control and expansion joints with non-load-bearing steel framing members. Frame both sides of joints independently.

3.2 INSTALLING FRAMED ASSEMBLIES

- A. Install framing system components according to spacings indicated, but not greater than spacings required by referenced installation standards for assembly types.
- B. Where studs are installed directly against exterior masonry walls or dissimilar metals at exterior walls, install isolation strip between studs and exterior wall.
- C. Install studs so flanges within framing system point in same direction.
- D. Install tracks (runners) at floors and overhead supports. Extend framing full height to structural supports or substrates above suspended ceilings, except where partitions are indicated to terminate at suspended ceilings. Continue framing around ducts penetrating partitions above ceiling.
 - 1. Slip-Type Head Joints: Where framing extends to overhead structural supports, install to produce joints at tops of framing systems that prevent axial loading of finished assemblies.
 - 2. Door Openings: Screw vertical studs at jambs to jamb anchor clips on door frames; install runner track section (for cripple studs) at head and secure to jamb studs.
 - a. Install two studs at each jamb unless otherwise indicated.
 - b. Install cripple studs at head adjacent to each jamb stud, with a minimum 1/2-inch clearance from jamb stud to allow for installation of control joint in finished assembly.
 - c. Extend jamb studs through suspended ceilings and attach to underside of overhead structure.

3. Other Framed Openings: Frame openings other than door openings the same as required for door openings unless otherwise indicated. Install framing below sills of openings to match framing required above door heads.
4. Fire-Resistance-Rated Partitions: Install framing to comply with fire-resistance-rated assembly indicated and support closures and to make partitions continuous from floor to underside of solid structure.
 - a. Firestop Track: Where indicated, install to maintain continuity of fire-resistance-rated assembly indicated.
5. Sound-Rated Partitions: Install framing to comply with sound-rated assembly indicated.
6. Curved Partitions:
 - a. Bend track to uniform curve and locate straight lengths so they are tangent to arcs.
 - b. Begin and end each arc with a stud, and space intermediate studs equally along arcs. On straight lengths of no fewer than two studs at ends of arcs, place studs 6 inches o.c.

E. Direct Furring:

1. Screw to wood framing.
2. Attach to concrete or masonry with stub nails, screws designed for masonry attachment, or powder-driven fasteners spaced 24 inches o.c.

F. Installation Tolerance: Install each framing member so fastening surfaces vary not more than 1/8 inch from the plane formed by faces of adjacent framing.

3.3 INSTALLING SUSPENSION SYSTEMS

- A. Install suspension system components according to spacings indicated, but not greater than spacings required by referenced installation standards for assembly types.
- B. Isolate suspension systems from building structure where they abut or are penetrated by building structure to prevent transfer of loading imposed by structural movement.

- C. Suspend hangers from building structure as follows:
1. Install hangers plumb and free from contact with insulation or other objects within ceiling plenum that are not part of supporting structural or suspension system.
 - a. Splay hangers only where required to miss obstructions and offset resulting horizontal forces by bracing, countersplaying, or other equally effective means.
 2. Where width of ducts and other construction within ceiling plenum produces hanger spacings that interfere with locations of hangers, install supplemental suspension members and hangers in the form of trapezes or equivalent devices.
 3. Do not attach hangers to steel roof deck.
 4. Do not attach hangers to permanent metal forms. Furnish cast-in-place hanger inserts that extend through forms.
 5. Do not attach hangers to rolled-in hanger tabs of composite steel floor deck.
 6. Do not connect or suspend steel framing from ducts, pipes, or conduit.
- D. Fire-Resistance-Rated Assemblies: Wire tie furring channels to supports.
- E. Installation Tolerances: Install suspension systems that are level to within 1/8 inch in 12 feet measured lengthwise on each member that will receive finishes and transversely between parallel members that will receive finishes.

END OF SECTION

**SECTION 09 29 00
GYPSUM BOARD**

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Interior gypsum board.
 - 2. Texture finishes.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Fire-Resistance-Rated Assemblies: For fire-resistance-rated assemblies, provide materials and construction identical to those tested in assembly indicated according to ASTM E 119 by an independent testing agency.
- B. STC-Rated Assemblies: For STC-rated assemblies, provide materials and construction identical to those tested in assembly indicated according to ASTM E 90 and classified according to ASTM E 413 by an independent testing agency.

2.2 INTERIOR GYPSUM BOARD

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. American Gypsum.
 - 2. Georgia-Pacific Gypsum LLC.
 - 3. National Gypsum Company.
 - 4. USG Corporation.

- B. Moisture- and Mold-Resistant Gypsum Board: ASTM C 1396/C 1396M. With moisture- and mold-resistant core and paper surfaces.

- 1. Core: 5/8 inch (15.9 mm), Type X.
- 2. Long Edges: Tapered.
- 3. Mold Resistance: ASTM D 3273, score of 10.

2.3 TRIM ACCESSORIES

- A. Interior Trim: ASTM C 1047.

- 1. Material: Galvanized or aluminum-coated steel sheet or rolled zinc.

- B. Aluminum Trim: ASTM B 221 (ASTM B 221M), Alloy 6063-T5.

2.4 JOINT TREATMENT MATERIALS

- A. General: Comply with ASTM C 475/C 475M.

- B. Joint Tape:

- 1. Interior Gypsum Board: Paper.

- C. Joint Compound for Interior Gypsum Board: For each coat use formulation that is compatible with other compounds applied on previous or for successive coats.

2.5 AUXILIARY MATERIALS

- A. Laminating Adhesive: Adhesive or joint compound recommended for directly adhering gypsum panels to continuous substrate.

- B. Steel Drill Screws: ASTM C 1002, unless otherwise indicated.

- C. Acoustical Joint Sealant: ASTM C 834. Product effectively reduces airborne sound transmission through perimeter joints and openings as demonstrated by testing according to ASTM E 90.

- 1. Products: Subject to compliance with requirements, provide one of the following:

- a. Accumetric LLC; BOSS 824 Acoustical Sound Sealant.
- b. Grabber Construction Products; Acoustical Sealant GSC.
- c. Specified Technologies, Inc.; Smoke N Sound Acoustical Sealant.
- d. USG Corporation; SHEETROCK Acoustical Sealant.

- D. Thermal Insulation: As specified in Division 07 Section "Thermal Insulation."

2.6 TEXTURE FINISHES

- A. Primer: As recommended by textured finish manufacturer.
- B. Non-Aggregate Finish: Premixed vinyl texture finish for spray application.
 - 1. Products: Subject to compliance with requirements, available products that may be incorporated into the work include, but are not limited to the following:
 - a. CertainTeed Corp.; Pro Roc Easi-Tex Spray Texture
 - b. USG Corporation; BEADX FasTex Wall & Ceiling Spray Texture
 - 2. Texture: Orange Peel

PART 3 - EXECUTION

3.1 APPLYING AND FINISHING PANELS

- A. Comply with ASTM C 840.
- B. Examine panels before installation. Reject panels that are wet, moisture damaged, and mold damaged.
- C. Isolate perimeter of gypsum board applied to non-load-bearing partitions at structural abutments, except floors. Provide 1/4- to 1/2-inch- (6.4- to 12.7-mm-) wide spaces at these locations and trim edges with edge trim where edges of panels are exposed. Seal joints between edges and abutting structural surfaces with acoustical sealant.
- D. Install trim with back flanges intended for fasteners, attach to framing with same fasteners used for panels. Otherwise, attach trim according to manufacturer's written instructions.
 - 1. Aluminum Trim: Install in locations indicated on Drawings.
 - 2. Control Joints: Install control joints at locations indicated on Drawings and according to ASTM C 840 and in specific locations approved by Architect for visual effect.
- E. Prefill open joints, rounded or beveled edges, and damaged surface areas.
- F. Apply joint tape over gypsum board joints, except for trim products specifically indicated as not intended to receive tape.
- G. Gypsum Board Finish Levels: Finish panels to levels indicated below and according to ASTM C 840:
 - 1. Level 2: Ceiling plenum areas, concealed areas, and where indicated.
 - 2. Level 5: Exposed walls and ceilings.

- H. Texture Finish Application: Prepare and apply primer to gypsum panels and other surfaces receiving texture finishes. Mix and apply finish using powered spray equipment, to produce a uniform texture matching approved mockup and free of starved spots or other evidence of thin application or of application patterns.
- I. Protect adjacent surfaces from drywall compound and texture finishes and promptly remove from floors and other non-drywall surfaces. Repair surfaces stained, marred, or otherwise damaged during drywall application.
- J. Remove and replace panels that are wet, moisture damaged, and mold damaged.

END OF SECTION

SECTION 09 90 00
PAINTING AND PROTECTIVE COATINGS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes coating and painting systems for concrete, ferrous metals, steel, and other materials. Coating systems include surface preparation, shop priming, field priming, and/or coating, cleaning, inspecting, and touch-up. Coating systems for Architectural systems are not included in this section, refer to Section 09 91 20.
- B. Coating system schedules and finish schedules may be provided herein and/or on the Contract Drawings, which identify specific coating systems and paint colors to be used. However, these schedules do not necessarily cover all items to be coated. Where the selection of a specific Coating system for a particular application is not clear, it shall be the responsibility of the Contractor to request clarification from the Owner/Engineer.
- C. In general, and unless otherwise specifically noted, items to be coated include:
 - 1. Prime coats which may be applied in shop under other sections.
 - 2. Prime Coating unprimed surfaces to be coated under this Section.
 - 3. Coating items furnished with a prime coat of paint, including touching up of or repairing of abraded, damaged, or rusted prime coats applied by others.
 - 4. Coating pipes, concrete-encased pipes, pipe coverings, supports, and other mechanical equipment.
 - 5. Coating surfaces above, behind or below grilles, gratings, diffusers, louvers lighting fixtures, and the like, which are exposed to view through these items.
 - 6. Coating includes coatings specified and striping or markers and identity markings.
 - 7. Incidental Coating and touching up as required to produce proper finish for coated surfaces, including touching up of factory finished items.
 - 8. Incidental Coating of existing items, including but not limited to, concrete, piping, fittings, supports, or equipment, for which existing coating(s) may be damaged or affected by demolition or installation of items within this scope of work, or at the transition of existing components to new components.
 - 9. Coating of any surface not specifically mentioned to be coated herein or on construction documents, but for which Coating is obviously necessary to complete the job, or work which comes within the intent of these specifications, is to be included as though specified.
- D. In general, and unless otherwise specifically noted, items NOT to be coated include:
 - 1. Items with Owner/Engineer approved factory finish.
 - 2. Thermoplastic; aluminum, excluding aluminum in contact with concrete or dissimilar metals; galvanized metals; stainless steel; or FRP grating, plates, valves, fittings, and conduit or piping, unless otherwise noted.
 - 3. Certifying labels and equipment identification/rating nameplates.
 - 4. Sidewalks, mow strips, equipment pads.
 - 5. Exterior concrete walkways and floors.
 - 6. Interior concrete walkways and floors, unless otherwise noted.

E. Related Requirements:

1. Section 05 50 00 – Miscellaneous Metal Fabrications.
2. Section 08 11 13 - Hollow Metal Doors and Frames.
3. Section 09 91 20 – Painting (for use on architectural construction)
4. Section 40 05 07 - Hangers and Supports for Process Piping.
5. Section 40 05 19 – Piping System, Ductile Iron Process Pipe.
6. Section 40 05 24 - Piping System, Steel Process Pipe.
7. Section 40 05 97 - Identification for Process Piping and Equipment.
8. Section 43 31 13.13 – Activated Carbon Liquid Purification Filters

F. Definitions:

1. Dry Film Thickness (DFT): Thickness of a coat of paint in fully cured state measures in mills (1/1000 inch).
2. Submerged:
 - a. Less than one foot above the maximum liquid surface of water holding structures.
 - b. Below top of channels, under cover of slabs of channels or tanks.
 - c. In other damp or covered locations (e.g., vaults, wetwells, utility corridors, etc.)
3. Exposed: Exposed to the atmosphere (not buried, submerged, wetted, or embedded).
4. Volatile Organic Compound (VOC): Content of air polluting hydrocarbons in uncured coating product measured in units of grams per liter or pounds per gallon as determined by EPA Method 24.
5. Ferrous: Cast iron, ductile iron, wrought iron, and all steel alloys except stainless steel.
6. Abbreviations noted on Contract Drawings:
 - a. PT = Paint.

1.2 REFERENCES

A. American Society for Testing and Materials International (ASTM):

1. ASTM D6386 - Preparation of Zinc (Hot-Dip Galvanized) Coated Iron and Steel Product and Hardware Surfaces for Coating.
2. ASTM D950 - Test Method for Impact Strength of Adhesive Bonds.
3. ASTM D4258 - Practice for Surface Cleaning Concrete for Coating.
4. ASTM D4259 - Practice for Abrading Concrete.
5. ASTM D4261 - Surface Cleaning Concrete Masonry Units for Coating.
6. ASTM D4263 - Test Method for Indicating Moisture in Concrete by the Plastic Sheet Method.
7. ASTM D4541 - Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers.
8. ASTM D4787 - Practice for Continuity Verification of Liquid or Sheet Lining Applied to Concrete Substrates.

B. Society for Protective Coatings (SSPC) Surface Preparation Specifications:

1. SSPC SP1 - Solvent Cleaning: Removes oil, grease, soil, drawing and cutting

- compounds, and other soluble contaminants.
- 2. SSPC SP6 - Commercial Blast Cleaning: Two-thirds of every nine square inches free of all visible residues; remainder only light discoloration.
- 3. SSPC SP10 - Near White Blast Cleaning.
- 4. SSPC SP11 - Power Tool Cleaning to Bare Metal.
- C. National Association of Pipe Fabricators, Inc. (NAPF):
 - 1. NAPF 500-03-04 - Abrasive Blast Cleaning for Ductile Iron Pipe
 - 2. NAPF 500-03-05 - Abrasive Blast Cleaning for Cast Ductile Iron Fittings
- D. National Sanitation Foundation (NSF):
 - 1. NSF 61 - Drinking Water Treatment Chemicals - Health Effects.

1.3 COORDINATION

- A. Coordinate Work of this Section with installation of all material and equipment to be coated.

1.4 SUBMITTAL

- A. Per Section 01 33 00 - Submittal Procedures: Requirements for submittals.
- B. Submittals for industrial coatings shall be prepared by, or have assistance in preparation of, a corrosion Engineer or industrial coatings technical representative of the coating manufacturer.
- C. Product Data:
 - 1. Technical sheets for each product with information including:
 - a. List of compatible primers and finish coats as applicable.
 - b. Volatile organic compounds concentrations.
 - c. Pot life.
 - d. Theoretical coverage rates.
 - e. Material storage and handling procedures.
 - 2. Material safety data sheets.
 - 3. For submerged applications, provided proof of NSF 61 certification.
- D. Shop Drawings:
 - 1. Submit schedule of products and paint systems to be used. Schedule shall include the following information:
 - a. Description of substrate for system to be applied and location(s) to be applied.
 - b. Description of substrate surface preparation methods.
 - c. Product manufacturer, name, and number for each coat to be applied.
 - d. Method of application and dry film mil thickness for each coat to be applied.
 - 2. Submit color charts illustrating available colors for selection. Submit physical hard samples four by ten inches if requested by Owner/Engineer.
- E. Manufacturer's Certificate: Certify that all coatings are suitable for service intended as specified herein and on the Contract Drawings. Certify that products meet or exceed specified requirements.

- F. Manufacturer instructions: Submit application guide to indicate at minimum, surface preparation requirements, application equipment requirements and application temperature requirements.
- G. Field Quality-Control Submittals: Contractor shall certify in writing to the Owner/Engineer that applicators have previously applied all coating systems to be used and have the ability and equipment to prepare the surfaces and apply the coatings per the manufacturers instruction.

1.5 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing products specified in this Section with minimum 10 years documented experience.
- B. Installer Qualifications: Acceptable to manufacturer with documented experience on at least 3 projects of similar industrial nature in the past 3 years. In addition, experience must include at minimum one project experience of epoxy coatings application on metal building systems, a minimum of one project of epoxy coatings on process piping, and a minimum of one project coating concrete.
- C. Materials in Contact with Potable Water: Certified according to NSF 61.
- D. Coatings systems from only one manufacturer for each type of application shall be applied.
- E. In the event a problem occurs with coating system, surface preparation, or application, Contractor shall require coating applicator and coating manufacturer's technical representative to promptly investigate the problem and submit findings results to Owner/Engineer.
- F. A coating report shall be completed daily by Contractor at each phase of the coating system starting with surface preparation. An example form is attached at the end of this Section.
- G. Regulatory Requirements:
 - 1. In addition to requirements specified elsewhere for environmental protection, provide coating materials that conform to the restrictions of the local and regional jurisdiction. Notify Owner/Engineer of any coating specified herein that fails to conform to the requirements for the location of the Project or location of application.
 - 2. Lead Content: Use only coatings that are lead free.
 - 3. Chromate Content: Do not use coatings containing zinc-chromate or strontium chromate.
 - 4. Asbestos Content: Materials shall not contain asbestos.
 - 5. Mercury Content: Materials shall not contain mercury or mercury compounds.
 - 6. Where SSPC surface preparation standards are specified or implied for ductile iron pipe or fittings, the equivalent NAPF surface preparation standard shall be substituted for the SSPC standard.
 - 7. Stated VOC shall be un-thinned maximum VOC certified by manufacturer.
- H. Pre-Installation meeting:
 - 1. Convene a pre-application meeting before the start of application of the coating system(s). Require, at minimum, attendance of parties directly affecting work of this section, including Owner, Engineer, Contractor, applicator, and coating system manufacturer's authorized representative. Review at minimum:

- a. Drawings and Specification Sections affecting work of this section.
- b. Proposed painting schedule, including specific application locations and systems.
- c. Protection of adjacent surfaces.
- d. Surface preparation and substrate conditions.
- e. Application.
- f. Field quality control measures.
- g. Cleaning.
- h. Protection of coating system.
- i. Repair of coating system.
- j. Coordination with other work.

1.6 DELIVERY, STORAGE AND HANDLING

- A. Deliver materials to site in manufacturer's sealed container marked to show following:
 1. Name of manufacturer.
 2. Product type.
 3. Batch number.
 4. Instructions for use.
 5. Safety precautions.
- B. In addition to manufacturer's label, provide a label legibly printed as following:
 1. Surface upon which material is to be applied.
 2. Specify Coat Types: Prime; body; finish; etc.
- C. Maintain space for storage and handling of Coating materials and equipment in a ventilated, neat, and orderly condition to prevent spontaneous combustion from occurring or igniting adjacent items.
- D. Store materials at site at least 24 hours before using, at a temperature between 45- and 85-degrees F.

1.7 PROJECT CONDITIONS

- A. Maintain environmental conditions (temperature, humidity, and ventilation) within limits recommended by manufacturer for optimum results. Do not install products under environmental conditions outside manufacturer's absolute limits.
- B. Weather:
 1. Air and Surface Temperatures: Prepare surfaces and apply and cure coatings within air and surface temperature range in accordance with manufacturer's instructions.
 2. Surface Temperature: Minimum of 45 degrees F (7 degrees C) above dew point.
 3. Relative Humidity: Prepare surfaces and apply and cure coatings within relative humidity range in accordance with manufacturer's instructions.
 4. Precipitation: Do not prepare surfaces or apply coatings in rain, snow, fog, or mist.
 5. Wind: Do not spray coatings if wind velocity is above manufacturer's recommended limit.

- C. Ventilation: Provide ventilation during coating evaporation stage in confined or enclosed areas in accordance with manufacturer's instructions.
- D. Dust and Contaminants:
 - 1. Schedule coating work to avoid excessive dust and airborne contaminants.
 - 2. Protect work areas from excessive dust and airborne contaminants during coating application and curing.

PART 2 - PRODUCTS

2.1 COATINGS AND APPLICATION SCHEDULE

- A. Manufacturers:
 - 1. Carboline Global.
 - 2. International Protective Coatings.
 - 3. PPG Protective and Marine Coatings.
 - 4. Tnemec Company, Inc.
- B. Specific product names and numbers specified herein have been preselected. Equal materials produced by manufacturers not listed shall be acceptable subject to prior Owner/Engineer review.
- C. Design and Performance Requirements:
 - 1. Coatings systems shall be specifically designed and adapted for use in water and wastewater treatment facilities.
 - 2. Pigment design shall be inclusive of materials that do not discolor, darken, or fade due to action of chlorine, ammonia, or hydrogen sulfide gas.
 - 3. Unless otherwise indicated finish colors shall be selected by the Owner/Engineer during submittal process.
- D. System EC-1:
 - 1. Applicable Substrates:
 - a. Indoor exposed ductile iron pipe, fittings, and valves.
 - 2. Maximum Volatile Organic Compounds Concentration: 2.08 lb./gal (250 g/L).
 - 3. Surface Preparation: NAPF 500-03-04 Abrasive Blast Cleaning for Ductile Iron Pipe, and NAPF 500-03-05 Abrasive Blast Cleaning for Cast Ductile Iron Fittings.
 - 4. First (Primer) Coat: Shop Applied.
 - a. Product: Tnemec Series N69 or approved equal.
 - b. Coverage Rate: 4.0 to 6.0 mils dry film thickness.
 - 5. Intermediate Coat:
 - a. Product: N/A
 - b. Coverage Rate: N/A
 - 6. Finish Coat:
 - a. Product: Tnemec Series N69 or approved equal.
 - b. Coverage Rate: 4.0 to 6.0 mils dry film thickness.
 - 7. System Total Minimum Dry Film Thickness: 8.0 to 12.0 mils.

8. Testing Requirements:
 - a. Surface preparation visual inspection.
 - b. Holiday testing.
 - c. DFT testing.
- E. System EC-2:
 1. Applicable Substrates:
 - a. Indoor exposed steel pipe and fittings.
 - b. Indoor exposed steel pipe supports.
 - c. Indoor exposed structural steel, angles, plates, and other miscellaneous steel framing not covered by another Section.
 2. Maximum Volatile Organic Compounds Concentration: 2.08 lb./gal (250 g/L).
 3. Surface Preparation: Commercial Blast Cleaning per SSPC-SP6/NACE 3. Anchor profile shall be 1.5 to 2.0 mils as per ASTM D 4417, Method C or NACE Standard RP0287.
 4. First (Primer) Coat: Shop Applied.
 - a. Product: Tnemec Series 90G-1K97 Tneme-Zinc or approved equal.
 - b. Coverage Rate: 2.5 to 3.5 mils dry film thickness.
 5. Intermediate Coat:
 - a. Product: Tnemec Series N69 or approved equal.
 - b. Coverage Rate: 4.0 to 6.0 mils dry film thickness.
 6. Finish Coat:
 - a. Product: Tnemec Series N69 or approved equal.
 - b. Coverage Rate: 4.0 to 6.0 mils dry film thickness.
 7. System Total Minimum Dry Film Thickness: 8.0 to 12.0 mils.
 8. Testing Requirements:
 - a. Surface preparation visual inspection.
 - b. Holiday testing.
 - c. DFT testing.
- F. System EC-3:
 1. Applicable Substrates:
 - a. All surfaces in contact with potable water or water that will become potable, excluding concrete (refer to System CC-3).
 2. Maximum Volatile Organic Compounds Concentration: 2.08 lb./gal (250 g/L).
 3. Surface Preparation: Commercial Blast Cleaning per SSPC-SP10/NACE 3.
 4. First (Primer) Coat: Shop Applied.
 - a. Product: Tnemec Series 94-H2O Hydro-Zinc or approved equal.
 - b. Coverage Rate: 2.5 to 3.5 mils dry film thickness.
 5. Intermediate Coat:
 - a. Product: N/A
 - b. Coverage Rate: N/A
 6. Finish Coat:

- a. Product: Tnemec Series 21 Epoxoline or approved equal.
 - b. Coverage Rate: 15.0 to 18.0 mils dry film thickness.
 - 7. System Total Minimum Dry Film Thickness: 17.5 to 21.5 mils.
 - 8. Testing Requirements:
 - a. Surface preparation visual inspection.
 - b. Holiday testing.
 - c. DFT testing.
- G. System EC-4:
- 1. Applicable Substrates:
 - a. Outdoor exposed ductile iron pipe and fittings, including piping to be insulated.
 - b. Outdoor exposed steel pipe and fittings, including piping to be insulated.
 - c. Outdoor exposed steel pipe supports.
 - d. Outdoor steel doors and frames.
 - e. Outdoor steel monorails.
 - f. Outdoor steel bollards.
 - g. Outdoor exposed miscellaneous structural steel, lintels, angles, plates.
 - 2. Maximum Volatile Organic Compounds Concentration: 2.08 lb/gal (250 g/L).
 - 3. Surface Preparation: Commercial Blast Cleaning to SSPC-SP6/NACE 3
 - 4. First (Primer) Coat: Shop Applied.
 - a. Product: Tnemec Series 90G-1K97 Tnemec-Zinc or approved equal.
 - b. Coverage Rate: 2.5 to 3.5 mils dry film thickness.
 - 5. Intermediate Coat:
 - a. Product: Tnemec Series N69 Hi-Build Epoxoline II or approved equal.
 - b. Coverage Rate: 4.0 to 6.0 mils dry film thickness.
 - 6. Finish Coat:
 - a. Product: Tnemec Series V290 CRU or approved equal.
 - b. Coverage Rate: 2.0 to 3.0 mils dry film thickness.
 - 7. System Total Minimum Dry Film Thickness: 8.5 to 12.5 mils dry film thickness.
 - 8. Testing Requirements:
 - a. Surface preparation visual inspection.
 - b. Holiday testing.
 - c. DFT testing.
- H. System EC-5:
- 1. Applicable Substrates:
 - a. Ferrous metals encased in concrete, plaster, fireproofing, and similar materials.
 - 2. Maximum Volatile Organic Compounds Concentration: 1.91 lb/gal (229 g/L).
 - 3. Surface Preparation: Commercial Blast Cleaning to SSPC-SP6/NACE 3
 - 4. Shop Primer and Field Touch Up:
 - a. Product: Tnemec Series 46H-413 red or approved equal.

- b. Coverage Rate: 2.0 to 2.5 mils dry film thickness.
 - 5. System Total Minimum Dry Film Thickness: 2.0 to 2.5 mils dry film thickness.
 - 6. Testing Requirements:
 - a. None.
- I. System EC-6:
 - 1. Applicable Substrates:
 - a. Aluminum in contact with concrete.
 - 2. Maximum Volatile Organic Compounds Concentration: 1.91 lb/gal (229 g/L).
 - 3. Surface Preparation: Remove all foreign matter.
 - 4. Finish Coat:
 - a. Product: Tnemec Series 46H-413 red or approved equal.
 - b. Coverage Rate: 16.0 to 20.0 mils dry film thickness.
 - 5. System Total Minimum Dry Film Thickness: 16.0 to 20.0 mils dry film thickness.
 - 6. Testing Requirements:
 - a. None.
- J. System EC-7:
 - 1. Applicable Substrates:
 - a. Aluminum in contact with dissimilar metals.
 - 2. Maximum Volatile Organic Compounds Concentration: 3.02 lb/gal (362 g/L).
 - 3. Surface Preparation: Remove all foreign matter.
 - 4. Finish Coat:
 - a. Product: Tnemec Series 66 Hi-Build Epoxoline or approved equal.
 - b. Coverage Rate: Two coats of 2.0 to 6.0 mils dry film thickness.
 - 5. System Total Minimum Dry Film Thickness: 4.0 to 12.0 mils dry film thickness.
 - 6. Testing Requirements:
 - a. None.
- K. System EC-8:
 - 1. Applicable Substrates:
 - a. Uninsulated PVC piping, interior and exterior.
 - 2. Maximum Volatile Organic Compounds Concentration: 3.02 lb/gal (362 g/L).
 - 3. Surface Preparation: As recommended by coating manufacturer.
 - 4. Finish Coat:
 - a. Product: Tnemec Series 66 Hi-Build Epoxoline.
 - b. Coverage Rate: Two coats of 2.0 to 6.0 mils dry film thickness.
 - 5. System Total Minimum Dry Film Thickness: 4.0 to 12.0 mils dry film thickness.
 - 6. Testing Requirements:
 - a. None.
- L. System CC-1 **(NOT USED)**
- M. System CC-2:

1. Applicable Substrates:
 - a. Cast-in Place Concrete Walls and Ceilings with "smooth rubbed finish," Interior non-submerged, where painting is required, including chemical containment room floors and containment sump. For chemical containment room floors, add 50 mesh dry wash silica sand to topcoat to provide a non-skid surface in walkway areas
 - b. Concrete Equipment Bases, Pipe Supports, and Similar Surfaces, with "smooth rubbed finish," Interior non-submerged, where painting is required
2. Maximum Volatile Organic Compounds Concentration: 2.08 lb/gal (250 g/L).
3. Surface Preparation: per SSPC-SP13 or acid-etch.
4. First (Primer) Coat:
 - a. Product: Tnemec 66 Hi-Build Epoxoline or approved equal.
 - b. Coverage Rate: 5.0 mils dry film thickness
5. Intermediate Coat:
 - a. Product: N/A
 - b. Coverage Rate: N/A
6. Finish Coat:
 - a. Product: Tnemec 66 Hi-Build Epoxoline or approved equal.
 - b. Coverage Rate: 4.0 mils dry film thickness.
7. Testing Requirements:
 - a. Surface preparation visual inspection.
 - b. DFT testing.
- N. System CC-3 **(NOT USED)**
- O. System CC-4 **(NOT USED)**

2.2 EXAMINATION

- A. Do not begin installation until substrates have been properly prepared.
- B. Verify compatibility of new material with existing conditions or shop applied material.
- C. If substrate preparation is the responsibility of another installer, notify Engineer of unsatisfactory preparation before proceeding.

2.3 PROTECTION

- A. Protect surrounding areas and surfaces not scheduled to be coated from damage during surface preparation and application of coatings.
- B. Immediately remove coatings that fall on surrounding areas and surfaces not scheduled to be coated.
- C. Mask, remove, or otherwise protect finish hardware, machined surfaces, grilles, lighting fixtures, and prefinished units as necessary.
- D. Provide cover or shields to prevent surface preparation media and coatings from entering orifices in electrical or mechanical Equipment. Where ventilation systems must be kept in operation at time of surface preparation, take precautions to shield intakes and exhausts to

prevent the materials from entering system or being dispersed.

- E. Provide signs to indicate fresh paint areas.
- F. Provide daily cleanup of both storage and working areas and removal of all paint refuse, trash, rags, and thinners. Dispose of leftover containers, thinners, rags, brushes, and rollers which cannot be reused in accordance with applicable regulations.

2.4 SURFACE PREPARATION

- A. Prepare surfaces for each coating system as required conforming to applicable SSPC or ASTM surface preparation standards.
 - 1. If grease or oils are present, SSPC-SP1 shall precede any other method specified for metal substrates.
 - 2. Remove surface irregularities such as weld spatter, burrs, or sharp edges prior to specified surface preparation.
- B. Depth of profile will be as specified or as recommended by the manufacturer for each system, but in no instance shall it exceed one-third of the total dry film thickness of complete system.
- C. Prepare only those areas which will receive the first coat of the system on the same day. On steel substrates, apply coating before rust bloom forms.
- D. Unless documented, all new galvanized steel to be coated is to be tested for hexavalent stain inhibitors as described in ASTM D6386, Appendix X2, and removed by one of the methods described therein.
- E. New concrete and masonry surfaces shall have cured a minimum of 28 days, unless otherwise approved by coating manufacturer. Concrete surfaces shall be tested for capillary moisture in the concrete in accordance with ASTM D4263. Capillary moisture for 24 hours shall not exceed the coating manufacturer's recommendation.
- F. Clean the substrate of dust, debris, curing compounds, and other substances that would be detrimental to the performance of the coating system:
 - 1. Oil and grease shall be completely removed by use of detergents before sandblasting.
 - 2. All surfaces to be coated shall be cleaned in accordance with ASTM D4258 and blasted in accordance with ASTM D4259. Or, if more restrictive, prepare surface as recommended by the coating manufacturer.
 - a. Acid etching surface preparation is not recommended.

2.5 APPLICATION

- A. Spray Coating is required. Small areas may be touched-up with a brush or roller only with prior approval by the Owner/Engineer.
- B. All prime coats to be shop applied prior to delivery to Site. Shop primed surfaces shall be inspected by the Owner/Engineer to determine the extent of coating damage and assess suitability of the finish coating systems.
- C. Apply coatings in accordance with coating manufacturer's recommendations.
- D. Use properly designed brushes, rollers, and spray equipment for all applications.
- E. Dry film thickness of each coat and system total shall meet the minimum specified.

Maximum dry film thickness shall not exceed the minimum specified plus 20 percent or coating manufacturer's stated maximum whichever is less. Where a dry film thickness range is specified, the range shall not be less than or exceeded.

- F. Shop and field Coating shall remain 3 inches away from unprepared surface of any substrate such as areas to be welded or bolted.
- G. Environmental Conditions:
 - 1. Atmospheric temperature must be 50°F or higher during application, unless otherwise approved by coating manufacturer. Do not apply coatings when inclement weather or freezing temperature may occur within coating recoat cure times.
 - 2. Wind velocities for Outdoor applications shall be at a minimum to prevent overspray or fallout and not greater than coating manufacturer's limits.
 - 3. Relative humidity must be less than 85 percent and the temperature of the surface to be coated must be at least 5°F above the dew point.
 - 4. Provide adequate ventilation in all areas of application to ensure that at no time does the content of air exceed the Threshold Limit Value given on the manufacturer's Material Safety Data Sheets for the specific coatings being applied.
- H. Recoat Time: In the event a coating, such as an epoxy, has exceeded recoat time limit, prepare the applied coating in accordance with manufacturer's recommendations.
- I. Do not remove or paint over Equipment data plates, code stamps on piping, or UL fire rating labels.

2.6 REPAIR / RESTORATION

- A. Remove spilled, dripped, or splattered paint from all surfaces not scheduled to be coated.
- B. Touch up and restore damaged finishes to original condition. This includes surface preparation and application of complete coating system specified.
- C. Extent of surface to be repaired to be surface prepped in accordance with the specifications.

2.7 TOUCH UP

- A. Touch up and restore damaged finishes to new condition. This includes surface preparation and application of the complete coating system specified.

2.8 FINISHING

- A. Remove spilled, dripped, or splattered paint from all surfaces not scheduled to be coated.

2.9 FIELD QUALITY CONTROL

- A. Surface Preparation Inspection:
 - 1. Surface preparation shall be based upon comparison with "Pictorial Surface Preparation Standards for Coating Steel Surfaces: SSPC-VIS 1", ASTM Designation D2200, "Standard Methods of Evaluating Degree of Rusting on Coated Surfaces", ASTM D 4417, Method A and/or Method C or NACE Standard RP0287, and ASTM Designation D610 "Visual Standard for Surfaces of New Steel Air Blast Cleaned with Sand Abrasive". In all cases the written standard shall take precedence over the visual standard.

- B. Holiday Testing:
 - 1. After coating is installed, an independent, certified, third party shall conduct holiday or discontinuity detection per ASTM D5162. Tests shall use an acceptable high-voltage electrical spark tester set at the recommended voltage. The electrode movement shall be continuous and shall proceed in a systematic manner that will cover 100 percent of the coated surface.
 - 2. All detected voids and pinholes shall be marked and repaired as recommended by the coating manufacturer.
- C. Mil Thickness Testing:
 - 1. Contractor shall provide and use a wet film gauges to test each application thickness approximately every 15 minutes and immediately correct if film thickness is under or over that specified.
 - 2. Contractor shall provide and use a dry film gauge to check each coat mm (mil) thickness when dry, and the total system mm (mil) thickness when completed.
- D. Environmental Testing:
 - 1. Furnish a sling psychrometer and perform periodic checks on both relative humidity and temperature limits.
 - 2. Check temperature of the substrate at regular intervals to be certain surface is 5°F or more above the dew point.
- E. In the event field quality control tests reveal noncompliance with the requirements of the Contract, the Contractor shall bear the cost of such corrective measures deemed necessary by the Owner, as well as the cost of subsequent retesting.

2.10 ATTACHMENTS

- A. Example Coating Report Form

END OF SECTION

SECTION 09 90 00 - ATTACHMENT A

EXAMPLE COATING REPORT FORM

Contract Name:..... Contract Number:

Coating Contractor: Foreman:

Unit or Surface Identification:
.....
.....

Unit or Surface Location: Outdoor..... Indoor:.....

SURFACE PREPARATION:

Date/Time: Air Temp:°F; Surface Temperature:%

Method of Surface Preparation:

Profile Achieved: mils (if applicable).

TOUCH UP:

Date/Time: Air Temp:°F; Surface Temperature:%

Relative humidity:% Dew Point:°F

Coating used: Dry film obtained:.....mils.

FIRST COAT:

Date/Time: Air Temp:°F; Surface Temperature:%

Relative humidity:% Dew Point:°F

Coating used:

Dry time before recoat: hrs. Dry film obtainedmils.

SECOND COAT:

Date/Time: Air Temp:°F; Surface Temperature:%

Relative humidity:% Dew Point:°F

Coating used:

Dry time before recoat:..... hrs. Dry film obtained.....mils.

THIRD COAT:

Date/Time: Air Temp:°F; Surface Temperature:%

Relative humidity:% Dew Point:°F

Coating used:

Dry time before recoat:..... hrs. Dry film obtained.....mils.

SECTION 09 91 20
PAINTING (PROFESSIONAL LINE PRODUCTS)

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes surface preparation and field painting of exposed exterior and interior architectural building items and surfaces.

1.2 RELATED SECTIONS

- A. 09 90 00 – Painting and Protective Coatings

1.3 SUBMITTALS

- A. Product Data: For each product indicated.
- B. Drawdown Samples: Provide drawdown samples of each color and sheen specified.

1.4 PROJECT CONDITIONS

- A. Store materials not in use in tightly covered containers in a well-ventilated area at a minimum ambient temperature of 45 deg F (7 deg C). Maintain storage containers in a clean condition, free of foreign materials and residue.
- B. Apply waterborne paints only when temperatures of surfaces to be painted and surrounding air are between 50 and 90 deg F (10 and 32 deg C).
- C. Apply solvent-thinned paints only when temperatures of surfaces to be painted and surrounding air are between 45 and 95 deg F (7 and 35 deg C).
- D. Do not apply paint in snow, rain, fog, or mist; or when relative humidity exceeds 85 percent; or at temperatures less than 5 deg F (3 deg C) above the dew point; or to damp or wet surfaces.

1.5 EXTRA MATERIALS

- A. Furnish extra paint materials from the same production run as the materials applied and in the quantities described below. Package with protective covering for storage and identify with labels describing contents. Deliver extra materials to Owner.
 - 1. Quantity: 5 percent, but not less than 1 gal. (3.8 L) or 1 case, as appropriate, of each material and color applied.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers' Names: Shortened versions (shown in parentheses) of the following manufacturers' names are used in other Part 2 articles:
1. Benjamin Moore & Co. (Benjamin Moore).
 2. PPG Industries, Inc. (Pittsburgh Paints).
 3. Sherwin-Williams Co. (Sherwin-Williams).
 4. Tnemec Company, Inc. (Tnemec).

2.2 PAINT MATERIALS, GENERAL

- A. Material Compatibility: Provide block fillers, primers, and finish-coat materials that are compatible with one another and with the substrates indicated under conditions of service and application, as demonstrated by manufacturer based on testing and field experience.
- B. Material Quality: Provide manufacturer's best-quality paint material of the various coating types specified that are factory formulated and recommended by manufacturer for application indicated. Paint-material containers not displaying manufacturer's product identification will not be acceptable.
- C. Chemical Components of Interior Paints and Coatings: Provide products that comply with the following limits for VOC content when calculated according to 40 CFR 59, Subpart D (EPA Method 24) and the following chemical restrictions:
1. Flat Paints and Coatings: VOC not more than 50 g/L.
 2. Non-Flat Paints and Coatings: VOC not more than 150 g/L.
 3. Anticorrosive Coatings: VOC not more than 250 g/L.
 4. Varnishes and Sanding Sealers: VOC not more than 350 g/L.
 5. Stains: VOC not more than 250 g/L.
 6. Aromatic Compounds: Paints and coatings shall not contain more than 1.0 percent by weight total aromatic compounds (hydrocarbon compounds containing one or more benzene rings).
 7. Restricted Components: Paints and coatings shall not contain acrolein; acrylonitrile; antimony; benzene; butyl benzyl phthalate; cadmium; di (2-ethylhexyl) phthalate; di-n-butyl phthalate; di-n-octyl phthalate; 1,2-dichlorobenzene; diethyl phthalate; dimethyl phthalate; ethylbenzene; formaldehyde; hexavalent chromium; isophorone; lead; mercury; methyl ethyl ketone; methyl isobutyl ketone; methylene chloride; naphthalene; toluene (methylbenzene); 1,1,1-trichloroethane; or vinyl chloride.
- D. Colors: To be selected by Architect.

PART 3 - EXECUTION

3.1 APPLICATION

- A. Examine substrates, areas, and conditions, with Applicator present, for compliance with requirements for paint application.
- B. Coordination of Work: Review other Sections in which primers are provided to ensure compatibility of the total system for various substrates. On request, furnish information on characteristics of finish materials to ensure use of compatible primers.
- C. Remove hardware and hardware accessories, plates, machined surfaces, lighting fixtures, and similar items already installed that are not to be painted. If removal is impractical or impossible because of size or weight of the item, provide surface-applied protection before surface preparation and painting.
 - 1. After completing painting operations in each space or area, reinstall items removed using workers skilled in the trades involved.
- D. Surface Preparation: Clean and prepare surfaces to be painted according to manufacturer's written instructions for each particular substrate condition and as specified.
 - 1. Provide barrier coats over incompatible primers or remove and reprime.
 - 2. Cementitious Materials: Remove efflorescence, chalk, dust, dirt, grease, oils, and release agents. Roughen as required to remove glaze. If hardeners or sealers have been used to improve curing, use mechanical methods of surface preparation.
 - 3. Wood: Clean surfaces of dirt, oil, and other foreign substances with scrapers, mineral spirits, and sandpaper, as required. Sand surfaces exposed to view smooth and dust off.
 - a. Scrape and clean small, dry, seasoned knots, and apply a thin coat of white shellac or other recommended knot sealer before applying primer. After priming, fill holes and imperfections in finish surfaces with putty or plastic wood filler. Sand smooth when dried.
 - b. Prime, stain, or seal wood to be painted immediately on delivery. Prime edges, ends, faces, undersides, and back sides of wood, including cabinets, counters, cases, and paneling.
 - c. If transparent finish is required, backprime with spar varnish.
 - d. Backprime paneling on interior partitions where masonry, plaster, or other wet wall construction occurs on back side.
 - e. Seal tops, bottoms, and cutouts of unprimed wood doors with a heavy coat of varnish or sealer immediately on delivery.
 - 4. Ferrous Metals: Clean ungalvanized ferrous-metal surfaces that have not been shop coated; remove oil, grease, dirt, loose mill scale, and other foreign substances. Use solvent or mechanical cleaning methods that comply with SSPC's recommendations.
 - a. Blast steel surfaces clean as recommended by paint system manufacturer and according to SSPC's recommendations.

- b. Treat bare and sandblasted or pickled clean metal with a metal treatment wash coat before priming.
 - c. Touch up bare areas and shop-applied prime coats that have been damaged. Wire-brush, clean with solvents recommended by paint manufacturer, and touch up with same primer as the shop coat.
- 5. Galvanized Surfaces: Clean galvanized surfaces with nonpetroleum-based solvents so surface is free of oil and surface contaminants. Remove pretreatment from galvanized sheet metal fabricated from coil stock by mechanical methods.
- E. Material Preparation:
 - 1. Maintain containers used in mixing and applying paint in a clean condition, free of foreign materials and residue.
 - 2. Stir material before application to produce a mixture of uniform density. Stir as required during application. Do not stir surface film into material. If necessary, remove surface film and strain material before using.
- F. Exposed Surfaces: Include areas visible when permanent or built-in fixtures, grilles, convactor covers, covers for finned-tube radiation, and similar components are in place. Extend coatings in these areas, as required, to maintain system integrity and provide desired protection.
 - 1. Paint surfaces behind movable equipment and furniture the same as similar exposed surfaces. Before final installation of equipment, paint surfaces behind permanently fixed equipment or furniture with prime coat only.
 - 2. Paint interior surfaces of ducts with a flat, nonspecular black paint where visible through registers or grilles.
 - 3. Paint back sides of access panels and removable or hinged covers to match exposed surfaces.
 - 4. Finish exterior doors on tops, bottoms, and side edges the same as exterior faces.
 - 5. Finish interior of wall and base cabinets and similar field-finished casework to match exterior.
- G. Sand lightly between each succeeding enamel or varnish coat.
- H. Scheduling Painting: Apply first coat to surfaces that have been cleaned, pretreated, or otherwise prepared for painting as soon as practicable after preparation and before subsequent surface deterioration.
 - 1. Omit primer over metal surfaces that have been shop primed and touchup painted.
 - 2. If undercoats, stains, or other conditions show through final coat of paint, apply additional coats until paint film is of uniform finish, color, and appearance.
- I. Application Procedures: Apply paints and coatings by brush, roller, spray, or other applicators according to manufacturer's written instructions.
- J. Minimum Coating Thickness: Apply paint materials no thinner than manufacturer's recommended spreading rate. Provide total dry film thickness of the entire system as recommended by manufacturer.

- K. Mechanical and Electrical Work: Painting of mechanical and electrical work is limited to items exposed in equipment rooms and occupied spaces.
- L. Block Fillers: Apply block fillers to concrete masonry block at a rate to ensure complete coverage with pores filled.
- M. Prime Coats: Before applying finish coats, apply a prime coat, as recommended by manufacturer, to material that is required to be painted or finished and that has not been prime coated by others. Recoat primed and sealed surfaces where evidence of suction spots or unsealed areas in first coat appears, to ensure a finish coat with no burn-through or other defects due to insufficient sealing.
- N. Pigmented (Opaque) Finishes: Completely cover surfaces as necessary to provide a smooth, opaque surface of uniform finish, color, appearance, and coverage. Cloudiness, spotting, holidays, laps, brush marks, runs, sags, ropiness, or other surface imperfections will not be acceptable.
- O. Transparent (Clear) Finishes: Use multiple coats to produce a glass-smooth surface film of even luster. Provide a finish free of laps, runs, cloudiness, color irregularity, brush marks, orange peel, nail holes, or other surface imperfections.
- P. Stipple Enamel Finish: Roll and redistribute paint to an even and fine texture. Leave no evidence of rolling, such as laps, irregularity in texture, skid marks, or other surface imperfections.

3.2 CLEANING AND PROTECTING

- A. At the end of each workday, remove empty cans, rags, rubbish, and other discarded paint materials from Project site.
- B. Protect work of other trades, whether being painted or not, against damage from painting. Correct damage by cleaning, repairing or replacing, and repainting, as approved by Architect.
- C. Provide "Wet Paint" signs to protect newly painted finishes. After completing painting operations, remove temporary protective wrappings provided by others to protect their work.
 - 1. After work of other trades is complete, touch up and restore damaged or defaced painted surfaces. Comply with procedures specified in PDCA P1.

3.3 PAINT SCHEDULE

- A. Finish schedule: Catalog names and numbers refer to products as manufactured by Sherwin Williams.

B. Exterior Materials:

1. Wood Wall Brackets – Transparent Finish
 - a. Filler coat (for open grained wood only)
 - b. One coat stain
 - c. One coat sealer
 - d. Two coat varnish satin

C. Interior Materials:

1. Concrete Block
 - a. Pretreatment: One component block filler
 - b. Primer: One coat epoxy polyamide—6 mils
 - c. Finish: One coat epoxy polyamide—6 mils
 - d. Total dry film thickness: 12 mils
2. Gypsum Board: Ceilings – Eg-Shel
 - a. Primer: One coat alkyd enamel primer sealer 2 mils
 - b. Finish: Two coats alkyd enamel, eggshell 2 mils
 - c. Total dry film thickness: 6 mils
3. Wood and Hardboard:
 - a. Alkyd-Enamel Finish: Two finish coats over a primer.
 - 1) Primer: Interior wood primer for acrylic-enamel and semigloss alkyd-enamel finishes.
 - 2) Finish Coats: Interior semigloss alkyd enamel.

END OF SECTION

SECTION 10 40 00
SAFETY SIGNS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Furnish all labor, materials, tools, equipment, and perform all work and services for furnishing and installing safety signage as shown on the drawings and as specified herein.
 - 2. Provide all supplementary or miscellaneous items, including connections and mounting hardware, necessary for a sound, secure, and complete installation.
- B. Related Sections:
 - 1. Division 09 Section 09 90 00 "Painting and Protective Coatings" for surface preparation and coating system requirements.
 - 2. Division 10 Section 10 90 00 "Identification, Stenciling and Tagging" for identification devices for piping, valves, equipment and other items.

1.3 REFERENCES

- A. American National Standards Institute (ANSI):
 - 1. A13.1 – Schemes for the Identification of Piping Systems
 - 2. Z53.1 – Safety Color Code for Marking Physical Hazards
- B. Colorado Department of Transportation
 - 1. Manual on Uniform Traffic Control Devices
- C. Federal Specification (FS):
 - 1. L-P-387A(1) Plastic Sheet, Laminated, Thermosetting (For Designation Plates)
- D. National Fire Protection Association (NFPA):
 - 1. 49-75 Hazardous Chemical Data
 - 2. 704-90 Standard System for the Identification of the Fire Hazards of Materials
- E. Occupational Safety and Health Act (OSHA):
 - 1. §1910.144 Safety Color Code for Marking Physical Hazards
 - 2. §1910.145 Specifications for accident Prevention Signs and Tags

1.4 SYSTEM DESCRIPTION

- A. Safety signage shall be installed at non-potable water locations, equipment that automatically starts, covers for rotating machinery, electrical control centers, firefighting apparatus locations, eye and noise protection, hazardous material locations, chlorine and chemical areas, and other designated locations.

1.5 SUBMITTALS

- A. Product Data:
 - 1. Submit copies of manufacturer's technical brochure including color chart and list of standard signs.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following available manufacturers:
1. Brady Corporation, Milwaukee, WI
 2. Seton Name Plate Corp., New Haven, CT

2.2 SAFETY SIGNS

- A. Plastic Signs (Type A):
1. 60-mil rigid plastic for indoor/outdoor use, endures temperatures of -40°F to 176°F.
 2. Rounded corners with mounting holes.
- B. Signs, Self-Sticking (Type B):
1. Flexible 4-mil peel and stick vinyl for indoor/outdoor use, endures temperatures of -40°F to 176°F.
 2. Adhesive backing shall adhere quickly and firmly to smooth surfaces.
- C. Fiberglass Signs (Type C):
1. Material: Multi-ply laminated fiberglass, minimum 0.100-inch thick, with guaranteed not to chip, fade, rust, shatter or peel for 15 years.
 2. Message encapsulated between two clear weather-resistant surface layers.
 3. Indoor/outdoor use, endures temperatures of -40°F to 190°F and graffiti resistance.
- D. Metal Signs (Type D):
1. Material: Silk-screened, baked enamel finish or synthetic film laminate, 0.040 aluminum panels.
 2. Round-cornered and punched for application to wall surfaces.
- E. Painted Signs (Type E):
1. Stencils: Standard stencils prepared with letter sizes complying with recommendations in ASME A13.1. Minimum letter height is 1-1/4 inches for ducts, and 3/4 inch for access door signs and similar operational instructions.
 2. Material: Fiberboard.
 3. Stencil Paint: Exterior, oil-based, alkyd-gloss black enamel, unless otherwise indicated. Paint may be in pressurized spray-can form.
 4. Identification Paint: Exterior, oil-based, alkyd enamel in colors according to ASME A13.1, unless otherwise indicated.
- F. Exit Signs (Type F):
1. Material: Plastic, 1/8-inch (minimum) thickness.
 2. Description: 6-inch high, 3/4-inch stroke, red letters on white background.
 3. Illumination: As required by applicable jurisdictional agency fire code.
- G. Safety Sign Message:
1. Consists of two parts; the OSHA Heading and the Specific Message.
 2. OSHA Heading will consist of one of the following:
 - a. DANGER. White letters on red oval surrounded by a rectangular black field.
 - b. NOTICE. White letters on a blue field.
 - c. SAFETY FIRST. White letters on a green field.
 - d. CAUTION. Yellow letters on a black field.
 - e. RADIATION. Yellow letters on a purple field.

- f. THINK. White letters on a green field.
 - g. BE CAREFUL. White letters on a green field.
- 3. Safety signs shall comply with the requirements of OSHA 1920.145 with respect to size, color, and symbols.
- 4. Information regarding message, location, and related items shall be as shown in the Sign Schedule at END OF SECTION.
- H. All sign attachment and mounting hardware shall be Type 316 stainless steel. Each sign shall utilize 4 screws or 2 brackets.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions, with Installer present, for compliance with requirements for maximum moisture content, installation tolerances, and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATIONS

- A. Safety Signage: Provide and install at the following locations as applicable:
 - 1. Non-potable Water Faucets: CAUTION/Do Not Drink Water.
 - 2. Automatic Equipment Operation: CAUTION/Equipment Starts and Stops Automatically.
 - 3. Electrical Entrance and Fence Surrounding Electrical Equipment: DANGER/ High Voltage.
 - 4. Eye Wash Station: EMERGENCY/ Eye Wash Station Keep Area Clean.
 - 5. Safety Shower: EMERGENCY/ Safety Shower Keep Area Clean.
 - 6. Fence Surrounding Property: Notice/No Trespassing.
 - 7. Adjacent to Vertical Ladders: SAFETY FIRST/Remember Wear Safety Harness.
 - 8. Visitors: NOTICE/All Visitors Must Register at Office.
 - 9. Visitor Parking
 - 10. No Smoking: At designated locations.
- B. Warning Labels: Apply warning labels to equipment, machinery, electrical equipment, storage containers, and related items to the items as designated below. Label size shall be according to the space available. Do not apply label to concrete or masonry surfaces, use Type A or C signs.
 - 1. Electrical Disconnects: DANGER/480 Volts (Provide correct voltage or use High Voltage).
 - 2. Equipment Belt Guards: CAUTION/Keep Guard in Place.
 - 3. Flammable Material Storage: Flammable Liquids.
- C. Chemical and HazCom:
 - 1. Chemicals: Place NFPA Signs on chemical storage tanks, adjacent to chemical pumps, and related items communicating the following information:
 - a. Health Hazard.
 - b. Fire Hazard.
 - c. Specific Hazard.
 - d. Instability Hazard.
 - e. Type: Depending on application sign shall be self-adhesive vinyl (Type B) or fiberglass (Type C).

3.3 SIGN SCHEDULE

- A. Safety Signs: In addition to paragraph 3.2 above, refer to Safety Sign Schedule following the "End of Section" for other applications.

END OF SECTION

SAFETY SIGN SCHEDULE							
Item	Qty.	Type ⁽¹⁾	Size (inches)	OSHA Heading	Message	Location	Mounting
1	1	D	10" x 7"	CAUTION	NON-POTABLE WATER DO NOT DRINK	Treatment Building, Exterior Hose Station	On wall adjacent to hose station.
2	1	D	10" x 7"	CAUTION	NON-POTABLE WATER DO NOT DRINK	Treatment Building, Interior Hose Station	On wall adjacent to hose station.
3	1	D	10" x 7"	CAUTION	NON-POTABLE WATER DO NOT DRINK	Treatment Building, Exterior Backwash Waste Connection	On wall adjacent to pipe penetration.
4	1	C	10" x 7"	Not Applicable	*	NaOH Storage Room Exterior	Door 101
5	1	C	10" x 7"	Not Applicable	*	NaOCl Storage Room Exterior	Door 102
5	2	D	24" x 30"	Not Applicable - CDOT R11-50	EMERGENCY AND AUTHORIZED VEHICLES ONLY	Concrete approach to recreation path to parking lot and prior to double gate on driveway (refer to drawing C-102)	Via perforated square steel tube post with breakaway base, minimum 5 ft above grade

* NFPA Signage. Contractor to verify values for hazard ratings of chemicals being stored

Notes:

1. Type refers to Safety Sign type as designated in Part 2 – Products.
2. Messages shall be in both English and Spanish. English and Spanish messages shall be on the same side of one sign or shall be provided as two separate signs and mounted adjacent to one another.

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SECTION 10 44 16
FIRE EXTINGUISHERS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes portable, hand-carried fire extinguishers and mounting brackets for fire extinguishers.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.

1.3 INFORMATIONAL SUBMITTALS

- A. Warranty: Sample of special warranty.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

1.5 COORDINATION

- A. Coordinate type and capacity of fire extinguishers with fire-protection cabinets to ensure fit and function.

1.6 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace fire extinguishers that fail in materials or workmanship within specified warranty period.
 - 1. Failures include, but are not limited to, the following:
 - a. Failure of hydrostatic test according to NFPA 10.
 - b. Faulty operation of valves or release levers.
 - 2. Warranty Period: Six years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. NFPA Compliance: Fabricate and label fire extinguishers to comply with NFPA 10, "Portable Fire Extinguishers."
- B. Fire Extinguishers: Listed and labeled for type, rating, and classification by an independent testing agency acceptable to authorities having jurisdiction.

2.2 PORTABLE, HAND-CARRIED FIRE EXTINGUISHERS

- A. Fire Extinguishers: Type, size, and capacity for each fire-protection cabinet and mounting bracket indicated.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. JL Industries, Inc.; a division of the Activar Construction Products Group.
 - b. Larsens Manufacturing Company.
 - 2. Instruction Labels: Include pictorial marking system complying with NFPA 10, Appendix B, and bar coding for documenting fire-extinguisher location, inspections, maintenance, and recharging.
- B. Multipurpose Dry-Chemical Type Class ABC Steel Container: UL-rated 4-A: 60-B; C, 10 lb. nominal capacity, with monoammonium phosphate-based dry chemical in manufacturer's standard enameled container.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Examine fire extinguishers for proper charging and tagging.
 - 1. Remove and replace damaged, defective, or undercharged fire extinguishers.
- B. Install fire extinguishers and mounting brackets in locations indicated and in compliance with requirements of authorities having jurisdiction.

END OF SECTION

SECTION 10 90 00
IDENTIFICATION, STENCILING, AND TAGGING

PART 1 - GENERAL

1.1 WORK INCLUDED

- A. The Contractor shall furnish all labor, materials, tools, equipment, and perform all work and services for all identifications, stenciling and tagging as shown on the drawings and as specified.
- B. Items include but are not necessarily limited to the following areas of work:
 - 1. Paint and provide identification signs for all exposed piping, ductwork, and conduits in accordance with Schedule A at the end of this section.
 - 2. Provide identification tags and stenciling for all equipment, valves, instrumentation, and electrical components, including existing equipment and valves. Specific valve and equipment tag information shall be furnished by the Owner.
- C. Although such work is not specifically shown or specified, all supplementary or miscellaneous items, including connections and mounting hardware, necessary for a sound, secure, and complete installation shall be furnished and installed as part of this work.

1.2 QUALITY ASSURANCE

- A. Unless otherwise specified, all equipment and valves including mechanical, process, electrical, and instrumentation are required to be identified.
- B. Unless otherwise specified, openings, accesses and related locations are required to be identified.
- C. Coordination, development, and initiation of identification, marking, and tagging systems and determination of separation of subcontractor's and manufacturer's corresponding responsibilities is the sole responsibility of the Contractor.
- D. Referenced Standards: Comply with applicable provisions and recommendations of the following, except where otherwise shown or specified:
 - 1. ANSI A13.1, Scheme for the Identification of Piping Systems.
 - 2. Design Criteria for Potable Water Systems – Colorado Department of Public Health and Environment
 - 3. OSHA 1910.144, Safety Color Code for Marking Physical Hazards.
 - 4. SSPC Volume 2, System and Specifications, Surface Preparation Guide and Paint Application Specifications.

1.3 SUBMITTALS

- A. Submit identification register acknowledging all designated or scheduled equipment, instruments, gauges, valves, HVAC equipment, mechanical and electrical equipment. All items on register shall be tagged. Numbering system will be determined by the Owner.
- B. Develop and submit full identification register acknowledging equipment, valves, instruments, mechanical equipment and electrical equipment which is not designated or scheduled in drawings and specifications. Provide identifications compatible but not

conflicting with designated or scheduled equipment and related items. All items on register shall be tagged.

- C. Submit assurances that subcontractors and manufacturers have been advised of register requirements.
- D. Update identification register immediately prior to final acceptance of Work.
- E. Pipe Markers and Safety Signs:
 - 1. Submit for approval samples of each type of marker and sign specified.
 - 2. Submit copies of manufacturer's technical brochure including color chart and list of standard signs.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Acceptable Manufacturers: Provide products by one of the following:
 - 1. Brady Corporation.
 - 2. Seton Identification Products.
 - 3. Or approved equal.
- B. General:
 - 1. Pipe marker and safety sign materials shall withstand normal washing as required to remove grease, oil, chemicals, etc., without showing discoloration, loss of gloss, staining or other damage.
 - 2. Piping markers shall be formed from laminated plastic. All printing shall be sealed with a formed butyrate plastic film. Markers for piping up to 6-inch diameter shall be pre-formed to completely wrap around the pipe requiring no adhesive. Markers for pipes over 6-inch diameter shall be performed to the contour of the pipe and attached with stainless steel spring fastener.
 - 3. Each marker shall consist of at least one legend descriptive of the function of the pipe, as listed in Schedule A, and a directional arrow.
 - 4. The size of lettering and marker shall conform to ANSI A13.1.
 - 5. Location of markers:
 - a. Adjacent to each valve and "T" connection.
 - b. At each branch and riser takeoff.
 - c. At each pipe passage through a wall, floor and ceiling.
 - d. On all horizontal and vertical pipe runs at 20-foot intervals.
 - e. Labels on pipes not indicated to be painted shall be placed along the pipe at no greater than 5-foot intervals.
 - f. Bands shall be placed along the pipe at no greater than 5-foot intervals.
 - 6. Safety signs shall be in accordance with Section 10 40 00 "Safety Signs".

2.2 COLORS AND FINISHES

- A. Color Schedule: Paint colors will be selected by the Engineer from the approved manufacturer's color chips.

- B. Color Coding: In general, all color coding of piping, ducts and equipment shall comply with applicable standards of ANSI A13.1 and OSHA 1910.144 and shall meet the CDPHE requirements in the Design Criteria for Potable Water Systems.
- C. Piping and Sign Color Code: Refer to colors listed in Schedule A. Selections shall be similar to the following standard colors by Tnemec Company:

Dark Blue: 11SF "True Blue/Safety"
 Aqua: 22BL "Spring Rain"
 Red: 17SF "Safety Red"
 Gray: 31GR "Slate Gray"
 Dark Gray: 33GR "Gray"
 Green: 09SF "Spearment Green/Safety"
 Dark Green: 35GN "Garden"
 Olive Green: 17GN "Glen"
 Beige: 14WH "Veiled"
 Yellow: 02SF "Lemon Yellow/Safety"
 White: 00WH "Tnemec White"
 Orange: 04SF "Tangerine Orange/Safety"
 Light Brown: 66BR "Dust Bowl"
 Dark Brown: 15SF "Safety Brown"

2.3 IDENTIFICATION SYSTEMS

- A. Tagging system and stenciling system may be selected by the Contractor. Valve tags shall include identification/tag number, process, size, valve type, direction to open and number of turns to open.
- B. Tagging of Equipment:
 - 1. Yard Valves: Identify with brass marking plate (minimum 1/8-inch thick) with embedment for placement in concrete.
 - 2. Slide Gates: Provide stainless steel plates with black enamel filled embossed lettering. Provide minimum plate of 2-1/2 inches with minimum letter height of 2 inches. Attach to gate frames at visible location by stainless steel fasteners.
 - 3. Process valves, mechanical valves, instrumentation, and mechanical and process equipment (interior/exterior):
 - a. Provide minimum 2-1/2-inch stainless steel plate with black enamel filled lettering.
 - b. Attach to valves by nylon strap or stainless steel nonremovable beaded chains or to equipment by stainless steel fasteners.
 - c. Provide general color scheme of tagging for listed items with black letter and numbers on background as follows:

Instrumentation tags	White
Process valves and equipment tags	Red
Water valves tags	Blue
Mechanical valve and equipment tags	Green
Electrical equipment	Yellow

4. Electrical Equipment: Observe requirements and provisions stated in Division 26 of these specifications.
- C. Identification of piping, process tanks, galleries, pits, chemical liquid or solid storage tanks and silos, storage vessels, air ducts and similar items.
 1. Use Tagging Systems by W. H. Brady Company, as follows:
 - a. Vinyl film cloth for interior non-insulated piping systems (Category B-500).
 - b. Thin film for insulated piping systems (Category B-350).
 - c. All weather film for outdoor exposed piping (Category B-350). Provide flow arrows, banding tape, and numbering and lettering of same materials for corresponding applications.
 2. Use stenciling systems in accordance with accepted practices.
 3. Tagging and stenciling letter and number heights shall be:
 - a. Minimum 1/2 inch for piping less than 1-inch diameter.
 - b. Minimum 1-1/8 inches for piping 1-inch to 3-inch diameter.
 - c. Minimum 2-1/4 inches for piping greater than 3-inch diameter to 24-inch.
 - d. Minimum 3-1/2 inches for piping greater than 24-inch diameter and all process tanks, galleries, pits, chemical, liquid, or solid storage tanks and silos, storage vessels, mechanical heat exchangers, ducts, fans, and similar related items.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Protect printed surfaces and adjacent work and materials by suitable covering during progress of work.
- B. Ensure hardware, accessories, plates, fixtures, finished work and similar items are removed or protected.
- C. Paint or apply not less than one band on any length of pipe. Follow a clean-cut line around entire pipe.
- D. Install piping markers and safety signs only after all painting and finish work has been completed. This does not include temporary "wet paint" or construction safety signs.
- E. Provide arrows and identification stickers:
 1. At 20'-0" maximum centers along continuous lines.
 2. At changes in direction (route), valves, risers, joints, machinery, or equipment.
 3. On both sides of the assembly where pipes and ducts pass through floor, wall, ceiling, cladding assemblies, and similar obstruction.
 4. Apply markers on both sides of pipe and where view is not obstructed.
 5. Arrow markers must point away from pipe markers and in flow direction, if flow in both directions use double-headed arrow markers.
- F. Identify piping and ductwork including interior or exterior, exposed or covered, insulated or not, including pipes and ducts in open or covered floor or ceiling ducts or spaces.
- G. Apply tapes in uniform manner and parallel to piping and ducts.

Schedule A Water Piping Color Code			
Product	Piping Color	Lettering Color	Background Color for Label
Potable Water	Dark Blue	Black	Dark Blue
Backwash Air Scour	Dark Green	Black	Dark Green
Caustic Soda	Yellow with Green Band	Black	Yellow
Chlorine	Yellow	Black	Yellow
Compressed/Instrument Air	Dark Green	Black	Dark Green
Treatment Vessel/Filter Effluent	Aqua	Black	Aqua
Backwash Supply	Light Blue	Black	Dark Blue
Backwash Waste	Light Brown	Black	Light Brown
Drain	Dark Gray	Black	Dark Gray
Filter-to-Waste	Dark Gray	Black	Dark Gray
NPW	Aqua	Black	Aqua
Sewer	Dark Gray	Black	Dark Gray
Sludge	Dark Brown	Black	Dark Brown
Raw Water	Olive Green	Black	Olive Green
Recycle	Olive Green	Black	Olive Green

END OF SECTION

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SECTION 22 00 00
BASIC PLUMBING REQUIREMENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including the, General and Supplementary Conditions, Division-1 Conditions specification sections apply to the Division 22 specifications and drawings.
- B. Related Sections: Refer to all sections in Division 22 and Division 22 drawings. Refer to Division 26 specification section and Division 26 drawings.

1.2 SUMMARY

- A. This Section specifies the basic requirements for plumbing installations and includes requirements common to more than one (1) section of Division 22. It expands and supplements the requirements specified in sections of Division 1 and Division 22.
- B. The Contractor shall coordinate and co-operate with Owner at all times for all new to existing connections, system shutdowns and restart-up, flushing and filling both new and existing systems.
- C. Provide temporary piping services where required to maintain existing areas operable, as shown on the drawings.
- D. Coordinate all services shutdown with the Owner, provide temporary services as shown on the drawings.
- E. The Contractor shall be responsible for the maintenance operation and servicing of all new plumbing systems which are to be used by the Owner during the time of any occupancy and use of any areas within the construction limitations before final completion or acceptance of the systems. A written record of maintenance, operation and servicing shall be turned over to the Owner prior to final acceptance.

1.3 PROJECT CONDITIONS

- A. The Contractor shall be required to attend a mandatory pre-bid walk-thru and shall make themselves familiar with the existing conditions. No additional costs to the Owner shall be accepted for additional work for these existing conditions.
- B. Field verify all existing conditions prior to submitting bids.
- C. Report any existing damaged equipment or systems to the Owner prior to any work.
- D. Protect all plumbing and electrical work against theft, injury or damage from all causes until it has been tested and accepted.
- E. Be responsible for all damage to the property of the Owner or to the work of other contractors during the construction and guarantee period. Repair or replace any part of the Work which may show defect during one (1) year from the final acceptance of all work. Provided such defect is, in the opinion of the Architect, due to imperfect material or workmanship and not due to the Owner's carelessness or improper use.]

1.4 INSTALLER'S QUALIFICATIONS

- A. All Plumbing Work shall be performed by a State of Colorado Licensed Contractor under the supervision of a Licensed Plumber. The General Contractor shall verify that plumbers are currently licensed by the State of Colorado and shall supply the General Contractor Project Manager with names and license numbers. Plumbing Contractors shall have a minimum of three (3) years of satisfactory performance in conducting the type of work specified.

1.5 ACCESSIBILITY

- A. Install equipment and materials to provide required access for servicing and maintenance. Coordinate the final location of concealed equipment and devices requiring access with final location of required access panels and doors. Allow ample space for removal of all parts that require replacement or servicing.
- B. Furnish hinged steel access doors with concealed latch, whether shown on drawings or not, in all walls and ceilings for access to all concealed valves, shock absorbers, air vents, motors, balancing cocks, and other operating devices requiring adjustment or servicing. Refer to Division 1 for access door specification.
- C. The minimum size of any access door shall not be less than the size of the equipment to be removed or 24-inch x 24-inch if used for service only, unless size is indicated on Drawings.
- D. Furnish doors to trades performing work in which they are to be built, in ample time for building-in as the work progresses. Whenever possible, group valves, cocks, etc., to permit use of minimum number of access doors within a given room or space.
- E. Factory manufactured doors shall be of a type compatible with the finish in which they are to be installed.
- F. Access doors in fire-rated walls and ceilings shall have equivalent UL label and fire rating.

1.6 ROUGH-IN

- A. Verify final locations for rough-ins with field measurements and with the requirements of the actual equipment to be connected.
- B. Refer to equipment shop drawings and manufacturer's requirements for actual provided equipment for rough-in requirements.

1.7 REQUIREMENTS OF REGULATORY AGENCIES

- A. Refer to Division 1.
- B. Execute and inspect all work in accordance with all Underwriters, local and state codes, rules and regulations applicable to the trade affected as a minimum, but if the plans and/or specifications call for requirements that exceed these rules and regulations, the greater requirement shall be followed. Follow recommendations of NFPA, EPA, OSHA and ASHRAE.
- C. Comply with standards in effect at the date of these Contract Documents, except where a standard or specific date or edition is indicated.
- D. The handling, removal and disposal of regulated refrigerants shall be in accordance with U.S. EPA, state and local regulations.
- E. After entering into contract, Contractor will be held to complete all work necessary to meet these requirements without additional expense to the Owner.

1.8 REQUIREMENTS OF LOCAL UTILITY COMPANIES

- A. Comply with rules and regulations of local utility companies. Include in bid the cost of all valves, valve boxes, meter boxes, meters and such accessory equipment which will be required for the project.

1.9 PERMITS AND FEES

- A. Refer to Division 1.
- B. Owner shall pay all tap, development, meter, etc., fees required for connection to municipal and public utility facilities.
- C. Contractor shall arrange for and pay for all permits, inspections, licenses and certificates required in connection with the Work.

1.10 PLUMBING INSTALLATIONS

- A. Drawings are diagrammatic in character and do not necessarily indicate every required offset, valve, fitting, etc.
- B. Drawings and specifications are complementary. Whatever is called for in either is binding as though called for in both.
- C. Drawings shall not be scaled for rough-in measurements or used as shop drawings. Where drawings are required for these purposes or have to be made from field measurement, take the necessary measurements and prepare the drawings.
- D. Before any Work is installed, determine that equipment will properly fit the space; that required piping grades can be maintained and that ductwork can be run as contemplated without interferences between systems, with structural elements or with the work of other trades.
- E. Coordinate the installation of mechanical materials and equipment above and below ceilings with suspension system, light fixtures, and other building components.
 - 1. Coordinate ceiling cavity space carefully with all trades. In the event of conflict, install mechanical and electric systems within the cavity space allocation in the following order of priority.
 - a. Plumbing waste, vent piping and roof drain mains and leaders
 - b. Supply, return and exhaust ductwork
 - c. Fire sprinkler mains and leaders
 - d. Electrical conduit
 - e. Domestic cold water piping
 - f. Pneumatic control piping
 - g. Fire sprinkler branch piping and sprinkler runouts
- F. Verify all dimensions by field measurements.
- G. Arrange for chases, slots, and openings in other building components to allow for plumbing installations.
- H. 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.
- I. Sequence, coordinate, and integrate installations of plumbing materials and equipment for efficient flow of the work. Give particular attention to large equipment requiring positioning prior to closing-in the building.

- J. Coordinate the cutting and patching of building components to accommodate the installation of plumbing equipment and materials.
- K. Where mounting heights are not detailed or dimensioned, install plumbing piping and overhead equipment to provide the maximum headroom possible.
- L. Install plumbing equipment to facilitate maintenance and repair or replacement of equipment components. As much as practical, connect equipment for ease of disconnecting, with minimum of interference with other installations.
- M. Coordinate connection of plumbing systems with exterior underground and overhead utilities, services and Division 33. Comply with requirements of governing regulations, franchised service companies, and controlling agencies. Provide required connection for each service.

1.11 EXCAVATING AND BACKFILLING

- A. General:
 - 1. Provide all necessary excavation and backfill for installation of Plumbing Work in accordance with Division 1.
 - 2. In general, follow all regulations of OSHA as specified in Part 1926, Subpart P, "Excavations, Trenching and Shoring". Follow specifications of Division 22 as they refer specifically to the Plumbing Work.
- B. Contact Owners of all underground utilities to have them located and marked, at least two (2) business days before excavation is to begin. Also, prior to starting excavation, brief employees on marking and color codes and train employees on excavation and safety procedures for natural gas lines. When excavation approaches gas lines, expose lines by carefully probing and hand digging.
- C. Provide all necessary pumping, cribbing and shoring.
- D. Walls of all trenches shall be a minimum of 6-inch clearance from the side of the nearest mechanical work. Install pipes with a minimum of 6-inch clearance between them when located in same trench.
- E. Pipe Trenching:
 - 1. Dig trenches to depth, width, configuration, and grade appropriate to the piping being installed. Dig trenches to 6-inches below the level of the bottom of the pipe to be installed. Install 6-inch bed of pea gravel or squeegee, mechanically tamp to provide a firm bed for piping, true to line and grade without irregularity. Provide depressions only at hubs, couplings, flanges, or other normal pipe protrusions.
- F. Backfilling shall not be started until all work has been inspected, tested and accepted. All backfill material shall be reviewed by the Soils Engineer. In no case shall lumber, metal or other debris be buried in with backfill.
- G. Trench Backfill:
 - 1. Backfill to 12-inches above top of piping with pea gravel or squeegee, the same as used for piping bed, compact properly.
 - 2. Continue backfill to finish grade, using friable material free of rock and other debris. Install in 6-inch layers, each properly moistened and mechanically compacted prior to installation of ensuing layer. Compaction by hydraulic jetting is not permissible.
- H. After backfilling and compacting, any settling shall be refilled, tamped, and refinished at this Contractor's expense.

- I. This Contractor shall repair and pay for any damage to finished surfaces.
- J. Complete the backfilling near manholes using pea gravel or squeegee, installing it in 6-inch lifts and mechanically tamping to achieve 95 percent compaction.
- K. Use suitable excavated material to complete the backfill, installed in 6-inch lifts and mechanically compacted to seal against water infiltration. Compact to 95 percent for the upper 30-inches below paving and slabs and 90 percent elsewhere.

1.12 CUTTING AND PATCHING

- A. This Article specifies the cutting and patching of mechanical equipment, components, and materials to include removal and legal disposal of selected materials, components, and equipment.
- B. Refer to Division 1.
- C. Do not endanger or damage installed work through procedures and processes of cutting and patching.
- D. Arrange for repairs required to restore other work, because of damage caused as a result of plumbing installations.
- E. No additional compensation will be authorized for cutting and patching work that is necessitated by ill-timed, defective, or non-conforming installations.
- F. Perform cutting, fitting, and patching of mechanical equipment and materials required to:
 - 1. Uncover work to provide for installation of ill-timed work;
 - 2. Remove and replace defective work;
 - 3. Remove and replace work not conforming to requirements of the Contract Documents;
 - 4. Remove samples of installed work as specified for testing;
 - 5. Install equipment and materials in existing structures;
 - 6. Upon written instructions from the Architect, uncover and restore work to provide for Architect observation of concealed work.
- G. Cut, remove and legally dispose of selected plumbing equipment, components, and materials as indicated, including, but not limited to removal of plumbing piping, plumbing fixtures and trim, and other plumbing items made obsolete by the new work.
- H. Protect the structure, furnishings, finishes, and adjacent materials not indicated or scheduled to be removed.
- I. Provide and maintain an approved type of temporary partitions or dust barriers adequate to prevent the spread of dust and dirt to adjacent areas.
- J. Locate, identify, and protect mechanical, plumbing and electrical services passing through remodeling or demolition area and serving other areas required to be maintained operational.

1.13 PRODUCT OPTIONS AND SUBSTITUTIONS

- A. Refer to the Instructions to Bidders and Division 1, "PRODUCTS, OPTIONS AND SUBSTITUTION".

1.14 PLUMBING SUBMITTALS

- A. Refer to the Conditions of the Contract (General and Supplementary), Division 1 and AIA Document A201, "SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES".

- B. The contractor is to prepare a submittal schedule that coincides with the overall construction schedule. This submittal schedule should include a list of individual products to be submitted under each specification section. This submittal schedule shall also include dates for anticipated review, shipment and on-site delivery times of the submitted product.
- C. The Engineer shall be given a submittal review time of ten (10) working days upon receipt of submittal. Previous submittal rejection or revision shall not compress this review time. It shall be the contractor's responsibility to ensure these review and/or re-review times are incorporated into the submittal schedule with enough lead time as not to affect overall construction schedule. If the project requires a commissioning agent to review the submittals, the engineer's review period does not start until after their review is complete.
 - 1. After review, submittals shall be returned together with review comments and specific actions (if required) to be taken by the Contractor. Typical comments and actions will be:
 - a. Reviewed – Resubmittal not required.
 - b. Rejected – Resubmittal required.
 - c. Revised and Resubmit – Resubmittal required.
 - d. Make Correction Noted – Resubmittal not required unless correction cannot be met.
- D. The manufacturer's material or equipment listed in the schedule or identified by name on the drawings are the types to be provided for the establishment of size, capacity, grade and quality. If alternates are used in lieu of the scheduled names, the cost of any changes in construction required by their use shall be borne by Contractor.
- E. Submittals shall be prepared by authorized equipment dealers, vendors, suppliers, or representative of the products submitted. Include contact and business information of the equipment dealers, vendors, suppliers and representatives. Products and equipment submitted shall also be representative of the products and equipment to be procured and installed. General product data and shop drawings downloaded from unaffiliated websites will not be reviewed or accepted.
- F. All equipment shall conform to the State and/or Local Energy Conservation Standards.
- G. Submittal of shop drawings, product data, and samples will be accepted only when submitted by and stamped by the Contractor. Data submitted from subcontractors and material suppliers directly to the Architect will not be processed unless prior written approval is obtained by the Contractor.
- H. Submit all submittal items required for each Specification Section Submittals shall be prepared and submitted in accordance with the submittal schedule. The contractor is to determine and coordinate submittal review times, lead times and delivery times of submitted products as it coincides with the overall construction schedule. Submittals submitted in bulk or under a single division will not be review and will be sent back as "revise and resubmit".
- I. If more than one (1) re-submittals (either for shop drawings or for as-built drawings) are made by the Contractor, the Owner reserves the right to charge the Contractor for subsequent reviews by their consultants. Such extra fees shall be deducted from payments by the Owner to the Contractor.

- J. Before starting Work, prepare and submit to the Architect all shop drawings and descriptive equipment data required for the project. Unless each item is identified with specification section and sufficient data to identify its compliance with the specifications and drawings, the item will be returned without action or "Revise and Resubmit". Continue to submit shop drawings after each Engineer's action, until a "Reviewed" action is received. The Contractor shall submit the total number of sets as called for in Division 1 to the Architect for final distribution.
- K. Wiring diagrams, control panelboards, motor test data, motors, starters and controls for electrically operated equipment furnished by plumbing trades.
- L. Identify each item with equipment tag with specification section and sufficient data to certify its compliance with the specifications.
- M. Electronic submittals shall be packaged as a bookmarked multi-page single PDF file and shall not be over 5MB. Electronic Submittals over 5MB will not be accepted and will be returned un-reviewed.

1.15 REQUESTS FOR INFORMATION

- A. All "Requests for Information" submitted by the Contractor shall include a proposed solution and an estimated cost/schedule impact. Any RFI's that do not contain this required information will be sent back to the Contractor unanswered.
- B. Schedule the work to provide the Engineer a minimum review time of five (5) days upon receipt of RFIs to provide a response.

1.16 PLUMBING COORDINATION DRAWINGS

- A. Prepare and submit a complete set of Coordination Drawings as necessary or required by the Engineer showing major elements, components, and systems of plumbing equipment and materials in relationship with other trades, sub-trades and building components. Prepare drawings to an accurate scale of 1/4"=1'-0" or larger. Indicate the locations of all equipment and materials, including clearances for installing and maintaining insulation, servicing and maintaining equipment, valve stem movement, and similar requirements. Indicate movement and positioning of large equipment into the building during construction.
- B. This project has been completed in Revit. This Contractor shall review the model created by the Architect/Engineer that illustrated the design intent of the project. This model is not intended to be used as a shop drawing, but as a tool to enable the Contractor to fabricate and coordinate the installation of the work described in these documents.

1.17 PRODUCT LISTING

- A. Prepare listing of major plumbing equipment and materials for the project, within two (2) weeks of signing the Contract Documents and transmit to the Mechanical Engineer.
- B. Unless otherwise specified, all materials and equipment shall be of domestic (USA) manufacture and shall be of the best quality used for the purpose in commercial practice.
- C. Provide all information requested.
- D. Submit this listing as a part of the submittal requirement specified in Division 1, "PRODUCTS AND SUBSTITUTION".

- E. When two (2) or more items of same material or equipment are required (plumbing fixtures, pumps, valves, etc.) they shall be of the same manufacturer. Product manufacturer uniformity does not apply to raw materials, bulk materials, pipe, tube, fittings (except flanged and grooved types), sheet metal, wire, steel bar stock, welding rods, solder, fasteners, motors for dissimilar equipment units, and similar items used in work, except as otherwise indicated.
- F. Provide products which are compatible within systems and other connected items.

1.18 NAMEPLATE DATA

- A. Provide permanent operational data nameplate on each item of plumbing equipment, indicating manufacturer, product name, model number, serial number, capacity, operating and power characteristics, labels of tested compliances, and similar essential data. Locate nameplates in an accessible location.

1.19 DELIVERY, STORAGE, AND HANDLING

- A. Refer to Division 1.
- B. Deliver products to project properly identified with names, model numbers, types, grades, compliance labels, and similar information needed for distinct identifications; adequately packaged and protected to prevent damage during shipment, storage, and handling.
- C. Store equipment and materials at the site, unless off-site storage is authorized in writing. Protect stored equipment and materials from damage, dirt, dust and moisture.
- D. Coordinate deliveries of plumbing materials and equipment to minimize construction site congestion. Limit each shipment of materials and equipment to the items and quantities needed for the smooth and efficient flow of installations.
- E. Provide factory-applied plastic end-caps on each length of pipe and tube, except for hub-and-spigot and no-hub pipe. Maintain end-caps through shipping, storage and handling to prevent pipe-end damage and prevent entrance of dirt, debris, and moisture.
- F. Protect stored pipes and tubes. Elevate above grade and enclose with durable, waterproof wrapping. When stored inside, do not exceed structural capacity of the floor.
- G. Protect flanges, fittings, and specialties from moisture and dirt by inside storage and enclosure, or by packaging with durable, waterproof wrapping.

1.20 RECORD DOCUMENTS

- A. Refer to Division 1. The following paragraphs supplement the requirements of Division 1.
- B. Keep a complete set of record document prints or electrical mark-ups in custody during entire period of construction at the construction site.
- C. Mark drawing prints to indicate revisions to piping, size and location both exterior and interior; including locations of control devices and units requiring periodic maintenance or repair; actual equipment locations, dimensioned from column lines; actual inverts and locations of underground piping; concealed equipment, dimensioned to column lines; mains and branches of piping systems, with valves and control devices located and numbered, concealed unions located, and with items requiring maintenance located (i.e., strainers, expansion compensators, tanks, etc.); RFI's; change orders; concealed control system devices. Changes to be noted on the drawings shall include final location of any piping relocated more than 1'-0" from where shown on the drawings.

- D. Mark Equipment Schedules on the drawings with changes to Manufacturer, Model Number, and data based on reviewed shop drawings.
- E. At the completion of the project, mark all valve tag numbers on the drawings and turn these drawings over to the General Contractor for his submission to the Architect. This Contract will not be considered completed until these record drawings have been received and reviewed by the Architect.

1.21 OPERATION AND MAINTENANCE DATA

- A. Refer to Division 1.
- B. In addition to the information required by Division 1 for maintenance data, include the following information:
 - 1. Description of plumbing equipment, function, normal operating characteristics and limitations, performance curves, engineering data and tests, and complete nomenclature and commercial numbers of all replaceable parts.
 - 2. Manufacturer's printed operating procedures to include start-up, break-in, routine and normal operating instructions; regulation, control, stopping, shutdown, and emergency instructions; and summer and winter operating instructions.
 - 3. Maintenance procedures for routine preventative maintenance and troubleshooting; disassembly, repair, and reassembly; aligning and adjusting instructions.
 - 4. Servicing instructions and lubrication charts and schedules.
 - 5. Manufacturer's service manuals for all plumbing equipment provided under this Contract.
 - 6. Include the valve tag list.
 - 7. Name, Address and Telephone Number of party to be contacted for twenty-four (24) hour service for each item of equipment.
 - 8. Starting, stopping, lubrication, equipment identification numbers and adjustment clearly indicated for each piece of equipment.
 - 9. Complete parts list.
 - 10. Plumbing warranties.
- C. This Contract will not be considered completed, nor will final payment be made, until all specified material is received in this Operating and Maintenance Report and the manual is reviewed by the Architect.

1.22 LUBRICATION OF EQUIPMENT

- A. Refer to Division 1. The following paragraphs supplement the requirements of Division 1.
- B. Contractor shall properly lubricate all plumbing pieces of equipment which he provided before turning the building over to the Owner. He shall attach a linen tag or heavy duty shipping tag on the piece of equipment showing the date of lubrication and the type and brand of lubricant used.
- C. Furnish the Engineer with a Electronic Document, of each item lubricated and type of lubricant used, no later than two (2) weeks before completion of the project, or at time of acceptance by the Owner of a portion of the building and the mechanical systems involved.

1.23 WARRANTIES

- A. Refer to Division 1 for procedures and submittal requirements for warranties. Refer to individual equipment specifications for warranty requirements. In any case, the entire mechanical system shall be warranted no less than one (1) year from the time of acceptance by the Owner.
- B. Compile and assemble the warranties specified in Division 22, into a separated set of vinyl covered, three-ring binders, tabulated and indexed for easy reference.
- C. Provide complete warranty information for each item to include product or equipment to include date or beginning of warranty or bond; duration of warranty or bond; and names, addresses, and telephone numbers and procedures for filing a claim and obtaining warranty services.

1.24 CLEANING

- A. Refer to Division 1.
- B. Refer to other sections of Division 22, for requirements cleaning strainers and disinfection of plumbing systems prior to final acceptance.

PART 2 - PRODUCTS – NOT USED

PART 3 - EXECUTION – NOT USED

END OF SECTION

SECTION 22 05 00
COMMON WORK RESULTS FOR PLUMBING

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

- A. Extent of Piping Specialties Work required by this section is indicated on drawings and schedules and by requirements of this section.
- B. Types of Piping Specialties specified in this section include the following:
 - 1. Escutcheons
 - 2. Dielectric Fittings
 - 3. Mechanical Sleeve Seal
 - 4. Fire and Smoke Barrier Penetration Seal
 - 5. Pipe Sleeve
 - 6. Sleeve Seals
- C. Piping Specialties furnished as part of factory-fabricated equipment, are specified as part of equipment assembly in other Division 22 sections.

1.2 QUALITY ASSURANCE

- A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of piping specialties of types and sizes required, whose products have been in satisfactory use in similar service for not less than five (5) years.
- B. Codes and Standards:
 - 1. ASME B 31.9 "Building Services Piping" for materials, products, and installation.
 - 2. Safety valves and pressure vessels shall bear the appropriate ASME label.
 - 3. Fabricate and stamp air separators and compression tanks to comply with ASME Boiler and Pressure Vessel Code, Section VIII, Division 1.
 - 4. ASME "Boiler and Pressure Vessel Code," Section IX, "Welding and Brazing Qualification" for qualifications for welding processes and operators.

1.3 SUBMITTALS

- A. Product Data: Submit manufacturer's technical product data, including installation instructions, and dimensioned drawings for each type of manufactured piping specialty. Include pressure drop curve or chart for each type and size of pipeline strainer. Submit schedule showing manufacturer's figure number, size, location, and features for each required piping specialty.
- B. Shop Drawings: Submit for fabricated specialties, indicating details of fabrication, materials, and method of support.
- C. Maintenance Data: Submit maintenance data and spare parts lists for each type of manufactured piping specialty. Include this data, product data, and shop drawings in maintenance manual; in accordance with requirements of Division 1.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturer: Subject to compliance with requirements, provide products by one of the following:
1. Pipe Escutcheons:
 - a. Brasscraft
 - b. Dearborn
 - c. Keeney
 - d. McGuire
 2. Dielectric Fittings:
 - a. B & K Industries, Inc. (Unions Only)
 - b. Capital Mfg. Co.; Division of Harsco Corp. (Unions Only)
 - c. Epco Sales, Inc. (Unions Only)
 - d. Jay R. Smith Mfg. CO
 - e. Precision Plumbing Products (PPP)
 3. Mechanical Sleeve Seal:
 - a. GPT Industries
 - b. "Metraseal" by Metraflex Co.
 4. Fire and Smoke Barrier Penetration Seal:
 - a. Electrical Products Division/3M
 - b. Dow Corning
 - c. Flame Stop, Inc.
 - d. MetaCaulk
 - e. Hilti
 - f. HoldRite

2.2 PIPE ESCUTCHEONS

- A. General: Provide pipe escutcheons as specified herein with inside diameter closely fitting pipe outside diameter, or outside of pipe insulation where pipe is insulated. Select outside diameter of escutcheon to completely cover pipe penetration hole in floors, walls, or ceilings; and pipe sleeve extension, if any. Furnish pipe escutcheons with nickel or chrome finish for occupied areas, prime paint finish for unoccupied areas.
- B. Pipe Escutcheons for Moist Areas: For waterproof floors, and areas where water and condensation can be expected to accumulate, provide cast brass or sheet brass escutcheons, solid or split hinged.
- C. Pipe Escutcheons for Dry Areas: Provide sheet steel escutcheons, solid or split hinged.

2.3 DIELECTRIC FITTINGS

- A. General: Provide standard products recommended by manufacturer for use in service indicated, which effectively isolate ferrous from non-ferrous piping (electrical conductance), prevent galvanic action, and stop corrosion.
- B. Dielectric Unions: Provide dielectric unions on open systems where indicated on the Drawings.

C. Dielectric Waterway Fittings:

1. electroplated steel nipple complying with ASTM F1545 with inert, non-corrosive polypropylene lining (NSF/FDA listed).
2. Thread x thread ends 1/2-inch x 3-inch through 4-inch x 6-inch.
3. Groove x thread ends 1/2-inch x 4-inch through 4-inch x 6-inch.
4. Pressure Rating and Temperature: 300psig at 225 deg F
5. Listed by IAPMO PS 66 / UPC.
6. Dielectric unions are not an acceptable substitute for dielectric waterway fittings.

D. Dielectric Flange Insulation Kits:

1. Field-assembled, companion flange assembly, full face or ring type.
2. Neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers.
3. Provide separate companion flanges and steel bolts and nuts.
4. Rated at 175 psi conforming to ANSI B16.42 (iron) B16.24 (bronze).
5. Factory certified to withstand minimum of 600 volts on a dry line without flashover.
6. Meets federal specifications for tensile strength and thread end connections.

2.4 MECHANICAL SLEEVE SEALS

- A. General: Modular mechanical type, consisting of interlocking synthetic rubber links shaped to continuously fill annular space between pipe and sleeve, connected with bolts and pressure plates which cause rubber sealing elements to expand when tightened, providing watertight seal and electrical insulation.

2.5 FIRE AND SMOKE BARRIER PENETRATION SEALS

- A. General: Provide UL Listed firestopping systems composed of components that are compatible with each other, the substrates forming openings, and the items, if any, penetrating the firestopping under conditions of service and application, as demonstrated by the firestopping manufacturer based on testing and field experience.
- B. Provide components for each firestopping system that are needed to install fill material. Use only components specified by the firestopping manufacturer and approved by the qualified testing agency for the designated fire-resistance-rated systems.
- C. Penetrations in Fire Resistive Rated Walls: Provide firestopping with ratings determined in accordance with UL 1479 or ASTM E 814.
1. F-Rating: Not less than the fire-resistance rating of the wall construction being penetrated.
- D. Penetration in Horizontal Assemblies: Provide firestopping with ratings determined in accordance with UL 1479 or ASTM E 814.
1. F-Rating: Minimum of 1-hour rating, but not less than the fire-resistance rating of the floor construction being penetrated.
 2. T-Rating: When penetrant is located outside of a wall cavity, minimum of 1-hour rating, but not less than the fire-resistance rating of the floor construction being penetrated.
 3. W-Rating: Class 1 rating in accordance with water leakage test per UL 1479.

- E. Penetrations in Smoke Barriers: Provide firestopping with ratings determined in accordance with UL1479 or ASTM E 814.
 - 1. L-Rating: Not exceeding 5.0 cfm/sq. ft. of penetration opening at both ambient and elevated temperatures.

2.6 FABRICATED PIPING SPECIALTIES

- A. Pipe Sleeves: Provide pipe sleeves of one (1) of the following:
 - 1. Sheet Metal: Fabricate from galvanized sheet metal; round tube closed with snaplock joint, welded spiral seams, or welded longitudinal joint. Fabricate from the following gauges: 3-inch and smaller, 20 gauge; 4-inch to 6-inch, 16 gauge; over 6-inch, 14 gauge.
 - 2. Steel Pipe: Fabricate from Schedule 40 galvanized steel pipe; remove burrs.
 - 3. Iron Pipe: Fabricate from cast iron or ductile iron pipe; remove burrs.
- B. Sleeve Seals: Provide sleeve seals for sleeves located in foundation walls below grade, or in exterior walls, of one (1) of the following:
 - 1. Mechanical Sleeve Seals: Installed between sleeve and pipe.

PART 3 - EXECUTION

3.1 INSTALLATION OF PIPING SPECIALTIES

- A. Pipe Escutcheons: Install pipe escutcheons on each pipe penetration through floors, walls, partitions, and ceilings where penetration is exposed to view; and on exterior of building. Secure escutcheon to pipe or insulation so escutcheon covers penetration hole and is flush with adjoining surface.
- B. Dielectric Unions: Install at each piping joint between ferrous and non-ferrous piping. Comply with manufacturer's installation instructions.
- C. Mechanical Sleeve Seals: Loosely assemble rubber links around pipe with bolts and pressure plates located under each bolt head and nut. Push into sleeve and center. Tighten bolts until links have expanded to form watertight seal.
- D. Fire or Fire/Smoke Barrier Penetration Seals: Where pipe penetration occurs in fire or fire/smoke rated walls, provide: a complete listed protection assembly equal to the rating of the wall/floor.
- E. Provide dielectric waterways or insulating flanges, as required by pipe size, on all connections of dissimilar metals.

3.2 SLEEVES AND SEALS

- A. Pipes:
 - 1. Pipes:
 - a. New Construction: Pipes penetrating concrete or masonry construction, whether insulated or not, shall be provided with sheet metal or pipe sleeves fitted into place at time of construction. In poured concrete, the sleeves shall be steel pipe with a full circle, continuously welded water stop plate to also act as a sleeve anchor. When installing Link-Seal the sleeve and Link-Seal shall be of matched sizes. Otherwise, sleeves shall be of such size to provide all around clearance of 1/4-inch to 1-inch. Seal entire space between pipe and sleeve with fire stopping as specified in "Seals".

- b. Sleeves in non-fire rated or non-bearing walls, floors, or ceilings, new or existing construction, shall be steel pipe or galvanized sheet metal with lock-type longitudinal seam. Pack all open spaces on each end with mineral wool or other non-combustible material, positively fastened in place. Asbestos is not acceptable.
 - c. Where a pipe of any description passes through a concrete floor, the sleeve shall extend at least 2-inch above the finished floor, except when using the ProSet Systems.
 - d. At Contractor's option, where uninsulated pipes penetrate cast-in-place concrete floors, the "ProSet Systems," Atlanta, Georgia, sleeving may be employed.
 - e. For pipes penetrating foundation walls, water-proofing membrane floors or other places where water leakage could be encountered, install Link-Seal wall sleeves by GPT Industries in manner recommended by the manufacturer.
- B. Where pipe penetrations occur in non-fire rated floors, roof slabs, or walls, the space between pipe insert and the sleeve shall be packed on each end with mineral wool or other non-combustible material, positively fastened in place. Use plenum rated caulk to seal packing around pipe.
- C. Seals:
 - 1. General:
 - a. Seal all holes or voids where mechanical systems penetrate fire rated floors and walls with a fire stopping sealant having a fire rating equal to or greater than that of the construction being penetrated. The sealant shall meet the requirements of ASTM E-814, ASTM E-119 and UL-1479. It shall be installed with strict adherence to the manufacturer's instructions and according to the product's UL Laboratory listing. The use of asbestos in any form is not permitted.
 - 2. Conduct tests according to manufacturer's written recommendations to verify that substrates are free of oil, grease, rolling compounds, incompatible primers, loose mill scale, dirt, and other foreign substances capable of impairing bond of firestopping.
 - 3. Do not cover firestopping with other construction until approval of authority having jurisdiction has been received.
- D. Escutcheons:
 - 1. In finished parts of the building, after painting is completed, install chromium plated escutcheons on all pipes passing through walls and floors where piping is exposed to view.
- E. Flash and counterflash where mechanical equipment passes through weather or water-proofed walls, floors, and roofs per roof manufacturer's instructions.
- F. Provide dielectric waterways or insulating flanges, as required by pipe size, on all connections of dissimilar metals.

3.3 INSTALLATION OF FABRICATED PIPING SPECIALTIES

- A. Pipe Sleeves: Install pipe sleeves of types indicated where piping passes through walls, floors, ceilings, and roofs. Do not install sleeves through structural members of work, except as detailed on drawings, or as reviewed by Architect/Engineer. Install sleeves accurately centered on pipe runs. Size sleeves so that piping and insert will have free movement in sleeve, including allowance for thermal expansion; but not less than two (2) pipe sizes larger than piping run. Install length of sleeve equal to thickness of construction penetrated, and finish flush to surface, except floor sleeves. Extend floor sleeves in rooms 3/4-inch above level floor finish, and 4-inch above finished floor in all Mechanical Equipment Rooms and pipe chases. Provide temporary support of sleeves during placement of concrete and other work around sleeves and provide temporary closure to prevent concrete and other materials from entering sleeves.
1. Install sheet metal sleeves at interior partitions and ceilings other than suspended ceilings.
 2. Install iron pipe sleeves at exterior penetrations, both above and below grade.
 3. Install steel pipe sleeves except as otherwise indicated.

END OF SECTION

SECTION 22 05 19
METERS AND GAUGES FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

- A. Extent of Meters and Gauges required by this section is indicated on drawings and/or specified in other Division 22 sections.
- B. Types of Meters and Gauges specified in this section include the following:
 - 1. Pressure Gauges and Fittings:
 - a. Pressure Gauges
 - b. Pressure Gauge Cocks
- C. Meters and gauges furnished as part of factory-fabricated equipment are specified as part of equipment assembly in other Division 22 sections.

1.2 QUALITY ASSURANCE

- A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of meters and gauges, of types and sizes required, whose products have been in satisfactory use in similar service for not less than five (5) years.
- B. Codes and Standards:
 - 1. UL Compliance: Comply with applicable UL Standards pertaining to meters and gauges.
 - 2. ANSI and ISA Compliance: Comply with applicable portions of ANSI and Instrument Society of America (ISA) Standards pertaining to construction and installation of meters and gauges.
 - 3. NSF Compliance: Construct and install thermometers and gauges in compliance with the lead-free requirements of NSF 61 Annex G and/or NSF 372.
- C. Certification: Provide meters and gauges whose accuracies, under specified operating conditions, are certified by manufacturer.

1.3 SUBMITTALS

- A. Product Data: Submit manufacturer's technical product data, including installation instructions for each type of meter and gauge. Include scale range, ratings, and calibrated performance curves, certified where indicated. Submit meter and gauge schedule showing manufacturer's figure number, scale range, location, and accessories for each meter and gauge.
- B. All flow measuring devices to be provided shall be reviewed and approved by the Test and Balance Contractor for proper scale, rangeability and function prior to submitting shop drawings. The Test and Balance Contractor shall provide a typed letter stating this review has been completed and included with shop drawing submittals.
- C. Maintenance Data: Submit maintenance data and spare parts lists for each type of meter and gauge. Include this data and product data in Maintenance Manual; in accordance with requirements of Division 1.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturer: Subject to compliance with requirements, provide products by one of the following:
 - 1. Pressure Gauges, Snubbers and Pressure Gauge Cocks:
 - a. Ametek/U.S. Gauge
 - b. Miljoco Corp.
 - c. Dwyer
 - d. Trerice
 - e. Winters Instruments

2.2 PRESSURE GAUGES

- A. General: Provide pressure gauges of materials, capacities, and ranges indicated, designed, and constructed for use in service indicated. All wetted parts in contact with water shall be certified to meet the requirements of NSF 372.
- B. Type: General Use, 1 percent accuracy, ANSI B40.1 Grade A, phosphor bronze bourdon type, bottom connection.
- C. Case: Stainless steel, drawn steel, cast aluminum or brass, glass lens, 4-1/2 inch diameter.
- D. Connector: Brass with 1/4-inch male NPT.
- E. Scale: White coated aluminum, with permanent markings.
- F. Range: Conform to the following:
 - 1. Water: 0 - 160 PSI.

2.3 PRESSURE GAUGE COCKS

- A. General: Provide lead-free pressure gauge cocks between pressure gauges and gauge tees on piping systems. Construct gauge cock of brass with 1/4-inch female NPT on each end, and "T" handle brass plug.
- B. Snubber: 1/4-Inch lead-free brass bushing with corrosion resistant porous metal disc, through which pressure fluid is filtered. Select disc material for fluid served and pressure rating.

PART 3 - EXECUTION

3.1 INSPECTION

- A. Examine areas and conditions under which meters and gauges are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.2 INSTALLATION OF TEMPERATURE GAUGES

- A. General: Install temperature gauges in vertical upright position and tilted so as to be easily read by observer standing on floor.
- B. Thermometer Wells: Install in piping tee where indicated, in vertical upright position. Fill well with oil or graphite, secure cap.

3.3 INSTALLATION OF PRESSURE GAUGES

- A. General: Install pressure gauges in piping tee with pressure gauge cock, located on pipe at most readable position.
- B. Locations: Install in the following locations, and elsewhere as indicated:
 - 1. At suction and discharge of each pump.
 - 2. At water service outlet.
- C. Pressure Gauge Cocks: Install in piping tee with snubber.
- D. All pressure gauges shall have isolation gauge cock, "snubber" valve, to service the gauge and isolate it from the pipe system service without having to drain the piping system.

3.4 ADJUSTING AND CLEANING

- A. Adjusting: Adjust faces of meters and gauges to proper angle for best visibility.
- B. Cleaning: Clean windows of meters and gauges and factory-finished surfaces. Replace cracked or broken windows, repair any scratched or marred surfaces with manufacturer's touch-up paint.

END OF SECTION

SECTION 22 05 23
GENERAL-DUTY VALVES FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

- A. This Section includes potable cold, hot, and recirculated hot water valves within the building to a point 5-feet outside the building. This section includes the following:
1. Valves

1.2 QUALITY ASSURANCE

- A. Regulatory Requirements: Comply with the provisions of the following:
1. Comply with ASME B16.10 and ASME B16.34 for Dimension and Design Criteria.
 2. NSF Compliance: NSF 61 and NSF 372 for products that contact drinking water.
 3. Local Plumbing Code and Utility Department requirements.
 4. Colorado Cross Connection Control Manual.
 5. Safe Drinking Water Act – Public Law No. 111-380.

1.3 INSTALLER'S QUALIFICATIONS

- A. All Plumbing Work shall be performed by a State of Colorado Licensed Contractor under the supervision of a Licensed Plumber. Contractors shall verify that plumbers are currently licensed by the State of Colorado and shall supply the Project Manager with names and license numbers. Contractors shall have a minimum of three (3) years of satisfactory performance in conducting the type of work specified.

1.4 SUBMITTALS

- A. Submit under provisions of Division 1.

1.5 CLOSEOUT SUBMITTALS

- A. Submit under provisions of Division 1.
- B. Test Reports.
- C. Valve schedule listing valve designation number, valve type, size, location, and function of all valves.

PART 2 - PRODUCTS

2.1 VALVES

- A. General:
1. Valves shall be NSF/ANSI 61 and NSF/ANSI 372 compliant for potable-water service. Valves for domestic water shall be 3rd Party Certified.
 2. Comply with MSS-92 1980 "Valve Users Manual".
 3. Sizes: Provide valves of same size as upstream pipe size.
 4. Extended Stems: Where insulation is indicated or specified, provide extended stems to allow full operation of the valve without interference by the insulation.
 5. Bypass and Drain Connections: Comply with MSS SP-45.

B. Gate Valves:

1. 2-1/2 Inch and Larger: Lead-free, MSS-SP 70, 200 PSI CWP, non-rising stem, bolted bonnet, resilient wedge, NSF epoxy coated ASTM A126 Class B cast iron body or ASTM A536 ductile iron body, handwheel operator.
 - a. Acceptable Manufacturers:
 - 1) Nibco
 - 2) Apollo
 - 3) Watts
 - 4) Kennedy Valve
 - 5) Wilkens

C. Ball Valves:

1. 2-Inch and Smaller: MSS-SP-110, 100 PSI at 300°F, 600 PSI CWP, two-piece ASTM B-584 lead-free cast bronze body, full port, chrome plated brass/bronze ball, PTFE seats, anti-blowout stem, separate packnut with adjustable stem packing, extended stem, and vinyl covered steel handle. Threaded or soldered end connections. Valve shall be NSF/ANSI 61 and NSF/ANSI 372 compliant for potable-water service.
 - a. Acceptable Manufacturers:
 - 1) Nibco
 - 2) Apollo
 - 3) Milwaukee
 - 4) Hammond

D. Butterfly Valves:

1. 2-1/2 Inch and Larger: MSS-SP-67, ASTM A126 cast iron body or ASTM A536 ductile iron body, Class B fully lugged, lead-free aluminum bronze disc, stainless steel stem, EPDM liner, bronze bearings, non-metallic bushing and EPDM or Buna-N stem seals. Rated for 200 PSI bi-directional shutoff and 200 PSI dead-end service with downstream piping removed. The valve design shall be for ANSI 125 or 150 flanges. Provide extended neck for insulation. Sizes 3-inch – 6-inch shall be lever operated with 10-position throttling plate; sizes 8-inch and larger shall have weatherproof gear operators. Valve shall be NSF/ANSI 61 and NSF/ANSI 372 compliant for potable-water service.
 - a. Acceptable Manufacturers:
 - 1) Nibco
 - 2) Apollo
 - 3) Watts
 - 4) Val Matic Valve – American BfV
 - 5) Milwaukee
 - 6) Hammond
 - b. 3-Inch and Larger: MSS SP-71; Class 125, ASTM A126 Class B cast iron body with bronze trim, non-asbestos gasket, horizontal swing, and flanged ends. Valve shall be capable of being refitted without removing from pipe. Valve shall be NSF 61 and NSF/ANSI 372 compliant for potable-water service.
 - 1) Acceptable Manufacturers:
 - a) Nibco
 - b) Apollo

- E. Drain Valve: Lead-free bronze ball valve with threaded hose end and cap with chain. Valve upstream of backflow preventer shall have vacuum breaker and cap. MSS-SP-110, 600 PSI CWP, two-piece ASTM B-584 lead-free cast bronze body, full port, chrome plated brass/bronze ball, PTFE seats, anti-blowout stem, separate packnut with adjustable stem packing, extended stem, and vinyl covered steel handle. Threaded or soldered end connections. Valve shall be NSF/ANSI 61 and NSF/ANSI 372 compliant for potable-water service.
1. Acceptable Manufacturers:
 - a. Nibco
 - b. Apollo
 - c. Milwaukee
 - d. Hammond

PART 3 - EXECUTION

3.1 VALVES

- A. Installation:
1. Use gate valves only on domestic water service entrances as specified by the Authority Having Jurisdiction.
 2. Use ball or butterfly valves for isolation valves unless noted otherwise.
 3. Shutoff Valves: Install shutoff valves on inlet of each plumbing equipment item, and stops on inlet of each plumbing fixture, and elsewhere as indicated.
 4. Drain Valves: Install drain valves at the base of each riser, at low points of horizontal runs, and elsewhere as required to completely drain distribution piping system.
 5. Check Valves: Install check valves on discharge side of each pump, each side of reduced pressure backflow preventers and elsewhere as indicated.

3.2 ADJUSTING AND CLEANING

- A. Adjust or replace valve packing after piping systems have been tested and put into service but before final adjusting and balancing. Replace valves if persistent leaking occurs.

END OF SECTION

SECTION 22 05 29
HANGERS AND SUPPORTS FOR PLBG PIPING AND EQUIP

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

- A. Extent of Supports and Anchors required by this section is indicated on drawings and/or specified in other Division 22 sections.
- B. Types of Supports and Anchors specified in this section include the following:
 - 1. Horizontal-Piping Hangers and Supports
 - 2. Vertical-Piping Clamps
 - 3. Hanger-Rod Attachments
 - 4. Building Attachments
 - 5. Thermal Shield Inserts and Protective Shields
 - 6. Miscellaneous Materials
 - 7. Anchors
- C. Supports and anchors furnished as part of factory-fabricated equipment are specified as part of equipment assembly in other Division 22 sections.

1.2 QUALITY ASSURANCE

- A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of supports and anchors, of types and sizes required, whose products have been in satisfactory use in similar service for not less than five (5) years.
- B. Codes and Standards:
 - 1. Regulatory Requirements: Comply with applicable Plumbing Codes pertaining to product materials and installation of supports and anchors.
 - 2. MSS Standard Compliance:
 - a. Provide pipe hangers and supports of which materials, design, and manufacture comply with MSS SP-58.

1.3 SUBMITTALS

- A. Product Data: Submit manufacturer's technical product data, including installation instructions for each type of support and anchor. Submit pipe hanger and support schedule showing manufacturer's figure number, size, location, and features for each required pipe hanger and support.
- B. Shop Drawings: Submit manufacturer's assembly-type shop drawings for each type of support and anchor, indicating dimensions, weights, required clearances, and methods of assembly of components.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturer: Subject to compliance with requirements, provide products by one of the following:

1. Pipe Hangers and Supports:
 - a. B-Line Systems, Inc.
 - b. Carpenter and Patterson, Inc.
 - c. Fee & Mason Mfg. Co.; Division Figgie International
 - d. PHD Manufacturing, Inc.
 - e. Elcen Metal Products Company
 - f. Erico/Caddy
 - g. Unistrut Metal Framing Systems
 - h. Hubbard Enterprises (Supports for domestic water piping)
 - i. Hilti Construction Chemicals, Inc.
 - j. Anvil
2. Thermal Shields:
 - a. B-Line Systems, Inc.
 - b. Pipe Shields, Inc.
 - c. Insulation Pipe Supports Manufacturing
 - d. Insulated Saddle Shield Insert Product Inc.
 - e. Erico/Caddy
 - f. Component Products Co.
 - g. Value Engineered Products, Inc.
 - h. Snappitz
 - i. Anvil
3. Concrete Inserts and Anchors:
 - a. Phillips Drill Company
 - b. Erico/Caddy
 - c. Elcen Metal Products Company
 - d. ITW Ramset/Red Head
 - e. Hilti Construction Chemicals, Inc.
 - f. B-Line Systems, Inc.
 - g. Blue Banger Hanger

2.2 PIPE HANGERS AND SUPPORTS

A. Hangers and support components shall be factory fabricated of materials, design, and manufacturer complying with MSS SP-58.

1. Components shall have galvanized coatings where installed for piping and equipment that will not have field-applied finish.
2. Pipe attachments shall have nonmetallic coating for electrolytic protection where attachments are in direct contact with copper tubing.

B. Adjustable Clevis Hanger: MSS Type 1

1. Steel Pipe, size 3/8-inch thru 12-inch, B-Line B3100
2. Copper Pipe, size 1/2-inch thru 4-inch, B-Line B3104CT
3. Cast Iron Pipe, size 4-inch thru 24-inch, B-Line B3100

- C. Adjustable Swivel Ring: MSS Type 10
 - 1. Steel Pipe, size 1/2-inch thru 2-inch, B-Line B3170NF
 - 2. Copper Pipe, size 1/2-inch thru 4-inch, B-Line B3170CT
- D. Pipe Clamps: MSS Type 8
 - 1. Steel Pipe, size 3/4-inch thru 20-inch, B-Line B3373
 - 2. Copper Pipe, size 1/2-inch thru 4-inch, B-Line B3373CT
- E. Floor Standpipe Saddle Support: MSS Type 37
 - 1. Steel Pipe, size 1 1/2-inch thru 12-inch, B-Line B3095
- F. Hanger Rods: Continuous threaded steel, sizes as specified.
- G. Pipe Alignment Guides:
 - 1. Pipe Guides: Provide factory-fabricated guides, of cast semi-steel or heavy fabricated steel, consisting of bolted two-section outer cylinder and base with two-section guiding spider bolted tight to pipe. Size guide and spiders to clear pipe and insulation (if any), and cylinder. Provide guides of length recommended by manufacturer to allow indicated travel.
- H. Multiple or Trapeze: Structural steel channel (with web vertical), with welded spacers and hanger rods. Provide hanger rods one (1) size larger than for largest pipe in trapeze. If the deflection at center of trapeze exceeds 1/360 of the distance between the end hangers, install an additional hanger at mid-span or use a larger channel.
- I. Wall Supports for Horizontal Pipe:
 - 1. 1/2-Inch thru 3-1/2 Inch: Steel offset hook.
 - 2. 4-Inch and Over: Welded steel bracket and wrought steel clamp.
- J. Supports for Vertical Pipe: Steel or Copper Coated riser clamp.
- K. Upper Attachments:
 - 1. Beam Clamps:
 - a. All thread rod sized 3/8-inch and 1/2-inch, B-Line B3034
 - b. All thread rod sizes 5/8-inch, B-Line B3033
 - c. All thread rod sizes 3/4-inch and up, B-Line B3055

2.3 CONCRETE INSERTS AND ANCHORS

- A. Inserts: Case shall be of galvanized carbon steel with square threaded concrete insert nut for hanger rod connection; 3/4-inch lateral adjustment; top lugs for reinforcing rods, nail holes for attaching to forms. Erico Hanger Models 355 and 355N or equal. This type of upper attachment is to be used for all areas having poured in place concrete construction.
 - 1. Size inserts to suit threaded hanger rods.
- B. Anchors: Carbon steel, zinc plated and coated with a clear chromate finish. Installation shall be in holes drilled with carbide-tipped drill bits or by use of self-drilling anchors.
 - 1. Provide anchors suitable for the location of installation and designed to withstand all forces and movements acting in the anchor. Manufacture pipe anchors in accordance with MSS SP 58. Provide a safety factor of four (4) for the anchor installation.
 - 2. Powder driven fasteners subject to approval of Structural Engineer. Each fastener shall be capable of holding a test load of 1,000 pounds whereas the actual load shall not exceed 50 pounds.

3. Self-drilling expansion shields. The load applied shall not exceed one-fourth the proof test load required.
4. Machine bolt expansion anchor. The load applied shall not exceed one-fourth the proof test load required.

2.4 THERMAL SHIELD INSERTS AND PROTECTIVE SHIELDS

- A. General: Provide thermal shield inserts under all insulated piping hangers. Provide thermal shield inserts on all piping through floors, wall and roof construction penetrations. Size saddles and thermal shield inserts for exact fit to mate with pipe insulation or a minimum of 1-inch thick for uninsulated pipe thermal shield inserts.
- B. Galvanized Protection Shields: MSS Type 40; of length recommended by manufacturer to prevent crushing of insulation. See also Part 3.H.3.
 1. B-Line B3151
- C. Thermal Shield Inserts: Provide 100-psi average compressive strength, waterproof, asbestos free calcium silicate, encased with galvanized steel protection shields or other listed system manufacturers. Insert and shield shall cover the entire circumference on vertical pipes, or the bottom half circumference of the pipe on horizontal mounting supports, and shall be of length recommended by the manufacturer for pipe size and thickness of insulation or the thickness of the wall, roof or floor construction.

<u>NPS</u>	<u>Length</u>	<u>Metal Shield Thickness</u>
1/4 thru 3-1/2	12	0.048
4	12	0.060
5 and 6	18	0.060
8 thru 14	24	0.075
16 thru 24	24	0.105

- D. Thermal Mechanical Pipe Shields: Self-locking insulated pipe supports/shields shall be provided at hanger, support, and guide locations on pipe requiring insulation. The insert shall consist of either hydrous calcium silicate or polyisocyanurate foam insulation (urethane) encircling the entire circumference of the pipe with a 360 degree PVC or galvanized steel jacket which complies with the International Mechanical Code for installation in plenum ceilings where applicable. The length of the jacket shall be sized for pipe expansion.

2.5 MISCELLANEOUS MATERIALS

- A. Steel Plates, Shapes, and Bars: ASTM A 36.
- B. Cement Grout: Portland cement (ASTM C 150, Type I or Type III) and clean uniformly graded, natural sand (ASTM C 404, Size No. 2). Mix ratio shall be 1.0 part cement to 3.0 parts sand, by volume, with minimum amount of water required for placement and hydration.
- C. Heavy-Duty Steel Trapezes: Fabricate from steel shapes selected for loads required; weld steel in accordance with AWS Standards.

PART 3 - EXECUTION

3.1 INSPECTION

- A. Examine areas and conditions under which supports and anchors are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.2 PREPARATION

- A. Proceed with installation of hangers, supports and anchors only after required building structural work has been completed in areas where the work is to be installed. Correct inadequacies including (but not limited to) proper placement of inserts, anchors and other building structural attachments.
- B. Prior to installation of hangers, supports, anchors and associated work, Installer shall meet at Project Site with Contractor, installer of each component of associated work, inspection and testing agency representatives (if any), installers of other work requiring coordination with work of this section and Architect/Engineer for purpose of reviewing material selections and procedures to be followed in performing the work in compliance with requirements specified.

3.3 INSTALLATION OF BUILDING ATTACHMENTS

- A. Install building attachments within concrete or on structural steel. Space attachments within maximum piping span length indicated in MSS SP-69 and tables in this section. Install additional attachments at concentrated loads, including valves, flanges, guides, strainers, expansion joints, and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten insert to forms. Where concrete with compressive strength less than 2,500 psi is indicated, install reinforcing bars through openings at top of inserts.
- B. New Construction:
 - 1. Use inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams wherever practicable.
 - 2. Set inserts in position in advance of concrete work. Provide reinforcement rod in concrete for inserts carrying pipe over 4-inch.
 - 3. Where concrete slabs form finished ceiling, finish inserts flush with slab surface.
 - 4. Use drop-in anchors for concrete structures.
 - 5. Use beam clamps for steel structures.

3.4 INSTALLATION OF HANGERS AND SUPPORTS

- A. Install piping and supports as indicated in the detail on the drawings or the code, whichever is most restrictive.
- B. Do not use wire or perforated metal to support piping, and do not support piping from other piping.
- C. Support fire-water piping independently from other piping systems.
- D. Install hangers and supports to allow controlled movement of piping systems, to permit freedom of movement between pipe anchors, to facilitate action of expansion joints, expansion loops, expansion bends and similar units and within 1'-0" of each horizontal elbow.

- E. Load Distribution: Install hangers and supports so that piping live and dead loading and stresses from movement will not be transmitted to connected equipment.
- F. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes, and so that maximum pipe deflections allowed by ANSI B31.9 Building Services Piping Code is not exceeded.
- G. Each pipe drop to equipment shall be adequately supported. All supporting lugs or guides shall be securely anchored to the building structure.
- H. Install anchors and fasteners in accordance with manufacturer's recommendations and the following:
 - 1. In the event a self-drilling expansion shield or machine bolt expansion shield is considered to have been installed improperly, the Contractor shall make an acceptable replacement or demonstrate the stability of the anchor by performing an on-site test under which the anchor will be subjected to a load equal to twice the actual load.
 - 2. Powder-driven fasteners may be used only where they will be concealed after the construction is complete. Where an occasional fastener appears to be improperly installed, additional fastener(s) shall be driven nearby (not closer than six (6) inches) in undisturbed concrete. Where it is considered that many fasteners are improperly installed, the Contractor shall test load any fifty (50) successively driven fasteners. If 10 percent or more of these fasteners fail, the Contractor shall utilize other fastening means as approved and at no additional cost to the Owner.
 - 3. Hangers for piping shall be attached to cellular steel floor decks with steel plates and bolted rod conforming to the steel deck manufacturer's requirements. Where the individual hanger load exceeds the capacity of a single floor deck attachment, steel angles, beams or channels shall be provided to span the number of floor deck attachments required.
 - 4. Welding may be used for securing hangers to steel structural members. Welded attachments shall be designed so that the fiber stress at any point of the weld or attachment will not exceed the fiber stress in the hanger rod.

3.5 INSTALLATION OF ANCHORS

- A. Install anchors at proper locations to prevent stresses from exceeding those permitted by ANSI B31.9, and to prevent transfer of loading and stresses to connected equipment.
- B. Fabricate and install anchor by welding steel shapes, plates and bars to piping and to structure. Comply with ANSI B31.9 and with AWS Standards D1.1.
- C. Where expansion compensators are indicated, install anchors in accordance with expansion unit manufacturer's written instructions, to control movement to compensators.
- D. Anchor Spacings: Where not otherwise indicated, install anchors at ends of principal pipe-runs, at intermediate points in pipe-runs between expansion loops and bends. Make provisions for preset of anchors as required to accommodate both expansion and contraction of piping.

3.6 METAL FABRICATION

- A. Cut, drill, and fit miscellaneous metal fabrications for pipe anchors and equipment supports. Install and align fabricated anchors in indicated locations.

- B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.
- C. Field Welding: Comply with AWS D1.1 for procedures of manual shielded metal-arc welding, appearance and quality of welds made, methods used in correcting welding work, and the following:
 - 1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
 - 2. Obtain fusion without undercut or overlap.
 - 3. Remove welding flux immediately.
 - 4. Finish welds at exposed connections so that no roughness shows after finishing.

3.7 ADJUSTING

- A. Hanger Adjustment: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.
- B. Touch-Up Painting: Immediately after erection of anchors and supports, clean field welds and abraded areas of shop paint and paint exposed areas with same material as used for shop painting to comply with SSPC-PA-1 requirements for touch-up of field-painted surfaces.
 - 1. Apply by brush or spray to provide a minimum dry film thickness of 2.0 mils.
- C. For galvanized surfaces, clean welds, bolted connections and abraded areas and apply galvanizing repair paint to comply with ASTM A 780.

END OF SECTION

SECTION 22 05 53
IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

- A. Extent of Mechanical Identification Work required by this section is indicated on drawings and/or specified in other Division 22 sections.
- B. Types of Identification Devices specified in this section include the following:
 - 1. Plastic Pipe Markers
 - 2. Plastic Tape
 - 3. Underground-Type Plastic Line Marker
 - 4. Valve Tags
 - 5. Valve Schedule Frames
 - 6. Engraved Plastic-Laminate Signs
 - 7. Plasticized Tags
 - 8. Lettering and Graphics
- C. Refer to Division 26 sections for Identification Requirements of Electrical Work; not work of this section.

1.2 QUALITY ASSURANCE

- A. Manufacturer's Qualifications: Firms regularly engaged in manufacturer of identification devices of types and sizes required, whose products have been in satisfactory use in similar service for not less than five (5) years.
- B. Codes and Standards:
 - 1. ANSI Standards: Comply with ANSI A13.1 for lettering size, length of color field, colors, and viewing angles of identification devices.

1.3 SUBMITTALS

- A. Product Data: Submit manufacturer's technical product data and installation instructions for each identification material and device required.
- B. Schedules: Submit valve schedule for each piping system, typewritten and reproduced on 8-1/2" x 11" bond paper. Tabulate valve number, piping system, system abbreviation (as shown on tag), location of valve (room or space), size of valve, and variations for identification (if any). Only tag valves which are intended for emergency shutoff and similar special uses, such as valve to isolate individual system risers, individual floor branches or building system shut-off valves. In addition to mounted copies, furnish extra copies for Maintenance Manuals as specified in Division 1.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturer: Subject to compliance with requirements, provide products by one of the following:
 - 1. Allen Systems, Inc.

2. Brady (W.H.) Co.; Signmark Division
3. Brimar Industries, Inc.
4. Industrial Safety Supply Co., Inc.
5. Seton Name Plate Corp.

2.2 MECHANICAL IDENTIFICATION MATERIALS

- A. General: Provide manufacturer's standard products of categories and types required for each application as referenced in other Division 22 sections. Where more than single type is specified for application, selection is Installer's option, but provide single selection for each product category.

2.3 PLASTIC PIPE MARKERS

- A. Snap-On Type: Provide manufacturer's standard pre-printed, semi-rigid snap-on, color-coded pipe markers, complying with ANSI A13.1.
- B. Small Pipes: For external diameters less than 6-inch (including insulation if any), provide full-band pipe markers, extending 360 degrees around pipe at each location, fastened by one (1) of the following methods:
 1. Snap-on application of pre-tensioned semi-rigid plastic pipe marker.
 2. Taped to pipe (or insulation) with color-coded plastic adhesive tape, not less than 3/4-inch wide; full circle at both ends of pipe marker, tape lapped 1-1/2 inch.
- C. Large Pipes: For external diameters of 6-inch and larger (including insulation if any), provide either full-band or strip-type pipe markers, but not narrower than three (3) times letter height (and of required length), fastened by one (1) of the following methods:
 1. Steel spring or non-metallic fasteners.
 2. Taped to pipe (or insulation) with color-coded plastic adhesive tape, not less than 1-1/2 inch wide; full circle at both ends of pipe marker, tape lapped 3-inches.
 3. Strapped-to-pipe (or insulation) application of semi-rigid type, with manufacturer's standard stainless steel bands.
- D. Lettering: Comply with piping system nomenclature as specified, scheduled, shown, or to match existing building lettering nomenclature system and abbreviate only as necessary for each application length.
- E. Arrows: Print each pipe marker with arrows indicating direction of flow, either integrally with piping system service lettering (to accommodate both directions), or as separate unit of plastic.

2.4 PLASTIC TAPE

- A. General: Provide manufacturer's standard color-coded pressure-sensitive (self-adhesive) vinyl tape, not less than 3 mils thick.
- B. Width: Provide 1-1/2 inch wide tape markers on pipes with outside diameters (including insulation, if any) of less than 6-inch, 2-1/2 inch wide tape for larger pipes.
- C. Color: Comply with ANSI A13.1, except where another color selection is indicated.

2.5 UNDERGROUND-TYPE PLASTIC LINE MARKERS

- A. General: Manufacturer's standard permanent, bright-colored, continuous-printed plastic tape, intended for direct-burial service; not less than 6-inch wide x 4 mils thick. Provide tape with printing which most accurately indicates type of service of buried pipe.
- B. Provide multi-ply tape consisting of solid aluminum foil core between 2-layers of plastic tape.

2.6 VALVE TAGS

- A. Brass Valve Tags: Provide 19-gauge polished brass valve tags with stamp-engraved piping system abbreviation in 1/4-inch high letters and sequenced valve numbers 1/2-inch high, valve normal position 1/4-inch high letters, and with 5/32-inch hole for fastener.
 - 1. Provide 1-1/2 inch diameter tags, except as otherwise indicated.
 - 2. Fill tag engraving with Black enamel.
- B. Valve Tag Fasteners: Provide manufacturer's standard solid brass chain (wire link or beaded type), and solid brass S-hooks of the sizes required for proper attachment of tags to valves, and manufactured specifically for that purpose.
- C. Access Panel Markers: Provide manufacturer's standard 1/16-inch thick engraved plastic laminate access panel markers, with abbreviations and numbers corresponding to concealed valve. Include 1/8-inch center hole to allow attachment.

2.7 VALVE SCHEDULE

- A. Valve Schedule shall be printed on company letterhead and shall include the following columns:
 - 1. Valve Tag Number (*example*: HWS-1)
 - 2. Service (*example*: ISOLATE AHU-1 HEATING COIL)
 - 3. Room Number (location of valve)
 - 4. Size of Valve
 - 5. Type of Valve
 - 6. Normal Position of the Valve (open or closed)
- B. Frame: For each page of valve schedule, provide glazed display frame, with screws for removable mounting on masonry walls. Provide frames of finished hardwood or extruded aluminum, with non-glare type plexiglass.

2.8 ENGRAVED PLASTIC-LAMINATE SIGNS

- A. General: Provide engraving stock melamine plastic laminate, complying with FS L-P-387, in the sizes and thicknesses indicated, engraved with engraver's standard letter style of the sizes and wording indicated, Black with White core (letter color) except as otherwise indicated, punched for mechanical fastening except where adhesive mounting is necessary because of substrate.
- B. Thickness: 1/8-Inch, except as otherwise indicated.
- C. Fasteners: Self-tapping stainless steel screws, except contact-type permanent adhesive where screws cannot or should not penetrate the substrate.

2.9 PLASTICIZED TAGS

- A. General: Manufacturer's standard pre-printed or partially pre-printed accident-prevention tags, of plasticized card stock with matt finish suitable for writing, approximately 3-1/4 inch x 5-5/8 inch, with brass grommets and wire fasteners, and with appropriate pre-printed wording including large-size primary wording (As examples; DANGER, CAUTION, DO NOT OPERATE).

2.10 LETTERING AND GRAPHICS

- A. General: Coordinate names, abbreviations and other designations used in mechanical identification work, with corresponding designations shown, specified, scheduled and approved by the Owner/Engineer. Provide numbers, lettering and wording as indicated and approved by the Owner/Engineer for proper identification and operation/maintenance of mechanical systems and equipment.
- B. Multiple Systems: Where multiple systems of same generic name are shown and specified, provide identification which indicates individual system number as designated on the drawings or schedule as well as service.

PART 3 - EXECUTION

3.1 GENERAL INSTALLATION REQUIREMENTS

- A. Coordination: Where identification is to be applied to surfaces which require insulation, painting or other covering or finish, including valve tags in finished mechanical spaces, install identification after completion of covering and painting. Install identification prior to installation of acoustical ceilings and similar removable concealment.

3.2 PIPING SYSTEM IDENTIFICATION

- A. General: Install pipe markers of the following type on each system indicated to receive identification, and include arrows to show normal direction of flow. Existing building identification shall match the existing method which exists in the building.
- B. Plastic pipe markers, with application system as indicated under "MATERIALS" in this section. Install on pipe insulation segment where required for hot non-insulated pipes.
- C. Locate pipe markers and color bands as follows wherever piping is exposed to view in occupied spaces, machine rooms, accessible maintenance spaces (shafts, tunnels, plenums) and exterior non-concealed locations.
- D. Near each valve and control device.
- E. Near each branch, excluding short take-offs for fixtures; mark each pipe at branch, where there could be question of flow pattern.
- F. Near locations where pipes pass through walls or floors/ceilings, or enter non-accessible enclosures.
- G. At access doors, manholes and similar access points which permit view of concealed piping.
- H. Near major equipment items and other points of origination and termination.
- I. Spaced intermediately at maximum spacing of 25-foot along each piping run, except reduce spacing to 15-foot in congested areas of piping and equipment.

- J. On piping above removable acoustical ceilings.

3.3 UNDERGROUND PIPING IDENTIFICATION

- A. General: During back-filling/top-soiling of each exterior underground piping systems, install continuous underground-type plastic line marker, located directly over buried line at 6-inch to 8-inch below finished grade. Where multiple small lines are buried in common trench and do not exceed overall width of 16-inch, install single line marker. For tile fields and similar installations, mark only edge pipelines of field.

3.4 VALVE IDENTIFICATION

- A. General: Provide valve tag on valves in each piping system. List each tagged valve in valve schedule for each piping system.
 - 1. Building services main shutoff valves.
 - 2. Each individual system main shutoff valves.
 - 3. Each individual system riser shutoff valves.
 - 4. Each individual system major branch shutoff valves.
- B. Provide the following columns and information for each valve:
 - 1. Valve Tag Number (*example*: HWS-1)
 - 2. Service (*example*: ISOLATE AHU-1 HEATING COIL)
 - 3. Room Number (location of valve)
 - 4. Size of Valve
 - 5. Type of Valve
 - 6. Normal Position of the Valve (open or closed)
- C. Mount valve schedule frames and schedules in mechanical equipment rooms where directed by Architect/Owner/Engineer.

3.5 MECHANICAL EQUIPMENT IDENTIFICATION

- A. General: Install minimum 2-inch x 4-inch engraved plastic laminate equipment marker on each individual items of mechanical equipment. Provide signs for the following general categories of equipment.
 - 1. Main building systems control and operating valves, including safety devices and hazardous units.
 - 2. Pumps, and similar motor-driven units.
- B. Lettering Size: Minimum 1/4-inch high lettering for name of unit.
- C. Text of Signs: In addition to the identified unit, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations.

3.6 ADJUSTING AND CLEANING

- A. Adjusting: Relocate any mechanical identification device which has become visually blocked by work of this division or other divisions.
- B. Cleaning: Clean face of identification devices, and glass frames of valve charts.

END OF SECTION

SECTION 22 11 16
DOMESTIC WATER PIPING

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

- A. This Section includes potable cold, hot, and recirculated hot water piping, fittings, and specialties within the building to a point 5-feet outside the building. This section includes the following:
 - 1. Pipe and Tube Materials:
 - a. Above Grade, inside buildings.

1.2 DEFINITIONS

- A. Water Distribution Piping: A pipe within the building or on the premises, which conveys water from the water service pipe or meter to the points of usage.
- B. Water Service Piping: The pipe from the water main or other source of potable water supply to the water distributing system of the building served.

1.3 QUALITY ASSURANCE

- A. Regulatory Requirements: Comply with the provisions of the following:
 - 1. ASME B 31.9 "Building Services Piping" for materials, products and installation. Safety valves and pressure vessels shall bear the appropriate ASME label.
 - 2. ASME "Boiler and Pressure Vessel Code", Section IX, "Welding and Brazing Qualification" for Qualifications for Welding Processes and Operators.
 - 3. Comply with ANSI B31 Code for Pressure Piping.
 - 4. Local Plumbing Code and Utility Department requirements.
 - 5. Comply with NSF 61: Drinking Water System Components - Health Effects; Sections 1 through 9," For Potable Domestic Water Piping and Components; NSF 61 Annex G or NSF 372.
 - 6. Colorado Cross Connection Control Manual.
 - 7. Safe Water Drinking Act – Including Public Law 111-380 – Cited as the "Reduction of Lead in Drinking Water Act".
- B. All piping systems shall be installed to manufacturer's standards and in accordance with the pipe manufacturer's instructions. Contractor shall demonstrate prior to installation of any piping that joining methods and procedures are acceptable to the Engineer and/or Owner with the Factory Representative present. During the installation of the piping system, the Contractor shall be required to provide joint coupons as requested by the Owner or Engineer and repair and/or replace system if joints are deemed unsatisfactory.

1.4 INSTALLER'S QUALIFICATIONS

- A. All Plumbing Work shall be performed by a State of Colorado Licensed Contractor under the supervision of a Licensed Plumber. The General Contractor shall verify that plumbers are currently licensed by the State of Colorado Plumbing Contractors shall have a minimum of three (3) years of satisfactory performance in conducting the type of work specified.

1.5 SUBMITTALS

- A. Submit under provisions of Division 1.

1.6 CLOSEOUT SUBMITTALS

- A. Submit under provisions of Division 1.
- B. Test Reports.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers:
 - 1. Copper Pipe and Fittings:
 - a. Mueller Streamline
 - b. Cerro Flow Products
 - c. Cambridge-Lee Industries
 - d. Nibco
 - 2. Copper Pressure Sealed Fittings (Optional system):
 - a. Viega – Pro-Press
 - b. Apollo – Apollo Press

2.2 PIPE AND TUBE MATERIALS

- A. Above Grade Inside Buildings:
 - 1. Pipe 4-Inch and Smaller: ASTM B 88; Type L lead-free hard drawn copper tube.
 - a. Fittings:
 - 1) Lead-Free Wrought Copper Solder-Joint Fittings: ASME B16.22.
 - 2) Lead-Free Cast Copper Solder-Joint Fittings: ASME B16.18.
 - 3) Lead-Free Cast Copper Alloy Flanges Class 150 and 300, Flat-Face Type: ASME B16.24.
 - 4) Contractor Optional system: Cast and wrought copper press connect fittings: ASME B16.18, ASME B16.22, ASME B16.51, and IAPMO PS 177 approved. Press connect fittings shall be lead-free confirming to NSF 61 and NSF-372. Fitting shall be press type with EPDM sealing elements. Sealing elements shall be factory installed or an alternative supplied by fittings manufacturer. Contractor shall order valves and other components that are compatible with this press system. Solder joints are acceptable where press system is not the appropriate application.
 - b. Joining Material:
 - 1) Lead-Free Solder: ASTM B32; minimum tensile strength of 5,900 psi. Solder shall be certified to meet NSF 61 Annex G or NSF 372.
 - c. Fluxes:
 - 1) ASTM B813, Lead-Free Water Soluble, Liquid or Paste Type and be certified to meet NSF 61 Annex G or NSF 372.

PART 3 - EXECUTION

3.1 PIPING INSTALLATION

- A. Install pipes and pipe fittings in accordance with recognized industry practices to achieve permanently leak proof piping systems, capable of performing service without piping failure. Install each run with minimum joints and couplings, but with adequate and accessible unions for disassembly and maintenance/ replacement of valves and equipment. Reduce sizes by use of reducing fittings. Align piping accurately at connections, within 1/16-inch misalignment tolerance.
- B. Electrical Equipment Spaces: Do not run piping through transformer vaults and other electrical or electronic equipment spaces and enclosures. Only piping serving this type of equipment space shall be allowed.
- C. Use fittings for all changes in direction and all branch connections.
- D. Install piping straight, plumb, level and at right angles or parallel to building walls. Diagonal runs are not permitted, unless expressly indicated.
- E. Conceal all pipe installations in walls, pipe chases, utility spaces, above ceilings, below grade or floors, unless indicated to be exposed to view.
- F. Install piping tight to slabs, beams, joists, columns, walls, and other permanent elements of the building. Install piping free of sags or bends and allow sufficient space above removable ceiling panels to allow for panel removal.
- G. Locate groups of pipes parallel to each other, spaced to permit application of insulation and servicing of valves.
- H. Install means to drain the system at all low points in mains, risers, and branch lines.
- I. Fire and Smoke Wall Penetrations: Maintain the fire and smoke rated integrity where pipes pass through fire and smoke rated walls, partitions, ceilings, and floors.
- J. Exterior Wall Penetrations: Seal pipe penetrations through exterior walls using sleeves and mechanical sleeve seals. Use steel pipe for sleeves 6-inch and smaller. Use sheet metal for pipe sleeves 6-inch and larger.
- K. Coordinate foundation and all other structural penetrations with Structural Engineer.
- L. Install pipe ends clean and free from indentations, projections, and roll marks in the area from pipe end to groove for proper gasket seating.
- M. Pressure-Sealed Joints for Copper Tubing:
 - 1. Cut tubing with a tubing cutter ensuring a square cut.
 - 2. Ream pipe ends to remove internal and external burrs.
 - 3. Measure and mark full fitting cup depth on tubing to ensure fittings are completely seated and using the full cup depth during layout and fittings press.
 - 4. Join tubing and press connect fittings with tools recommended by fitting manufacturer.
 - 5. Installation training shall be provided on site by manufacturer personnel and documented with Engineer or safety director. Installation procedures, depth guides, and tool inspection shall be provided by manufacturer for all product types (steel or copper) for reference and safety assurance.

3.2 SERVICE ENTRANCE

- A. Extend water distribution piping 5'-0" outside of building.
- B. Install sleeve and mechanical sleeve seal at penetrations through foundation wall for watertight installation.
- C. Install shutoff valve at service entrance inside building; complete with strainer, pressure gauge, and test tee with valve.

3.3 EQUIPMENT CONNECTIONS

- A. Piping Runouts to Fixtures: Provide hot and cold water piping run outs to fixtures of sizes indicated, but in no case smaller than required by Plumbing Code.
- B. Mechanical Equipment Connections: Provide shutoff valve and union for each connection, provide drain valve on drain connection. For connections 2-1/2 inch and larger, use flanges instead of unions.

3.4 FIELD QUALITY CONTROL

- A. Inspections: Inspect water distribution piping as follows:
 - 1. Do not enclose, cover, or put into operation water distribution piping system until it has been inspected and approved by the Authority Having Jurisdiction.
 - 2. During the progress of the installation, notify the Plumbing Official Having Jurisdiction, at least forty-eight (48) hours prior to the time such inspection must be made. Perform tests specified below in the presence of the Plumbing Official.
 - a. Rough-In Inspection: Arrange for inspection of the piping system before concealed or closed-in after system is roughed-in, and prior to setting fixtures.
 - b. Final Inspection: Arrange for a final inspection by the Plumbing Official to observe the tests specified below and to insure compliance with the requirements of the Plumbing Code.
 - 3. Reinspections: Whenever the Plumbing Official finds that the piping system will not pass the test or inspection, make the required corrections and arrange for reinspection by the Plumbing Official.
 - 4. Reports: Prepare inspection reports, signed by the Plumbing Official.
- B. Piping Tests:
 - 1. General: Provide temporary equipment for testing, including pump and gauges. Test piping system before insulation is installed wherever feasible. Test each natural section of each piping system independently but do not use piping system valves to isolate sections where test pressure exceeds valve pressure rating. Fill each section with water and pressurize for indicated pressure and time.
 - 2. Test piping that is to be concealed before being permanently enclosed.
 - 3. As soon as work has been completed, conduct preliminary tests to ascertain compliance with specified requirements. Make repairs or replacements as required.
 - 4. Give a minimum of twenty-four (24) hours notice to Engineer of dates when acceptance test will be conducted. Conduct tests as specified for each system in presence of representative of Agency Having Jurisdiction or his representative. Submit three (3) copies of successful tests to the Engineer for his review. Report shall state system tested and date of successful test.

5. Obtain certificates of approval, acceptance and compliance with regulations of Agencies Having Jurisdiction. Work shall not be considered complete until such certificates have been delivered.
6. All costs involved in these tests shall be borne by Contractor.
7. System Tests:
 - a. Hydrostatic Test: Pressurize the system to 100psig or 150 percent of system pressure, whichever is greater. Maintain pressure until the entire system has been inspected for leaks, but in no case for a time period of less than four (4) hours.
 - b. Compressed Air or Nitrogen Test: Compressed air tests may be substituted for hydrostatic tests only when ambient conditions prohibit safe use of hydrostatic testing and must be reviewed by the Engineer prior to any testing. For tests of this type, subject the piping system to the gas pressure indicated for that specific system. Maintain the test pressure for the duration of a soapy water test of each joint. The air test is not allowed on CPVC piping systems.
 - c. Repair failed piping sections by disassembly and re-installation, using new materials to extent required to overcome leakage. Do not use chemicals, stop-leak compounds, mastics, or other temporary repair methods.
 - d. Drain test water from piping systems after testing and repair work has been completed.

3.5 ADJUSTING AND CLEANING

- A. Clean and disinfect water distribution piping as follows:
 1. Purge all new water distribution piping systems and parts of existing systems, which have been altered, extended, or repaired prior to use. Clean and replace strainers.
 2. Use the purging and disinfecting procedure prescribed by the Authority Having Jurisdiction, or in case a method is not prescribed by that authority, the procedure described in either AWWA C651, or AWWA C652, or as described below:
 - a. Flush the piping system with clean, potable water until dirty water does not appear at the points of outlet.
 - b. Fill the system or part thereof, with a water/chlorine solution containing at least 50 parts per million of chlorine. Isolate (valve off) the system, or part thereof, and allow to stand for twenty-four (24) hours or fill with a water/chlorine solution containing at least 200 parts per million of chlorine and isolate and allow to stand for three (3) hours.
 - c. Following the allowed standing time, flush the system with clean potable water until chlorine does not remain in the water coming from the system.
 - d. Submit water samples in sterile bottles to the Authority Having Jurisdiction. Repeat the procedure if the biological examination made by the authority shows evidence of contamination.
- B. Prepare reports for all purging and disinfecting activities.

END OF SECTION

SECTION 22 11 19
DOMESTIC WATER PIPING SPECIALTIES

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

- A. This Section includes potable cold, hot, and recirculated hot water specialties within the building to a point 5-feet outside the building. This section includes the following:
 - 1. Piping Specialties:
 - a. Strainers
 - b. Hose Bibbs
 - c. Backflow Preventers

1.2 QUALITY ASSURANCE

- A. Regulatory Requirements: Comply with the provisions of the following:
 - 1. Local Plumbing Code and Utility Department requirements.
 - 2. NSF 61 Compliance: Drinking Water System Components – Health Effects; Sections 1 through 9 and Annex G.
 - 3. Safe Drinking Water Act – Public Law No. 111-380.
 - 4. Colorado Cross Connection Control Manual.
 - 5. NSF/ANSI 372: Drinking Water System Components, Lead Content
- B. All piping systems shall be installed to manufacturer's standards and in accordance with the pipe manufacturer's instructions. Contractor shall demonstrate prior to installation of any piping that joining methods and procedures are acceptable to the Engineer and/or Owner with the Factory Representative present. During the installation of the piping system, the Contractor shall be required to provide joint coupons as requested by the Owner or Engineer and repair and/or replace system if joints are deemed unsatisfactory.

1.3 INSTALLER'S QUALIFICATIONS

- A. All Plumbing Work shall be performed by a State of Colorado Licensed Contractor under the supervision of a Licensed Plumber. Contractors shall verify that plumbers are currently licensed by the State of Colorado and shall supply the Project Manager with names and license numbers. Contractors shall have a minimum of three (3) years of satisfactory performance in conducting the type of work specified.

1.4 SUBMITTALS

- A. Submit under provisions of Division 1.

1.5 CLOSEOUT SUBMITTALS

- A. Submit under provisions of Division 1.
- B. Test Reports.
- C. Valve schedule listing valve designation number, valve type, size, location, and function of all valves.
- D. Backflow Preventer State Certification Test.

PART 2 - PRODUCTS

2.1 PIPING SPECIALTIES

A. Strainers:

1. Wye Pattern Strainers: 3-inch to 8-inch; 200 PSIG working pressure, cast iron construction body coated with FDA approved epoxy for domestic water service, bottom drain connection, ANSI Class 125 flanged connections, 300 series perforated screens (1/16-inch perforations for 3 and 4 inch size, 1/8-inch perforations for 6 and 8-inch size). Strainer shall be certified to meet the lead-free requirements of NSF 61 and NSF/ANSI 372.
 - a. Acceptable Manufacturers:
 - 1) Wilkins
 - 2) Watts
 - 3) Febco

B. Hose Bibbs:

1. Unfinished and Equipment Rooms: Rough chrome plated bronze body, renewable composition disc, removable handle, 3/4-inch NPT inlet, vacuum breaker, 3/4-inch hose outlet.
 - a. Acceptable Manufacturers:
 - 1) Woodford
 - 2) T&S Brass
 - 3) Zurn

C. Backflow Preventers:

1. Reduced Pressure Type: Ductile iron (2-1/2 inch - 10-inch) body, FDA approved fusion epoxy finish with two (2) independently operating, spring loaded check valves and one (1) differential relief valve with automatic intermediate atmospheric vent. Assembly to be furnished with full port, positive shutoff isolation valves, in-line strainer, flanged connections, funnel, and all test cocks. Assembly to have approval of National Sanitary Foundation, U.S.C. Foundation for Cross Connection Control, ASSE 1013, AWWA C511 compliant, FM Approved, UL Classified, State and or Local Authorities. Backflow preventer shall be certified to meet the lead-free requirements of NSF 61 and NSF/ANSI 372.
 - a. Acceptable Manufacturers:
 - 1) Wilkins
 - 2) Febco
 - 3) Watts

PART 3 - EXECUTION

3.1 INSTALLATION OF PIPING SPECIALTIES

A. Backflow Preventers:

1. Install in compliance with the International Plumbing Code, Colorado Cross Connection Control Department (CDPHE – Water Quality Control Division) and Authority Having Jurisdiction. Pipe relief outlet through air gap and without valves, to nearest floor drain.

2. Provide testing and report on all backflow prevention devices in accordance with the International Plumbing Code and the Colorado Cross Connection Control Manual (Latest Edition) requirements. Attach testing approval tag to all back flow preventers.

3.2 FIELD QUALITY CONTROL

A. Inspections: Inspect water distribution piping as follows:

1. Do not enclose, cover, or put into operation water distribution piping system until it has been inspected and approved by the Authority Having Jurisdiction.
2. During the progress of the installation, notify the Plumbing Official Having Jurisdiction, at least forty-eight (48) hours prior to the time such inspection must be made. Perform tests specified below in the presence of the Plumbing Official.
 - a. Rough-In Inspection: Arrange for inspection of the piping system before concealed or closed-in after system is roughed-in, and prior to setting fixtures.
 - b. Final Inspection: Arrange for a final inspection by the Plumbing Official to observe the tests specified below and to insure compliance with the requirements of the Plumbing Code.
3. Reinspections: Whenever the Plumbing Official finds that the piping system will not pass the test or inspection, make the required corrections and arrange for reinspection by the Plumbing Official.
4. Reports: Prepare inspection reports, signed by the Plumbing Official.

END OF SECTION

SECTION 22 13 16
SANITARY WASTE & VENT PIPING

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

- A. This Section specifies the following:
 - 1. Pipe and Tube Materials:
 - a. Sanitary Drainage, Vents
 - b. Sump Pump Discharge
 - c. Equipment Drains and Overflows

1.2 DEFINITIONS

- A. Building Drain: That part of the lowest piping of a drainage system which receives the discharge from soil, waste, and other drainage pipes inside the walls of the building and conveys it to the building sewer to a point 5'-0" outside the building wall.
- B. Building Sewer: That part of the horizontal piping of a drainage system which extends from the end of the building drain and conveys its discharge to a public sewer, private sewer, individual sewage disposal system, or other point of disposal.
- C. Drainage System: Includes all the piping within a public or private premises which conveys sewage, rain water or other liquid wastes to a point of disposal. It does not include the mains of public sewer systems or a private or public sewage treatment or disposal plant.
- D. Vent System: Pipe or pipes installed to provide a flow of air to or from a drainage system, or to provide a circulation of air within such system to protect trap seals from siphonage and back pressure.

1.3 SUBMITTALS

- A. Submit under provisions of Division 1.

1.4 CLOSEOUT SUBMITTALS

- A. Submit under provisions of Division 1.

1.5 QUALITY ASSURANCE

- A. Regulatory Requirements: Comply with the provisions of the following:
 - 1. Plumbing Code Compliance: Comply with applicable portions of the International Plumbing Code.
 - 2. ANSI Compliance: Comply with applicable ANSI standards pertaining to materials, products, and installation of soil and waste systems.
 - 3. ASSE Compliance: Comply with applicable ASSE standards pertaining to materials, products, and installation of soil and waste systems.
 - 4. ASTM Compliance: Comply with applicable ASTM Standards pertaining to materials, products, and installation of soil and waste systems.
 - 5. CISPI Compliance: Comply with applicable CISPI Standards pertaining to materials, products, and installation of soil and waste systems.

6. PDI Compliance: Comply with applicable PDI standards pertaining to products and installation of soil and waste systems.
7. PVC Pipe: Only Contractor's personnel which have received training in the installation of this material and meet the manufacturer's qualifications shall do the assembly of such material.

PART 2 - PRODUCTS

2.1 SANITARY DRAINAGE AND VENTS

A. Below Grade:

1. Pipe 2-Inch to 15-Inch: Service class cast iron hub-and-spigot soil pipe, ASTM A74. Pipe and fittings shall be marked with the collective trademark of the Cast Iron Soil Pipe Institute and be listed by NSF International.
 - a. Fittings: ASTM A74 cast iron service class, hub and spigot compression joint, long sweep bends.
 - b. Neoprene Compression Gaskets: ASTM C564.
2. Pipe 2-Inch to 16-Inch: Iron Pipe Size (IPS) Polyvinyl Chloride (PVC) Solid Wall Schedule 40 DWV.
 - a. Manufactured from virgin Type 1, Grade 1 PVC 1120 (Cell Class 12454-B) per ASTM D-1784.
 - b. Meet the dimensional, physical properties, and tolerances of ASTM D-1785 and ASTM D-2665.
 - c. Mark pipe with ASTM D-2665, nominal pipe size, and the symbols PVC and DWV at 5-foot intervals.
 - d. Fittings: ASTM D2665, PVC, solvent cement with long sweep bends. Injection molded conforming to National Sanitation Standard 14.
 - e. Joining Material:
 - 1) Solvent cement suitable for type and size of pipe installed as recommended by the pipe manufacturer.
 - 2) Make solvent cement joints from a two-step process with ASTM F656 primer manufactured for thermoplastic piping systems and solvent cement conforming to ASTM D-2564.
3. Manufacturers (Cast Iron Pipe):
 - a. Tyler Pipe
 - b. AB&I
 - c. Charlotte Pipe & Foundry

2.2 SUMP PUMP DISCHARGE

A. Above Grade - Inside Buildings:

1. Pipe 4-Inch and Smaller: ASTM B 88; Type L hard drawn copper tube.
 - a. Fittings:
 - 1) Wrought Copper Solder-Joint Fittings: ASME B16.22.
 - 2) Cast Copper Solder-Joint Fittings: ASME B16.18
 - 3) Cast Copper Alloy Flanges, Class 150 and 300, Flat-Face Type: ASME B16.24
 - b. Joining Material:
 - 1) Solder: Lead-free, ASTM B32, Solder shall be certified to meet NSF 61 Annex G and/or NSF 372.

- c. Fluxes:
 - 1) Lead-free, ASTM B813.
 - d. Flange Adapters:
 - 1) Ductile Iron ASTM A-536, engaging directly into roll grooved copper tube and fittings and bolting directly to ANSI Class 125 cast iron and Class 150 steel flanged components.
 - e. Mechanical Couplings:
 - 1) Rigid couplings for copper consisting of a ductile iron cast housing, ASTM A-536, Grade "E" EPDM gasket, ASTM D-2000, pressure responsive design, with plated nuts and bolts to secure unit together.
- B. Gate Valve:
- 1. 3-Inch and Larger: MSS-SP70, Class 125 OS&Y, bolted bonnet, ASTM A126 Class B cast iron body and bonnet, bronze trimmed, non-asbestos packing and gaskets, and cast iron hand wheel. Flanged end connections.
 - a. Acceptable Manufacturers:
 - 1) Nibco
 - 2) Milwaukee
 - 3) Hammond
- C. Swing Check Valve:
- 1. 3-Inch and Larger: MSS SP-71; Class 125, ASTM A126 Class B cast iron body with bronze trim, non-asbestos gasket, horizontal swing, and flanged ends.
 - a. Acceptable Manufacturers:
 - 1) Nibco
 - 2) Milwaukee
 - 3) Hammond

2.3 EQUIPMENT DRAINS AND OVERFLOWS

- A. Copper Pipe and Fittings:
- 1. DWV Copper Tube: ASTM B 306.
 - 2. Fittings:
 - a. Cast Copper Solder-Joint Drainage Fittings: ASME B16.23.
 - b. Wrought Copper Solder-Joint Drainage Fittings: ASME B16.29.
 - 3. Joining Material:
 - a. Solder: Lead-free, ASTM B32, Solder shall be certified to meet NSF 61 Annex G and/or NSF 372.
 - 4. Fluxes:
 - a. Lead-free, ASTM B813.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. General: Install piping in accordance with Authorities Having Jurisdiction, except where more stringent requirements are indicated.
- B. Inspect piping before installation to detect apparent defects. Mark defective materials with white paint and promptly remove from site.

- C. Verify all dimensions by field measurements. Verify that all drainage and vent piping and specialties may be installed in accordance with pertinent codes and regulations, the original design, and the referenced standards.
- D. Verify all existing grades, inverts, utilities, obstacles, and topographical conditions prior to installations.
- E. Examine rough-in requirements for plumbing fixtures and other equipment having drain connections to verify actual locations of piping connections prior to installation.
- F. Examine walls, floors, roof, and plumbing chases for suitable conditions where piping and specialties are to be installed.
- G. Do not proceed until unsatisfactory conditions have been corrected.

3.2 PIPING INSTALLATION

- A. Install plumbing drainage piping with 1/4-inch per foot (2 percent) downward slope in direction of drain for piping 3-inch and smaller, and 1/8-inch per foot (1 percent) for piping 4-inch and larger.
- B. Provide thrust restraints consisting of bracing to structure and rodded joints at branches and changes in direction for cast iron pipe 5-inches and larger suspended within the building and for all changes in diameter greater than two pipe sizes.
- C. Provide sway bracing to prevent shear at joints on cast iron piping suspended in excess of 18-inches on single rod hangers.
- D. Provide rigid support sway bracing at all changes in direction greater than 45 degrees for all suspended cast iron piping for pipe sizes 4-inch and larger.
- E. Suspended PVC piping shall be installed using the same requirements as cast iron piping for thrust and sway bracing as indicated in the articles above. Hanger spacing shall be as recommended by the manufacturer and code.
- F. Install underground cast iron drain piping to conform with the plumbing code, and in accordance with the Cast Iron Soil Pipe Institute Engineering Manual. PVC piping shall be installed in accordance with ASTM D 2321 and the plumbing code.
- G. Lay piping beginning at low point of system, true to grades and alignment indicated, with unbroken continuity of invert.
- H. Place bell ends or groove ends of piping facing upstream.
- I. Install gaskets in accordance with manufacturer's recommendations for use of lubricants, cements, and other special installation requirements.
- J. Grade trench bottoms to provide a smooth, firm, and stable foundation, free from rock, throughout the length of the pipe.
- K. Remove unstable, soft, and unsuitable materials at the surface upon which pipes shall be laid, and backfill with clean sand or pea gravel to indicated invert elevation.
- L. Shape bottom of trench to fit the bottom 1/4 of the circumference of pipe. Fill unevenness with tamped sand. At each pipe joint dig bell holes to relieve the bell of the pipe of all loads, and to ensure continuous bearing of the pipe barrel on the foundation.

M. Minimum size of waste and vent piping installed under floor slab on grade shall be 2-inches.

3.3 SERVICE CONNECTIONS

A. Before commencing work, check invert elevations required for sewer connections, confirm inverts and ensure that these can be properly connected with slope for drainage and cover to avoid freezing.

3.4 CONNECTIONS

A. Piping Runouts to Fixtures: Provide drainage and vent piping runouts to plumbing fixtures and drains, with approved trap, of sizes indicated; but in no case smaller than required by the Plumbing Code.

B. Locate piping runouts as close as possible to bottom of floor slab supporting fixtures or drains.

3.5 FIELD QUALITY CONTROL

A. Inspections:

1. Do not enclose, cover, or put into operation drainage and vent piping system until it has been inspected and approved by the Authority Having Jurisdiction.
2. During the progress of the installation, notify the Plumbing Official Having Jurisdiction, at least forty-eight (48) hours prior to the time such inspection must be made. Perform tests specified below in the presence of the Plumbing Official.
 - a. Rough-In Inspection: Arrange for inspection of the piping system before concealed or closed-in after system is roughed-in, and prior to setting fixtures.
 - b. Final Inspection: Arrange for a final inspection to observe the tests specified and to insure compliance with the requirements of the Plumbing Code.
3. Re-Inspections: Whenever the piping system fails to pass the test or inspection, make the required corrections, and arrange for re-inspection.
4. Reports: Prepare inspection reports, signed by the Plumbing Official.

B. Piping System Test: Test drainage and vent system in accordance with the procedures of the Authority Having Jurisdiction, or in the absence of a published procedure, as follows.

1. Subject all waste and vent piping, including building drain, and building sewer to a water test.
2. Tightly close all openings in the piping system except the highest opening, and fill the system with water to the point of overflow.
3. Maintain water in the system, or in the portion under test, for at least fifteen (15) minutes before inspection starts; the system shall then be tight to all points. No section shall be tested with less than a 10-foot head of water.

3.6 ADJUSTING AND CLEANING

A. Clean interior of piping. Remove dirt and debris as work progresses.

B. Clean drain strainers, domes, and traps. Remove dirt and debris.

3.7 PROTECTION

A. Protect drains during remainder of construction period, to avoid clogging with dirt and debris, and to prevent damage from traffic and construction work.

- B. Place plugs in ends of uncompleted piping at end of day or whenever work stops. Piping shall not be left open ended during construction.
- C. Exposed PVC Piping: Protect plumbing vents exposed to sunlight with two (2) coats of water-based latex paint. Color selected by Architect.

END OF SECTION

SECTION 22 13 19
SANITARY WASTE PIPING SPECIALTIES

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

- A. This Section specifies the following:
 - 1. Drainage Piping Specialties:
 - a. Cleanouts
 - b. Floor Drains

1.2 DEFINITIONS

- A. Building Drain: That part of the lowest piping of a drainage system which receives the discharge from soil, waste, and other drainage pipes inside the walls of the building and conveys it to the building sewer to a point 5'-0" outside the building wall.
- B. Building Sewer: That part of the horizontal piping of a drainage system which extends from the end of the building drain and conveys its discharge to a public sewer, private sewer, individual sewage disposal system, or other point of disposal.
- C. Drainage System: Includes all the piping within a public or private premises which conveys sewage, rain water or other liquid wastes to a point of disposal. It does not include the mains of public sewer systems or a private or public sewage treatment or disposal plant.
- D. Vent System: Pipe or pipes installed to provide a flow of air to or from a drainage system, or to provide a circulation of air within such system to protect trap seals from siphonage and back pressure.

1.3 SUBMITTALS

- A. Submit under provisions of Division 1.

1.4 CLOSEOUT SUBMITTALS

- A. Submit under provisions of Division 1.

1.5 QUALITY ASSURANCE

- A. Regulatory Requirements: Comply with the provisions of the following:
 - 1. Plumbing Code Compliance: Comply with applicable portions of the International Plumbing Code.
 - 2. ANSI Compliance: Comply with applicable ANSI standards pertaining to materials, products, and installation of soil and waste systems.
 - 3. ASSE Compliance: Comply with applicable ASSE standards pertaining to materials, products, and installation of soil and waste systems.
 - 4. ASTM Compliance: Comply with applicable ASTM Standards pertaining to materials, products, and installation of soil and waste systems.
 - 5. CISPI Compliance: Comply with applicable CISPI Standards pertaining to materials, products, and installation of soil and waste systems.
 - 6. PDI Compliance: Comply with applicable PDI standards pertaining to products and installation of soil and waste systems.

7. PVC Pipe: Only Contractor's personnel which have received training in the installation of this material and meet the manufacturer's qualifications shall do the assembly of such material.

PART 2 - PRODUCTS

2.1 DRAINAGE PIPING SPECIALTIES

A. Acceptable Manufacturers:

1. Josam Mfg. Co.
2. Smith (Jay R.) Mfg. Co.
3. Tyler Pipe; Subs. of Tyler Corp.
4. Zurn Industries Inc; Hydromechanics Division
5. Wade
6. Woodford
7. Precision Plumbing Products
8. Watts

B. Cleanouts:

1. Cleanout Plugs: ASTM A74, Cast brass, threads complying with ANSI B2.1, and Local Plumbing Code.
2. Floor Cleanout: Round, cast iron body with recessed bronze closure plug; scoriated polished bronze frame and cover plate.
3. Wall Cleanout: Cleanout tee with raised head brass plug tapped for 1/4-20 thread; flat style chrome plated wall cover plate with holes for 1/4-inch bolt; 1/4-20 threaded bolt with chrome plated flat head.
4. Grade Cleanout or Interior Locations Subject to Vehicle Traffic: Round cast iron flanged housing with heavy duty ductile iron cover. Set in 36-inch square concrete pad. Available in pipe sizes 2-inch to 6-inch. Josam No. 58680-5.
5. Line Cleanout: Cast iron tapped cleanout ferrule with raised head brass plug.
6. Access Panels: Fire rated assembly compatible with wall rating.

C. Floor Drains:

1. Refer To Plumbing Fixture Schedule On Drawings

PART 3 - EXECUTION

3.1 EXAMINATION

- A. General: Install piping in accordance with Authorities Having Jurisdiction, except where more stringent requirements are indicated.
- B. Inspect piping before installation to detect apparent defects. Mark defective materials with white paint and promptly remove from site.
- C. Verify all dimensions by field measurements. Verify that all drainage and vent piping and specialties may be installed in accordance with pertinent codes and regulations, the original design, and the referenced standards.
- D. Verify all existing grades, inverts, utilities, obstacles, and topographical conditions prior to installations.

- E. Examine rough-in requirements for plumbing fixtures and other equipment having drain connections to verify actual locations of piping connections prior to installation.
- F. Examine walls, floors, roof, and plumbing chases for suitable conditions where piping and specialties are to be installed.
- G. Do not proceed until unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF PIPING SPECIALTIES

- A. Cleanouts: Lubricate plugs with mixture of graphite and linseed oil. Prior to building turnover remove cleanout plugs, re-lubricate and reinstall using only enough force to ensure permanent leakproof joint.
 - 1. Above Ground Cleanouts: Install in above ground piping and building drain piping as indicated, and:
 - a. As required by Plumbing Code;
 - b. At each change in direction of piping greater than 45 degrees below slab;
 - c. At minimum intervals of 50-feet;
 - d. At each upper terminal;
 - e. At egress of building (surface cleanout).
 - 2. Cleanout Covers: Install floor and wall cleanout covers for concealed piping, types as indicated, and in accessible locations.
 - 3. Access Panels: Where cleanouts are located at a fire rated wall, provide and install fire-rated access panels to maintain wall rating. Provide panel sized to allow access to the cleanout.
- B. Floor Drains:
 - 1. Install floor drains at low points of surface areas to be drained, or as indicated. Set tops of drains flush with finished floor.
 - 2. Position drains so that they are accessible and easy to maintain.

3.3 SERVICE CONNECTIONS

- A. Before commencing work, check invert elevations required for sewer connections, confirm inverts and ensure that these can be properly connected with slope for drainage and cover to avoid freezing.

3.4 FIELD QUALITY CONTROL

- A. Inspections:
 - 1. Do not enclose, cover, or put into operation drainage and vent piping system until it has been inspected and approved by the Authority Having Jurisdiction.
 - 2. During the progress of the installation, notify the Plumbing Official Having Jurisdiction, at least forty-eight (48) hours prior to the time such inspection must be made. Perform tests specified below in the presence of the Plumbing Official.
 - a. Rough-In Inspection: Arrange for inspection of the piping system before concealed or closed-in after system is roughed-in, and prior to setting fixtures.
 - b. Final Inspection: Arrange for a final inspection to observe the tests specified and to insure compliance with the requirements of the Plumbing Code.
 - 3. Re-Inspections: Whenever the piping system fails to pass the test or inspection, make the required corrections, and arrange for re-inspection.

4. Reports: Prepare inspection reports, signed by the Plumbing Official.
 - B. Piping System Test: Test drainage and vent system in accordance with the procedures of the Authority Having Jurisdiction, or in the absence of a published procedure, as follows.
 1. Subject all waste and vent piping, including building drain, roof drain and building sewer to a water test.
 2. Tightly close all openings in the piping system except the highest opening, and fill the system with water to the point of overflow.
 3. Maintain water in the system, or in the portion under test, for at least fifteen (15) minutes before inspection starts; the system shall then be tight to all points. No section shall be tested with less than a 10-foot head of water.
- 3.5 ADJUSTING AND CLEANING
- A. Clean interior of piping. Remove dirt and debris as work progresses.
 - B. Clean drain strainers, domes, and traps. Remove dirt and debris.
 - C. Rod all new piping to ensure there are not blockages or debris in piping.
- 3.6 PROTECTION
- A. Protect drains during remainder of construction period, to avoid clogging with dirt and debris, and to prevent damage from traffic and construction work.
 - B. Place plugs in ends of uncompleted piping at end of day or whenever work stops. Piping shall not be left open ended during construction.

END OF SECTION

SECTION 22 14 29
SUMP PUMPS

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

- A. Extent of Sump Pumps Work required by this section is indicated on drawings and schedules, and by requirements of this section.
- B. Types of Pumps specified in this section include the following:
 - 1. Submersible Sump Pumps
- C. Pumps furnished as part of factory-fabricated equipment, are specified as part of equipment assembly in other Division 22 sections.
- D. Refer to other Division 22 sections for insulation of pump housings; vibration control of plumbing pumps; not work of this section.
- E. Refer to Division 26 sections for the following work; not work of this section.
 - 1. Power supply wiring from power source to power connection on pumps. Include starters, disconnects, and required electrical devices, except where specified as furnished, or factory-installed, by manufacturer.
 - 2. Interlock wiring between pumps; and between pumps and field-installed control devices.
 - a. Interlock wiring specified as factory-installed is work of this section.
- F. Provide the following Electrical Work as work of this section, complying with requirements of Division 26 sections:
 - 1. Control wiring between field-installed controls, indicating devices, and pump control panels.

1.2 QUALITY ASSURANCE

- A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of plumbing pumps with characteristics, sizes, and capacities required, whose products have been in satisfactory use in similar service for not less than five (5) years.
- B. Codes and Standards:
 - 1. HI Compliance: Design, manufacture, and install plumbing pumps in accordance with HI "Hydraulic Institute Standards".
 - 2. UL Compliance: Design, manufacture, and install plumbing pumps in accordance with UL 778 "Motor Operated Water Pumps".
 - 3. UL and NEMA Compliance: Provide electric motors and components which are listed and labeled by Underwriters Laboratories and comply with NEMA Standards.
- C. Certification, Pump Performance: Provide pumps whose performances, under specified operating conditions, are certified by manufacturer.

1.3 SUBMITTALS

- A. Product Data: Submit manufacturer's pump specifications, installation and start-up instructions, and current accurate pump characteristic performance curves with selection points clearly indicated.

- B. Shop Drawings: Submit manufacturer's assembly-type shop drawings indicating dimensions, weight loadings, required clearances, and methods of assembly of components.
- C. Wiring Diagrams: Submit manufacturer's electrical requirements for power supply wiring to plumbing pumps. Submit manufacturer's ladder-type wiring diagrams for interlock and control wiring. Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed.
- D. Maintenance Data: Submit maintenance data and parts lists for each type of pump, control, and accessory; including "trouble-shooting" maintenance guide. Include this data, product data, shop drawings, and wiring diagrams in maintenance manual; in accordance with requirements of Division 1.

1.4 DELIVERY, STORAGE, AND HANDLING

- A. Handle plumbing pumps and components carefully to prevent damage, breaking, denting and scoring. Do not install damaged plumbing pumps or components; replace with new.
- B. Store plumbing pumps and components in clean dry place. Protect from weather, dirt, fumes, water, construction debris, and physical damage.
- C. Comply with Manufacturer's rigging and installation instructions for unloading plumbing pumps, and moving them to final location.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturer: Subject to compliance with requirements, provide products by one of the following:
 - 1. Submersible Sump Pumps:
 - a. Goulds
 - b. Weil
 - c. Zoeller
 - d. Bell & Gossett

2.2 PUMPS

- A. General: Provide factory-tested pumps, thoroughly cleaned, and painted with one (1) coat of machinery enamel prior to shipment. Type, size, and capacity of each pump is listed in pump schedule. Provide pumps of same type by same manufacturer.

2.3 SUBMERSIBLE SUMP PUMPS

- A. General: Provide submersible sump pumps as indicated, of size and capacity as scheduled.
- B. Pump: Cast iron shell, bronze impeller, stainless steel shaft, factory-sealed grease lubricated ball bearings, ceramic mechanical seal, and perforated steel strainer. The volute shall consist of smooth contoured surfaces and fluid passages. The impeller shall be a multi-vane, semi-open type. Impellers shall not require the use of wear rings for proper operation. All exterior hardware shall be 304 stainless steel.

- C. Motor: NEMA 6, shall be air filled with Class F insulation. Motor shall be for a non-hazardous environment. Motors 5 HP and above shall include moisture sensor and temperature limiter. Single phase motors shall include built in thermal and overload protection. The motor shell shall have cooling fins. The motor shaft shall be solid stainless steel. Both upper and lower bearings shall be double sealed and permanently lubricated. Bearings shall be capable of handling radial and axial thrust loads. The motor cover shall include a cable sealing system to prevent water from entering the motor.
- D. Mechanical Seal: The pump sealing system shall incorporate a Tandem mechanical seal system. Upper seal shall consist of Carbon against Ceramic and the lower seal consisting of Silicon Carbide against Silicon Carbide. All elastomers shall be Buna-N material.
- E. Removal System: The removal system shall permit the removal and re-installation of a pump without disturbing the discharge piping. Personnel shall not be required to enter the wet well. The pump sliding bracket shall be constructed of heavy duty cast iron. The floor elbow shall be constructed of cast iron. The pump sliding bracket shall act as a wedge type coupling between the pump and floor elbow. Systems that require gaskets, diaphragms or O-rings to ensure a watertight seal are not acceptable. Duplex systems shall use a steel base plate for mounting of floor elbows. Removal system shall be a complete package including all hardware and components. . Pump shall include a lifting handle and stainless steel lifting cable.
- F. Controls:
 - 1. Control Panel
 - a. UL Listed Label
 - b. NEMA 4 Enclosure
 - c. TEST-OFF-AUTO switch for each pump
 - d. Through-the-door disconnect
 - e. High Water Alarm (HWA) with 95dB horn and silence button
 - f. Indicator Lights For: Control Power, Pump Run, High Water Alarm, Pump Overload
 - g. Fused Control Transformer
 - h. Overload Protection
 - i. One set of dry contacts for monitoring: HWA
 - j. Hour Meter for each pump
 - k. Provide gold plated contact tethered float switches. Configure for Off/Stop, Lead/Start, Lag/Standby and High Water Alarm.
 - l. Pump power cable length, each pump, 20 feet.
- G. Basin: Concrete construction of indicated dimensions on schedule and detailed with inlet connections of size and location as indicated. Maintain minimum of 36 inch depth below lowest inlet invert

PART 3 - EXECUTION

3.1 INSPECTION

- A. Examine areas and conditions under which plumbing pumps are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.2 INSTALLATION OF PUMPS

- A. General: Install plumbing pumps where indicated, in accordance with manufacturer's published installation instructions, complying with recognized industry practices to ensure that plumbing pumps comply with requirements and serve intended purposes.
- B. Access: Provide access space around plumbing pumps for service as indicated, but in no case less than that recommended by manufacturer.
- C. Support: Refer to Division 22 section "Vibration and Seismic Controls for Plumbing Piping and Equipment" for support and mounting requirements of plumbing pumps.
- D. Basins: Install sump pump basins in indicated locations and connect to sewer lines. Brace interior of basin in accordance with manufacturer's instructions, to prevent distortion or collapse during concrete placement. Refer to Division 3 for concrete work; not work of this section. Set cover over basin, fasten to top flange of basin. Install so cover is flush with finished floor.
- E. Electrical Wiring: Install electrical devices furnished by manufacturer but not specified to be factory-mounted. Furnish copy of manufacturer's wiring diagram submittal to Electrical Installer.
 - 1. Verify that electrical wiring installation is in accordance with manufacturer's submittal and installation requirements of Division 26 sections. Do not proceed with equipment start-up until wiring installation is acceptable to equipment installer.
- F. Piping Connections: Refer to Division 22 plumbing piping sections. Provide piping, valves, accessories, gauges, supports, and flexible connections as indicated.

3.3 ADJUSTING AND CLEANING

- A. Alignment: Check alignment, and where necessary, realign shafts of motors and pumps within recommended tolerances by manufacturer, and in presence of manufacturer's service representative.
- B. Start-Up: Start-up in accordance with manufacturer's instructions.
- C. Cleaning: Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.

END OF SECTION

SECTION 23 00 00
BASIC MECHANICAL REQUIREMENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including the General and Supplementary Conditions, Division-1 Conditions specification sections apply to the Division 23 specifications and drawings.
- B. Related Sections: Refer to all sections in Division 23. Refer to Division 26 specification section and Division 26 drawings.

1.2 SUMMARY

- A. This Section specifies the basic requirements for mechanical installations and includes requirements common to more than 1 section of Division 23. It expands and supplements the requirements specified in sections of Division 1.
- B. The CONTRACTOR shall coordinate and co-operate with OWNER at all times for all new to existing connections, system shutdowns and restart-up, flushing and filling both new and existing systems.
- C. Coordinate all services shutdown with the OWNER, provide temporary services as shown on the drawings.
- D. The CONTRACTOR shall be responsible for the maintenance operation and servicing of all new mechanical systems which are to be used by the OWNER during the time of any occupancy and use of any areas within the construction limitations before final completion or acceptance of the systems. A written record of maintenance, operation and servicing shall be turned over to the OWNER prior to final acceptance.

1.3 PROJECT CONDITIONS

- A. The CONTRACTOR shall be required to attend a mandatory pre-bid walk-thru and shall make themselves familiar with the existing conditions. No additional costs to the OWNER shall be accepted for additional work for these existing conditions.
- B. Field verify all existing conditions prior to submitting bids.
- C. Protect all mechanical and electrical work against theft, injury or damage from all causes until it has been tested and accepted.
- D. Be responsible for all damage to the property of the OWNER or to the work of other CONTRACTOR s during the construction and guarantee period. Repair or replace any part of the Work which may show defect during 1 year from the final acceptance of all work. Provided such defect is, in the opinion of the Architect, due to imperfect material or workmanship and not due to the OWNER 's carelessness or improper use.

1.4 ACCESSIBILITY

- A. Install equipment and materials to provide required access for servicing and maintenance. Coordinate the final location of concealed equipment and devices requiring access with final location of required access panels and doors. Allow ample space for removal of all parts that require replacement or servicing.
- B. Extend all grease fittings to an accessible location.
- C. Furnish hinged steel access doors with concealed latch, whether shown on drawings or not, in all walls and ceilings for access to all concealed valves, shock absorbers, air vents, motors, fans, balancing cocks, and other operating devices requiring adjustment or servicing. Refer to Division 1 for access door specification and Division 23 for duct access door requirements.
- D. The minimum size of any access door shall not be less than the size of the equipment to be removed or 24-inch x 24-inch if used for service only.
- E. Furnish doors to trades performing work in which they are to be built, in ample time for building-in as the work progresses. Whenever possible, group valves, cocks, etc., to permit use of minimum number of access doors within a given room or space.
- F. Factory manufactured doors shall be of a type compatible with the finish in which they are to be installed. In lieu of these doors, shop fabricated access doors with DuroDyne hinges may be used.
- G. Access doors in fire-rated walls and ceilings shall have equivalent UL label and fire rating.

1.5 ROUGH-IN

- A. Verify final locations for rough ins with field measurements and with the requirements of the actual equipment to be connected.
- B. Refer to equipment shop drawings and manufacturer's requirements for actual provided equipment for rough-in requirements.

1.6 REQUIREMENTS OF REGULATORY AGENCIES

- A. Refer to Division 1.
- B. Execute and inspect all work in accordance with all Underwriters, local and state codes, rules, and regulations applicable to the trade affected as a minimum, but if the plans and/or specifications call for requirements that exceed these rules and regulations, the greater requirement shall be followed. Follow recommendations of NFPA, SMACNA, EPA, OSHA and ASHRAE.
- C. Comply with standards in effect at the date of these Contract Documents, except where a standard or specific date or edition is indicated.
- D. The handling, removal and disposal of regulated refrigerants shall be in accordance with U.S. EPA, state, and local regulations.
- E. After entering into contract, CONTRACTOR will be held to complete all work necessary to meet these requirements without additional expense to the OWNER.

1.7 REQUIREMENTS OF LOCAL UTILITY COMPANIES

- A. Comply with rules and regulations of local utility companies. Include in bid the cost of all valves, valve boxes, meter boxes, meters and such accessory equipment which will be required for the project.

1.8 PERMITS AND FEES

- A. Refer to Division 1.
- B. OWNER shall pay all tap, development, meter, etc., fees required for connection to municipal and public utility facilities.
- C. CONTRACTOR shall arrange for and pay for all inspections, licenses and certificates required in connection with the Work.

1.9 MECHANICAL INSTALLATIONS

- A. Drawings are diagrammatic in character and do not necessarily indicate every required offset, valve, fitting, etc.
- B. Drawings and specifications are complementary. Whatever is called for in either is binding as though called for in both.
- C. Drawings shall not be scaled for rough-in measurements or used as shop drawings. Where drawings are required for these purposes or have to be made from field measurement, take the necessary measurements and prepare the drawings.
- D. Before any Work is installed, determine that equipment will properly fit the space; that required piping grades can be maintained and that ductwork can be run as contemplated without interferences between systems, with structural elements or with the work of other trades.
- E. Coordinate the installation of mechanical materials and equipment above and below ceilings with suspension system, light fixtures, and other building components.
 - 1. Coordinate ceiling cavity space carefully with all trades. In the event of conflict, install mechanical and electric systems within the cavity space allocation in the following order of priority.
 - a. Plumbing waste, vent piping and roof drain mains and leaders
 - b. Supply, return and exhaust ductwork
 - c. Fire sprinkler mains and leaders
 - d. Electrical conduit
 - e. Domestic hot and cold water, medical gas piping
 - f. Fire sprinkler branch piping and sprinkler runouts
- F. Verify all dimensions by field measurements.
- G. Arrange for chases, slots, and openings in other building components to allow for mechanical installations.
- H. 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.

- I. 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.
- J. Coordinate the cutting and patching of building components to accommodate the installation of mechanical equipment and materials.
- K. Where mounting heights are not detailed or dimensioned, install mechanical services and overhead equipment to provide the maximum headroom possible.
- L. Install mechanical equipment to facilitate maintenance and repair or replacement of equipment components. As much as practical, connect equipment for ease of disconnecting, with minimum of interference with other installations.
- M. Coordinate 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.

1.10 CUTTING AND PATCHING

- A. This Article specifies the cutting and patching of mechanical equipment, components, and materials to include removal and legal disposal of selected materials, components, and equipment.
- B. Refer to Division 1.
- C. Do not endanger or damage installed work through procedures and processes of cutting and patching.
- D. Arrange for repairs required to restore other work, because of damage caused as a result of mechanical installations.
- E. No additional compensation will be authorized for cutting and patching work that is necessitated by ill-timed, defective, or non-conforming installations.
- F. Perform cutting, fitting, and patching of mechanical equipment and materials required to:
 - 1. Uncover work to provide for installation of ill-timed work.
 - 2. Remove and replace defective work.
 - 3. Remove and replace work not conforming to requirements of the Contract Documents.
 - 4. Remove samples of installed work as specified for testing.
 - 5. Upon written instructions from the Architect, uncover and restore work to provide for Architect observation of concealed work.
- G. Cut, remove and legally dispose of selected mechanical equipment, components, and materials as indicated, including, but not limited to removal of mechanical piping, heating units, and other mechanical items made obsolete by the new work.
- H. Protect the structure, furnishings, finishes, and adjacent materials not indicated or scheduled to be removed.
- I. Provide and maintain an approved type of temporary partitions or dust barriers adequate to prevent the spread of dust and dirt to adjacent areas.

- J. Locate, identify, and protect mechanical and electrical services passing through remodeling or demolition area and serving other areas required to be maintained operational. When services must be interrupted, provide temporary services for the affected areas, and notify the OWNER prior to changeover.

1.11 TEMPORARY FACILITIES

- A. Light, Heat, Power, etc.:
 - 1. Responsibility for providing temporary electricity, heat and other facilities shall be as specified in Division 1.
- B. Use of Permanent Building Equipment for Temporary Heating or Cooling:
 - 1. Permanent building equipment shall not be used without written permission from the OWNER. If this equipment is used for temporary heating or cooling, it shall be adequately maintained per manufacturer's instructions and protected with filters, strainers, controls, reliefs, etc. The guarantee period shall not start until the equipment is turned over to the OWNER for his use.

1.12 PRODUCT OPTIONS AND SUBSTITUTIONS

- A. Refer to the Instructions to Bidders and Division 1, "PRODUCTS, OPTIONS AND SUBSTITUTION".

1.13 MECHANICAL SUBMITTALS

- A. Refer to the Conditions of the Contract (General and Supplementary), Division 1 and AIA Document A201, "SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES".
- B. The CONTRACTOR is to prepare a submittal schedule that coincides with the overall construction schedule. This submittal schedule should include a list of individual products to be submitted under each specification section. This submittal schedule shall also include dates for anticipated review, shipment, and on-site delivery times of the submitted product.
- C. The ENGINEER shall be given a submittal review time of 10 working days upon receipt of submittal. Previous submittal rejection or revision shall not compress this review time. It shall be the CONTRACTOR's responsibility to ensure these review and/or re-review times are incorporated into the submittal schedule with enough lead time as not to affect overall construction schedule.
- D. The manufacturer's material or equipment listed in the schedule or identified by name on the drawings are the types to be provided for the establishment of size, capacity, grade, and quality. If alternates are used in lieu of the scheduled names, the cost of any changes in construction required by their use shall be borne by CONTRACTOR.
- E. Submittals shall be prepared by authorized equipment dealers, vendors, suppliers, or representative of the products submitted. Include contact and business information of the equipment dealers, vendors, suppliers, and representatives. Products and equipment submitted shall also be representative of the products and equipment to be procured and installed. General product data and shop drawings downloaded from unaffiliated websites will not be reviewed or accepted.

- F. All equipment shall conform to the State and/or Local Energy Conservation Standards.
- G. Submittal of shop drawings, product data, and samples will be accepted only when submitted by and stamped by the CONTRACTOR. Data submitted from subcontractors and material suppliers directly to the Architect will not be processed unless prior written approval is obtained by the CONTRACTOR.
- H. Submit all submittal items required for each Specification Section. Submittals shall be prepared and submitted in accordance with the submittal schedule. The CONTRACTOR is to determine and coordinate submittal review times, lead times and delivery times of submitted products as it coincides with the overall construction schedule. Submittals submitted in bulk or under a single division will not be reviewed and will be sent back as "revise and resubmit".
- I. If more than 1 re-submittals (either for shop drawings or for as-built drawings) are made by the CONTRACTOR, the OWNER reserves the right to charge the CONTRACTOR for subsequent reviews by their consultants. Such extra fees shall be deducted from payments by the OWNER to the CONTRACTOR.
- J. Before starting Work, prepare and submit to the Architect all shop drawings and descriptive equipment data required for the project. Unless each item is identified with specification section and sufficient data to identify its compliance with the specifications and drawings, the item will be returned without action or "Revise and Resubmit". Continue to submit shop drawings after each ENGINEER 's action, until a "Reviewed" action is received. The CONTRACTOR shall submit the total number of sets as called for in Division 1 to the Architect for final distribution. Submittals shall include the following specified materials, and, in addition, any materials not listed below but which are specified in the individual sections of Division 23 which follow.
 - 1. Process piping
 - 2. Thermometers and pressure gauges
 - 3. Supports, anchors and seals
 - 4. Terminal heat transfer units
 - 5. Fans, ductwork, dampers, louvers, grilles, registers, and diffusers
 - 6. Automatic control systems
- K. Wiring diagrams, control panelboards, motor test data, motors, starters, and controls for electrically operated equipment furnished by mechanical trades.
- L. Identify each item with specification section and sufficient data to certify its compliance with the specifications.
- M. Electronic submittals shall be packaged as a bookmarked multi-page single PDF file and shall not be over 5MB. Electronic Submittals over 5MB will not be accepted and will be returned un-reviewed.

1.14 REQUESTS FOR INFORMATION

- A. All "Requests for Information" submitted by the CONTRACTOR shall include a proposed solution and an estimated cost/schedule impact. Any RFI's that do not contain this required information will be sent back to the CONTRACTOR unanswered.

- B. Schedule the work to provide the ENGINEER a minimum review time of 5 business days upon receipt of RFIs to provide a response.

1.15 MECHANICAL COORDINATION DRAWINGS

- A. Prepare and submit a complete set of 3-D Coordination/Fabrication Drawings showing major elements, components, and systems of mechanical equipment and materials in relationship with other trades, sub-trades and building components. Prepare drawings within the remodeled area "Model" to an accurate scale of 1/4 inches=1 foot-0 inches or larger when plotted. Indicate the locations of all equipment and materials, including clearances for installing and maintaining insulation, servicing, and maintaining equipment, valve stem movement, and similar requirements. Indicate movement and positioning of large equipment into the building during construction.
- B. Review in detail all floor plans, reflected ceiling plans, elevations, sections, and details to conclusively coordinate with all trades and integrate all installations. Indicate locations where space is limited, and where sequencing and coordination of installations are of importance to the efficient flow of the work, including (but not necessarily limited to) the following:
 - 1. Mechanical equipment room layouts.
 - 2. Specific equipment installations, including:
 - a. Chillers.
 - b. Cooling Towers.
 - c. Boilers.
 - d. Pumps and Compressors.
 - e. Tanks and Heat Exchangers.
 - f. Furnaces.
 - g. Air Handling Units.
 - 3. Work in pipe spaces, chases, trenches, and tunnels.
 - 4. Exterior wall penetrations.
 - 5. Ceiling plenums which contain piping, ductwork, or equipment in congested arrangement.
 - 6. Installations in mechanical riser shafts, at typical sections and crucial offsets and junctures.

1.16 PRODUCT LISTING

- A. Prepare listing of major mechanical equipment and materials for the project, within 2 weeks of signing the Contract Documents and transmit to the Mechanical ENGINEER.
- B. Unless otherwise specified, all materials and equipment shall be of domestic (USA) manufacture and shall be of the best quality used for the purpose in commercial practice.
- C. Provide all information requested.
- D. Submit this listing as a part of the submittal requirement specified in Division 1, "PRODUCTS AND SUBSTITUTION".

- E. When 2 or more items of same material or equipment are required (pumps, valves, air conditioning units, etc.) they shall be of the same manufacturer. Product manufacturer uniformity does not apply to raw materials, bulk materials, fittings (except flanged and grooved types), sheet metal, wire, steel bar stock, welding rods, solder, fasteners, motors for dissimilar equipment units, and similar items used in work, except as otherwise indicated.
- F. Provide products which are compatible within systems and other connected items.

1.17 NAMEPLATE DATA

- A. Provide permanent operational data nameplate on each item of mechanical equipment, indicating manufacturer, product name, model number, serial number, efficiency rating (i.e., EER, etc.) capacity, operating and power characteristics, labels of tested compliances, and similar essential data. Locate nameplates in an accessible location.

1.18 DELIVERY, STORAGE, AND HANDLING

- A. Refer to Division 1.
- B. Deliver products to project properly identified with names, model numbers, types, grades, compliance labels, and similar information needed for distinct identifications; adequately packaged and protected to prevent damage during shipment, storage, and handling.
- C. Store equipment and materials at the site unless off-site storage is authorized in writing. Protect stored equipment and materials from damage, dirt, dust, and moisture.
- D. Coordinate deliveries of mechanical materials and equipment to minimize construction site congestion. Limit each shipment of materials and equipment to the items and quantities needed for the smooth and efficient flow of installations.
- E. Protect stored tubes. Elevate above grade and enclose with durable, waterproof wrapping. When stored inside, do not exceed structural capacity of the floor.
- F. Protect flanges, fittings, and specialties from moisture and dirt by inside storage and enclosure, or by packaging with durable, waterproof wrapping.

1.19 RECORD DOCUMENTS

- A. Refer to Division 1. The following paragraphs supplement the requirements of Division 1.
- B. Keep a complete set of record document prints or electronic mark-ups in custody during entire period of construction at the construction site.
- C. Mark drawing prints to indicate revisions to piping and ductwork, size and location both exterior and interior; including locations of coils, dampers and other control devices, filters, boxes, and similar units requiring periodic maintenance or repair; actual equipment locations, dimensioned from column lines; actual inverts and locations of underground piping; concealed equipment, dimensioned to column lines; mains and branches of piping systems, with valves and control devices located and numbered, concealed unions located, and with items requiring maintenance located (i.e., traps, strainers, expansion compensators, tanks, etc.); RFI's; change orders; concealed control system devices. Changes to be noted on the drawings shall include final location of any piping or ductwork relocated more than 1 feet-0 inches from where shown on the drawings.

- D. Mark Equipment Schedules on the drawings with changes to Manufacturer, Model Number, and data based on reviewed shop drawings.
- E. At the completion of the project, mark all valve tag numbers on the drawings and turn these drawings over to the General CONTRACTOR for his submission to the Architect. This Contract will not be considered completed until these record drawings have been received and reviewed by the Architect.

1.20 OPERATION AND MAINTENANCE DATA

- A. Refer to Division 1.
- B. The Testing and Balancing Report shall be submitted and received by the ENGINEER at least 5 calendar days prior to the CONTRACTOR 's request for final observation time frame requirements. Final Observation(s) will not proceed without T&B Report. Include in the O&M Manual after review with "Review" or "Make Corrections Noted" has been accomplished.
- C. In addition to the information required above and/or by Division 1 for maintenance data, include the following information:
 - 1. Description of mechanical equipment, function, normal operating characteristics and limitations, performance curves, engineering data and tests, and complete nomenclature and commercial numbers of all replaceable parts.
 - 2. Manufacturer's printed operating procedures to include start-up, break-in, routine and normal operating instructions; regulation, control, stopping, shutdown, and emergency instructions; and summer and winter operating instructions.
 - 3. Maintenance procedures for routine preventative maintenance and troubleshooting; disassembly, repair, and reassembly; aligning and adjusting instructions.
 - 4. Servicing instructions and lubrication charts and schedules.
 - 5. Manufacturer's service manuals for all mechanical equipment provided under this Contract.
 - 6. Include the valve tag list.
 - 7. Name, Address and Telephone Number of party to be contacted for 24 hour service for each item of equipment.
 - 8. Starting, stopping, lubrication, equipment identification numbers and adjustment clearly indicated for each piece of equipment.
 - 9. Complete parts list.
 - 10. Mechanical warranties.
- D. This Contract will not be considered completed, nor will final payment be made, until all specified material, including Testing and Balancing Report, is received in this Operating and Maintenance Report and the manual is reviewed by the Architect.

1.21 LUBRICATION OF EQUIPMENT

- A. Refer to Division 1. The following paragraphs supplement the requirements of Division 1.

- B. CONTRACTOR shall properly lubricate all mechanical pieces of equipment which he provided before turning the building over to the OWNER. He shall attach a linen tag or heavy-duty shipping tag on the piece of equipment showing the date of lubrication and the type and brand of lubricant used.
- C. Furnish the ENGINEER with a typewritten list in quadruplicate, of each item lubricated and type of lubricant used, no later than 2 weeks before completion of the project, or at time of acceptance by the OWNER of a portion of the building and the mechanical systems involved.

1.22 WARRANTIES

- A. Refer to Division 1 for procedures and submittal requirements for warranties. Refer to individual equipment specifications for warranty requirements. In any case, the entire mechanical system shall be warranted no less than 1 year from the time of acceptance by the OWNER.
- B. Compile and assemble the warranties specified in Division 23, into the Operating and Maintenance Manuals.
- C. Provide complete warranty information for each item to include product or equipment to include date or beginning of warranty or bond; duration of warranty or bond; and names, addresses, and telephone numbers and procedures for filing a claim and obtaining warranty services.

1.23 CLEANING

- A. Refer to Division 1.
- B. Refer to Division 23, "TESTING, ADJUSTING AND BALANCING" for requirements for cleaning filters, strainers, and mechanical systems prior to final acceptance.

END OF SECTION

**SECTION 23 01 00
M&E COORDINATION**

PART 1 - GENERAL

1.1 SUMMARY

- A. Carefully coordinate the interface between Division 23 (Mechanical) and Division 26 (Electrical) before submitting any equipment for review or commencing installation.
- B. Responsibility: Unless otherwise indicated, all motor and controls for Division 23 equipment shall be furnished, set in place and wired in accordance with the following schedule:

COORDINATION SCHEDULE				
ITEM	Furnished Under	Set in Place Under	Power Wiring Under	Control Wiring Under
Equipment Motor	23	23	26	--
Automatically Controlled Starters/Contactors:				
Separate	23	26	26	23
Factory Mounted and Wired	23	23	26	23
Manually Controlled Starter/Contactors:				
Separate	23	26	26	23
Factory Mounted and Wired	23	23	26	23
Special Duty Type Motor (Part Winding, etc.)	23	26	26	23
Disconnect Switches (Note 1)	26	26	26	--
Variable Frequency Drives	23	26	26	23
Contactors	26	26	26	--
Thermal Overload Switches (Note 1)	26	26	26	--
Manual Operating Switches (Note 2)	26	26	26	--
Control Relays (Note 2)	23	23	26	23
Control Transformers	23	23	26	23
Control Circuit Outlets	26	26	26	--
Thermostats (Note 2)	23	23	--	23
Push Button Stations, Pilot Lights (Note 2)	23	23	26	23
Thermostat and Controls Integral with Equipment or Directly Attached to Ducts, Pipes, etc. (Note 2)	23	23	26	23
Equipment in Temperature Control Panels (Note 2)	23	23	26	23
Standalone Control Panels (Note 2)	23	23	26	23
Valve Motors Damper Motors, Solenoid Valves, etc. (Note 2)	23	23	--	23
EP Valves or Switches, P.E. Switches, etc. (Note 2)	23	23	26	23
Fire Alarm System	26	26	26	26
Smoke Detectors Including Relays for Fan Control (Note 3)	26	23	26	23
Fire/Smoke Dampers	23	23	26	26
Equipment Interlock	23	23	N/A	23
Water Heater	22	22	26	23

COORDINATION SCHEDULE				
ITEM	Furnished Under	Set in Place Under	Power Wiring Under	Control Wiring Under
Notes: (1) If furnished as part of factory wired equipment, furnish, and set in place under Division 23, wiring and connections under Division 26. (2) If float switches, line thermostats, P.E. switches, time switches, or other controls carry the FULL LOAD CURRENT to any motor, they shall be furnished and set in place under Division 23, but they shall be connected under Division 26. If they do not carry the FULL LOAD CURRENT to any motor, they shall be furnished, set in place, and wired under Division 23. (3) Wiring from alarm contacts to alarm system by Division 26; all control function wiring by Division 23. Division 23 to coordinate locations with Division 26.				

- C. Control Wiring:
 - 1. Consists of wiring in pilot circuits of contactors, starters, sensors, controllers, and relays, and wiring for valve and damper operators.
- D. Connections:
 - 1. Make connections to all controls directly attached to ducts, piping, and mechanical equipment with flexible connections.
- E. Starters:
 - 1. Provide magnetic starters for all three phase motors and equipment complete with:
 - a. Control transformers.
 - b. 120V holding coils.
 - c. Integral hand-off auto switch.
 - d. Auxiliary contacts required for system operation plus 1 spare.
- F. Remote Switches and Pushbutton Stations:
 - 1. Provide all remote switches and/or pushbutton stations required for manually operated equipment (if no automatic controls have been provided) complete with pilot lights of an approved type lighted by current from load side of starter.
- G. Special Requirement:
 - 1. Motor, starters, and other electrical equipment installed in moist areas or areas of special conditions, such as explosion proof, shall be designed and approved for installation in such areas with appropriate enclosure.
- H. Identification:
 - 1. Provide identification of purpose for each switch and/or pushbutton station furnished. Identification may be either engraved plastic sign or permanent mounting to wall below switch or stamping on switch cover proper. All such identification signs and/or switch covers in finished areas shall match other hardware in the immediate area.

I. Control Voltage:

1. Maximum allowable control voltage is 120V. Fully protect control circuit conductors in accordance with National Electrical Code.
2. Fully coordinate the requirements of each division with regard to supplying a complete DDC Control System. J-Boxes and control transformer connections shall be provided under Division 26. The transformers shall be furnished and set in place under Div. 23.

PART 2 - PRODUCTS

2.1 MOTOR HORSEPOWER

- A. In general, all motors 3/4 HP and above shall be three phase, all motors less than 3/4 HP shall be single phase.
- B. Voltage and phase of motors as scheduled on the electrical drawings shall take precedence in the case of a conflict between the mechanical and electrical drawings or general conditions 2.1 A., above.
- C. Work under Division 23 includes coordinating the electrical requirements of all mechanical equipment with the requirements of the work under Division 26, before ordering the equipment.
 1. If motor horsepower's are changed under the work of Division 23, without a change in duty of the motor's driven device, coordination of additional electrical work (if any) and additional payment for the work (if any) shall be provided under the section of Division 23 initiating the change. Increases or decreases in motor horsepower from that specified shall not be made without written approval from the Architect.

PART 3 - EXECUTION - NOT USED.

END OF SECTION

SECTION 23 05 00
COMMON WORK RESULTS FOR HVAC

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

- A. Extent of Piping Specialties Work required by this section is indicated on drawings and schedules and by requirements of this section.
- B. Types of Piping Specialties specified in this section include the following:
 - 1. Mechanical Sleeve Seal
 - 2. Fire and Smoke Barrier Penetration Seal
 - 3. Sleeve Seals
- C. Piping Specialties furnished as part of factory-fabricated equipment, are specified as part of equipment assembly in other Division 23 sections.

1.2 QUALITY ASSURANCE

- A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of piping specialties of types and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.
- B. Codes and Standards:
 - 1. ASME B 31.9 "Building Services Piping" for materials, products, and installation.
 - 2. Safety valves and pressure vessels shall bear the appropriate ASME label.
 - 3. Fabricate and stamp air separators and compression tanks to comply with ASME Boiler and Pressure Vessel Code, Section VIII, Division 1.
 - 4. ASME "Boiler and Pressure Vessel Code," Section IX, "Welding and Brazing Qualification" for qualifications for welding processes and operators.

1.3 SUBMITTALS

- A. Product Data: Submit manufacturer's technical product data, including installation instructions, and dimensioned drawings for each type of manufactured piping specialty. Submit schedule showing manufacturer's figure number, size, location, and features for each required piping specialty.
- B. Shop Drawings: Submit for fabricated specialties, indicating details of fabrication, materials, and method of support.
- C. Maintenance Data: Submit maintenance data and spare parts lists for each type of manufactured piping specialty. Include this data, product data, and shop drawings in maintenance manual; in accordance with requirements of Divisions 23.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturer: Subject to compliance with requirements, provide products by one of the following:
 - 1. Mechanical Sleeve Seal:
 - a. Thunderline Corp.
 - b. "Metraseal" by Metraflex Co.
 - 2. Fire and Smoke Barrier Penetration Seal:
 - a. Electrical Products Division/3M
 - b. Dow Corning
 - c. Flame Stop, Inc.
 - d. MetaCaulk
 - e. Hilti
 - f. HoldRite

2.2 MECHANICAL SLEEVE SEALS

- A. General: Modular mechanical type, consisting of interlocking synthetic rubber links shaped to continuously fill annular space between pipe and sleeve, connected with bolts and pressure plates which cause rubber sealing elements to expand when tightened, providing watertight seal and electrical insulation.

2.3 FIRE AND SMOKE BARRIER PENETRATION SEALS

- A. General: Provide UL Listed firestopping systems composed of components that are compatible with each other, the substrates forming openings, and the items, if any, penetrating the firestopping under conditions of service and application, as demonstrated by the firestopping manufacturer based on testing and field experience.
- B. Provide components for each firestopping system that are needed to install fill material. Use only components specified by the firestopping manufacturer and approved by the qualified testing agency for the designated fire-resistance-rated systems.
- C. Penetrations in Fire Resistive Rated Walls: Provide firestopping with ratings determined in accordance with UL 1479 or ASTM E 814.
 - 1. F-Rating: Not less than the fire-resistance rating of the wall construction being penetrated.
- D. Penetration in Horizontal Assemblies: Provide firestopping with ratings determined in accordance with UL 1479 or ASTM E 814.
 - 1. F-Rating: Minimum of 1-hour rating, but not less than the fire-resistance rating of the floor construction being penetrated.
 - 2. T-Rating: When penetrant is located outside of a wall cavity, minimum of 1-hour rating, but not less than the fire-resistance rating of the floor construction being penetrated.
 - 3. W-Rating: Class 1 rating in accordance with water leakage test per UL 1479.

- E. Penetrations in Smoke Barriers: Provide firestopping with ratings determined in accordance with UL1479 or ASTM E 814.
 - 1. L-Rating: Not exceeding 5.0 cfm/sq. ft. of penetration opening at both ambient and elevated temperatures.

2.4 FABRICATED PIPING SPECIALTIES

- A. Sleeve Seals: Provide sleeve seals for sleeves located in foundation walls below grade, or in exterior walls, of 1 of the following:
 - 1. Mechanical Sleeve Seals: Installed between sleeve and pipe.

PART 3 - EXECUTION

3.1 INSTALLATION OF PIPING SPECIALTIES

- A. Mechanical Sleeve Seals: Loosely assemble rubber links around pipe with bolts and pressure plates located under each bolt head and nut. Push into sleeve and center. Tighten bolts until links have expanded to form watertight seal.
- B. Fire or Fire/Smoke Barrier Penetration Seals: Where pipe penetration occurs in fire or fire/smoke rated walls, provide a complete listed protection assembly equal to the rating of the wall/floor.
- C. Provide dielectric waterways or insulating flanges, as required by pipe size, on all connections of dissimilar metals.

3.2 SLEEVES AND SEALS

- A. Seals:
 - 1. General:
 - a. Seal all holes or voids where mechanical systems penetrate fire rated floors and walls with a fire stopping sealant having a fire rating equal to or greater than that of the construction being penetrated. The sealant shall meet the requirements of ASTM E-814, ASTM E-119 and UL-1479. It shall be installed with strict adherence to the manufacturer's instructions and according to the product's UL Laboratory listing. The use of asbestos in any form is not permitted.
 - 2. Conduct tests according to manufacturer's written recommendations to verify that substrates are free of oil, grease, rolling compounds, incompatible primers, loose mill scale, dirt and other foreign substances capable of impairing bond of firestopping.
 - 3. Do not cover firestopping with other construction until approval of authority having jurisdiction has been received.
- B. Flash and counterflash where mechanical equipment passes through weather or water-proofed walls, floors, and roofs per roof manufacturer's instructions.

END OF SECTION

SECTION 23 05 13
MECH/ELEC REQUIREMENTS FOR MECHANICAL EQUIPMENT

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

- A. This Section specifies the basic requirements for Electrical Components for Mechanical Equipment. These components include, but are not limited to, motors, starters, and disconnect switches for mechanical equipment.
- B. Wiring of field-mounted switches and similar mechanical-electrical devices provided for mechanical systems, to equipment control panels.
- C. Specific electrical requirements (i.e., horsepower and electrical characteristics) for mechanical equipment are scheduled on the Electrical Drawings. In case of conflict, Electrical Drawings shall take precedence. Do not purchase motors or electrical equipment until power characteristics available at building site location have been confirmed by CONTRACTOR.
- D. Refer to Table in Section 23 01 00 for Mechanical/Electrical Coordination.

1.2 QUALITY ASSURANCE

- A. Manufacturers: Firms regularly engaged in the manufacture of motors, motor starters and drives of types, ratings and characteristics required, whose products have been in satisfactory use in similar service for not less than 5 years.
- B. Installer's Qualifications: Firm with at least 3 years of successful installation experience on projects utilizing electric motors, motor starters, capacitors and drives similar to that required for this project.
- C. NFPA Compliance: Comply with applicable requirements of NFPA 70E, "Standard for Electrical Safety Requirements for Employee Workplaces."
- D. UL Compliance: Provide equipment and/or components which are UL-listed and labeled.
- E. Standards:
 - 1. NEMA Standards MG 1: Motors and Generators.
 - 2. NEMA Standard ICS 2: Industrial Control Devices, Controllers, and Assemblies.
 - 3. NEMA Standard 250: Enclosures for Electrical Equipment.
 - 4. NEMA Standard KS 1: Enclosed Switches.
 - 5. Comply with National Electrical Code (NFPA 70).
- F. Coordination with Electrical Work: Wherever possible, match elements of electrical provisions of Mechanical Work with similar elements of Electrical Work specified in Division 26 sections. Comply with applicable requirements of Division 26 sections for Electrical Work of this section which are not otherwise specified.

1.3 SUBMITTALS

- A. Listing, Motors of Mechanical Work: Concurrently, with submittal of mechanical products listing, submit separate listing showing rating, power characteristics, efficiencies, power factors, application, and general location of every motor to be provided with mechanical work. Submit updated information promptly when and if initial data is revised.
 - 1. Include in listing of motors, notations of whether motor starter is furnished or installed integrally with motor or equipment containing motor.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Subject to compliance with requirements, provide products by one of the following manufacturers for each type of product:
 - 1. Motors:
 - a. Century/MagneTek
 - b. Baldor
 - c. U.S. Motor
 - d. Reliance
 - e. General Electric
 - f. Louis Allis

2.2 MOTORS

- A. The following are basic requirements for simple or common motors. For special motors, more detailed and specific requirements are specified in the individual equipment specifications.
 - 1. Torque characteristics shall be sufficient to satisfactorily accelerate the driven loads with a time limit acceptable to the motor manufacturer. Motors shall be capable of starting the driven equipment while operating at 90 percent rated terminal voltage.
 - 2. Motor sizes shall be large enough so that the driven load will not require the motor to operate in the service factor range.
 - 3. Explosion proof motors shall meet Underwriters Laboratories Standards for use in hazardous locations and National Electrical Code (NEC), Article 500, Class, and Group.
 - 4. Temperature Rating: Rated for 40 degree C environment with maximum 80 degree C temperature rise for continuous duty at full load (Class B Insulation). Provide Class F insulation for variable frequency drive motors.
 - 5. Starting Capability: Frequency of starts as indicated by automatic control system, and not less than 5 evenly time spaced starts per hour for manually controlled motors.
 - 6. Service Factor: 1.15 for poly-phase motors and 1.35 for single-phase motors.
 - 7. Motor Construction: NEMA Standard MG 1, general purpose, continuous duty, Design "B", except "C" where required for high starting torque. Design "E" shall not be used.
 - a. Frames: NEMA Standard No. 48 or 54; Use driven equipment manufacturer's standards to suit specific application.

- b. Bearings:
 - 1) Ball bearings with inner and outer shaft seals.
 - 2) Re-greaseable, except permanently sealed where motor is normally inaccessible for regular maintenance.
 - 3) Bearings shall be rated for minimum L-10 life of 40,000 hours.
 - 4) Designed to resist thrust loading where belt drives or other drives produce lateral or axial thrust in motor.
 - 5) For fractional horsepower, light duty motors, sleeve type bearings are permitted.
 - c. Enclosure Type:
 - 1) Open drip-proof motors for indoor use where satisfactorily housed or remotely located during operation.
 - 2) Guarded drip-proof motors where exposed to contact by employees or building occupants.
 - 3) Weather protected Type I for outdoor use; Type II where not housed.
 - d. Noise Rating: "Quiet".
 - e. Efficiency: "Energy Efficient" motors shall have a minimum efficiency as scheduled in Table 1 in accordance with IEEE Standard 112, Test Method B. If efficiency not specified, motors shall have a higher efficiency than "average standard industry motors", in accordance with IEEE Standard 112, Test Method B.
 - f. Nameplate: Indicate the full identification of manufacturer, ratings, characteristics, construction, special features and similar information.
- 8. Phases and Current Characteristics: Unless indicated otherwise, provide squirrel-cage induction polyphase motors for 3/4 HP and larger, and provide capacitor-start single-phase motors for 1/2 HP and smaller, except 1/6 HP and smaller may, at equipment manufacturer's option, be split-phase type. Coordinate current characteristics with power specified in Division 26 sections. Do not purchase motors until power characteristics available at building site have been confirmed by CONTRACTOR.
 - 9. The CONTRACTOR shall be responsible for all additional electrical and other costs involved to accommodate any motors which differ from the scheduled horsepower sizes or correct any motor which does not meet the listed duty or efficiency as called for in Mechanical or Electrical Plans and Specifications.
 - 10. Motors shall be of the same manufacturer, except those that are an integral part of a factory assembled packaged unit. These motors shall likewise meet the conditions of the specification in this section except motors which are part of a motor/compressor assembly are exempted from this requirement.
 - 11. All motors 75 HP and larger shall be factory test certified for power factor, efficiency, and shall have a 3-year warranty. Factory certification of motor tests shall be provided to the OWNER.
 - 12. All equipment specified to operate with Variable Frequency Drives shall be provided with inverter-duty motors specifically designed for variable speed operation with high efficiency at part load conditions and constructed with Class F insulation.
 - 13. All motors which will be operated by a Variable Frequency Drive shall be warranted against any damage or defects as a result of being used with a variable frequency drive. VFD driven motors shall have 3-year warranties.

2.3 STARTERS

- A. Motor Starters: Refer to Section 230514.

2.4 DISCONNECT SWITCHES

- A. See Division 26 for requirements.

2.5 DRIVES

- A. V-Belt Drives:
 - 1. Capacity of V-Belt Drives at rated RPM shall be not less than 150 percent of motor nameplate horsepower rating.
 - 2. V-Belt Drive combinations shall be limited to A, B, C and fractional horsepower belts. 3V, 5V and 8V belts and sheaves shall not be used.
 - 3. All fixed pitch sheaves, including single groove fan sheaves, shall be of the bushed type. Fixed bore sheaves will not be acceptable for adjustable pitch sheaves.
 - 4. Unit manufacturer shall provide OSHA approved belt guard with tachometer holes.

2.6 VARIABLE FREQUENCY DRIVES

- A. Refer to Section 23 05 15.

2.7 EQUIPMENT FABRICATION

- A. General: Fabricate mechanical equipment for secure mounting of motors and other electrical items included in work. Provide either permanent alignment of motors with equipment, or adjustable mountings as applicable for belt drives, special couplings and similar indirect couplings of equipment. Provide safe, secure, durable, and removable guards for motor drives, arranged for lubrication and similar running-maintenance without removal of guards.

PART 3 - EXECUTION

3.1 TEST AND TEST DATA

- A. A factory load test shall be performed on each motor of 1,000-watt input or greater to assure compliance with the energy-efficiency section of this specification.
- B. Typical test data on every motor to be used on this project shall be made available upon request.

3.2 INSTALLATION

- A. Install motors on motor mounting systems in accordance with motor manufacturer's instructions, securely anchored to resist torque, drive thrusts, and other external forces inherent in mechanical work. Secure sheaves and other drive units to motor shafts with keys and Allen set screws, except motors of 1/3 HP and less may be secured with Allen set screws on flat surface of shaft. Unless otherwise indicated, set motor shafts parallel with machine shafts.
- B. Deliver starters and wiring devices which have not been factory-installed on equipment unit to electrical installer for installation.

- C. Install power and control connections for motors to comply with NEC and applicable provisions of Division 26 sections. Install grounding except where non-grounded isolation of motor is indicated.

3.3 INSTALLATION COORDINATION

- A. Furnish equipment requiring electrical connections to operate properly and to deliver full capacity at electrical service available.
- B. All control wiring to be in accordance with manufacturer's recommendations and shall be color-coded and individually numbered to facilitate checking.
- C. Unless otherwise indicated, all mechanical equipment motors and controls shall be furnished, set in place, and wired in accordance with the schedule contained in Division 23. The exact furnishing and installation of the equipment is left to the CONTRACTOR's involved. CONTRACTOR should note that the intent of the schedule is to have the Division 23 and 26 CONTRACTOR's responsible for coordinating all control wiring as outlined, whether or not specifically called for by the Mechanical or Electrical Drawings and Specifications. Comply with the applicable requirements of Division 26 for all electrical work which is not otherwise specified. No extras will be allowed for CONTRACTOR's failure to provide for these required items. The CONTRACTOR shall refer to the Division 26 and Division 23 specifications and plans for all power and control wiring and shall advise the Architect/ENGINEER of any discrepancies prior to bidding.

END OF SECTION

SECTION 23 05 14
MOTOR CONTROLLERS

PART 1 - GENERAL

1.1 SUMMARY

- A. Manual Motor Starters
- B. Single Phase Motor Starters
- C. Magnetic Motor Starters
- D. Combination Magnetic Motor Starters

1.2 RELATED DOCUMENTS

- A. Drawings, General and Special Conditions, Division 1 - General Requirements and other applicable technical specifications apply to work of this section.

1.3 RELATED SECTIONS

- A. Division 26 - Electrical: All Sections.
- B. Section 23 05 13 – Mechanical/Electrical Requirements for Mechanical Equipment.

1.4 REFERENCE STANDARDS

- A. Comply with the requirements of the reference standards noted herein, except where more stringent requirements are listed herein or otherwise required by the Contract Documents. A listing of applicable reference standards is contained in Division 1.
- B. ANSI/NFPA – 70, National Electrical Code
- C. ANSI/NEMA ICS 6 – 1993: Industrial Control and Systems: Enclosures.
- D. IEC 60947-5, 60947-4, 60947-3.
- E. NEMA AB 1 - Molded Case Circuit Breakers.
- F. NEMA ICS 2 - Industrial Control and Systems: Controllers, Contactors, and Overload Relays.
- G. UL 508, and UL 508A Industrial Control Equipment.

1.5 SUBMITTALS

- A. Submit under provisions of Division 1.
- B. Provide product data on motor starters and combination motor starters, relays, pilot devices, and switching and overcurrent protective devices.

1.6 OPERATION AND MAINTENANCE DATA

- A. Submit Operation and Maintenance Data under provisions of Division 1.
- B. Include spare parts data listing; source and current prices of replacement parts and supplies; and recommended maintenance procedures and intervals.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Deliver products to site under provisions of Division 1.
- B. Store and protect products under provisions of Division 23.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

- A. MOTOR STARTERS
 - 1. Allen-Bradley
 - 2. Cerus Industrial
 - 3. Cutler Hammer
 - 4. Square-D
 - 5. Siemens

2.2 MANUAL MOTOR STARTERS

- A. Manual Motor Starter: NEMA ICS 2; AC general-purpose Class A manually operated non-reversing full-voltage controller for induction motors rated in horsepower, with solid state electronic overload relay for each phase, phase loss protection, phase imbalance, ground fault protection, low-voltage protection, red pilot light, field-convertible auxiliary contact, and toggle operator.
- B. Fractional Horsepower Manual Starter: NEMA ICS 2; AC general-purpose Class A manually operated, full-voltage controller for fractional horsepower induction motors, with thermal overload unit, red pilot light, and key or toggle operator as indicated.
- C. Motor Starting Switch: NEMA ICS 2; AC general-purpose Class A manually operated pole, full-voltage controller for fractional horsepower induction motors, without thermal overload unit, red pilot light, field convertible auxiliary contact, and toggle operator.
- D. Enclosure: ANSI/NEMA ICS 6; Type 1 for Indoor applications, and Type 3R for Outdoor applications.

2.3 SINGLE PHASE MOTOR STARTERS

- A. Single Phase Motor Starter Control: The single-phase motor starter shall consist of a manually operated quick-make toggle mechanism lockable in the "Off" position which shall also function as the starter disconnect. Additionally, the starter shall provide thermal overload protection, run status pilot light, and fault pilot light. The starter must include the capability to operate in both manual and automatic modes. In automatic modes, the starter shall have the capability to integrate with a building automation system by providing terminals for run input, run status, output, and fault output. All control terminals shall be integrated in the starter. At a minimum, each single-phase starter shall include an interposing run relay and current sensing status output relay. Single phase motor starter shall be in a surface mount enclosure with the appropriate environmental rating.

2.4 MAGNETIC MOTOR STARTERS

- A. Magnetic Motor Starters: NEMA ICS 2; AC general-purpose Class A, combination type magnetic controller as specified herein, for induction motors, rated in horsepower.
- B. Magnetic Motor Starters shall be circuit breaker or motor circuit protector combination type, with external operator, in common enclosure with starter. External circuit breaker operator environmental rating shall match the enclosure rating. Disconnecting means shall be equipped with provisions enabling locking in the "OFF" position.
- C. Full Voltage Starting: Reversing or non-reversing type as indicated.
- D. Coil Operating Voltage: Unless otherwise specified, 120 volts, 60 hertz.
- E. Size: NEMA ICS 2; Size as shown on Drawings, or as required for the motor horsepower.
- F. Overload Relay: NEMA ICS 2; self-powered, adjustable trip solid state electronic overload relay type, which protects all 3 phases with selectable trip class operation. Motor protection functions shall include phase loss, phase unbalance, ground fault, locked rotor and stall protection.
- G. Enclosure: NEMA ICS 6; Type 1 for Indoor applications, and Type 3R for Outdoor applications.
- H. Auxiliary Contacts: NEMA ICS 2; 2 field-convertible contacts, 1 NO and 1 NC, in addition to seal-in contact.
- I. Selector Switches: NEMA ICS 2; HAND/OFF/AUTO, maintained type, in front cover.
- J. Indicating Lights: NEMA ICS 2; RUN: Red LED type, in front cover with press-to-test lamp testing feature.
- K. Relays: NEMA ICS 2; as required.
- L. For 480-Volt applications, an individually fused 480-120 Volt control transformer shall be furnished with each combination starter. The Control Transformer shall be sized by the manufacturer to have a minimum of 20 percent capacity in excess of the continuous volt-ampere requirements of the holding coil, indicating lights and any externally located devices such as solenoid valves, external relays, etc. The control transformer shall be capable of operation with an inrush current 20 percent greater than required by the holding coil, indicating lights and external device, if any.
- M. When remotely controlled by an automation system, the starter shall include remote run terminals which accept both a voltage input signal and a contact closure. The voltage run input shall accept both AC and DC signals including 24 VAC, 120 VAC, 24 VDC and 48 VDC to allow direct connection of the transistorized signal to the starter.
- N. In applications where the motor is interlocked with a damper or valve, the actuator control must reside within the starter enclosure. The starter must provide a voltage output to operate the actuator to open the damper or valve without closing the motor circuit. The starter will only close the motor circuit and start the motor after it has received a contact closure from a limit or end switch confirming the damper or valve position.

- O. The starter shall provide a provision for Fireman's Override operation. When activated, the starter runs the motor in any mode (Hand, Off or Auto) regardless of other inputs or lack of inputs either manual or automatic. The purpose of the Fireman's Override input is to act as a smoke purge function. Fireman's Override has priority over the Emergency Shutdown input.
- P. If the starter is controlled by a fire alarm or life safety system, the starter shall include an Emergency Shutdown input which will disable the starter from operating in either Hand or Auto mode regardless of other inputs either manual or automatic.
- Q. Acceptable disconnecting means for combination starters include motor circuit protectors, UL 489 circuit breakers, or a fused disconnect. All disconnects shall include a lock-out mechanism when in the off position.
- R. The Motor Circuit protector shall be a UL listed 508 current limiting manual motor starter with magnetic trip elements only. The breaker shall carry a UL 508 rating (up to 100A frame size) which provides for coordinated short circuit rating for use with motor contactor and provides a minimum interrupting rating of 30,000 AIC for the combination starter.
- S. Fused disconnect shall be UL 98 suitable for service entrance protection. It shall accommodate time delay J-style fuses.
- T. UL 489 breaker shall include thermal and magnetic trip mechanisms.
- U. Provide optional features, as required, to meet design performance according to the following requirements.
 - 1. Must provide over/under voltage phase monitoring capability. Monitor shall be field adjustable for both over and under voltage levels and a delay time before returning to normal operation after trip.
 - 2. Starter must measure and display output current on the front cover. If necessary, install digital or analog ammeter.
 - 3. The starter shall provide the capability to monitor and calculate power consumption (kWh) of the motor load. Each starter shall display the calculated kW and kWh. Additionally, provide either a pulse output (kWh) or 4-20 mA analog signal (kW) to the automation system to monitor the power consumption.
 - 4. Starter must be capable of communicating over BACnet MS/TP. At a minimum, reported points shall include starter mode, terminal input status, voltage, current, power factor, kW and kWh.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install motor control equipment in accordance with manufacturer's instructions.
- B. Select and adjust electronic overloads to match installed motor characteristics.
- C. Motor Data: Provide neatly typed label inside each motor starter enclosure door identifying motor served, nameplate horsepower, full load amperes, code letter, service factor, and voltage/phase rating.
- D. Floor mounted equipment shall be on a 4-inch concrete housekeeping pad.

- E. Provide Nameplates per Division 26.

END OF SECTION

SECTION 23 05 15
VARIABLE FREQUENCY CONTROLLERS

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Variable Frequency Drives (VFDs)

1.2 RELATED DOCUMENTS

- A. Drawings, General and Special Conditions, General Requirements, and other applicable technical specifications apply to work of this section.

1.3 RELATED SECTIONS

- A. Division 26 – Electrical; All Sections
- B. Section 23 05 13 - Mechanical/Electrical Requirements for Mechanical Equipment
- C. Section 23 05 14 – Motor Controllers

1.4 REFERENCE STANDARDS

- A. Comply with the requirements of the reference standards noted herein, except where more stringent requirements are listed herein or otherwise required by the Contract Documents.
- B. NFPA 70 - National Electrical Code.
- C. ANSI/NEMA ICS 6 - Enclosures for Industrial Controls and Systems.
- D. NEMA AB 1 – Molded Case Circuit Breakers.
- E. NEMA ICS 2 - Industrial Control Devices, Controllers, and Assemblies.
- F. NEMA ICS 3.1 - Safety Standards for Construction and Guide for Selection, Installation and Operation of Adjustable Speed Drive Systems.
- G. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum).
- H. ANSI/UL Standard 508.
- I. IEEE Standard 519-1992; For Voltage and Total Demand Distortion.
- J. FCC Rules and Regulations, Part 15, Subpart J; For Radiated RFI.

1.5 SUBMITTALS

- A. Submit under provisions of Division 1.
- B. Shop Drawings: Include front and side views of enclosures with overall dimensions and weights shown; conduit entrance locations and requirements; and nameplate legends.
- C. Product Data: Provide catalog sheets showing voltage, controller size, ratings, and size of switching and overcurrent protective devices, short circuit ratings, dimensions, and enclosure details.
- D. Test Reports: Indicate field test and inspection procedures and test results.

- E. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency specified under Regulatory Requirements. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of product.
- F. Manufacturer's Field Reports: Submit under provisions of Division 1.
- G. Manufacturer's Field Reports: Indicate Start-Up Inspection findings.

1.6 OPERATION AND MAINTENANCE DATA

- A. Submit under provisions of Division 1.
- B. Operation Data: Include instructions for starting and operating controllers and describe operating limits that may result in hazardous or unsafe conditions.
- C. Maintenance Data: Include routine preventive maintenance schedule.

1.7 REGULATORY REQUIREMENTS

- A. Conform to requirements of NFPA 70.
- B. Furnish products listed and classified by Underwriters Laboratories, Inc., and conforming to referenced standards as suitable for purpose specified and indicated.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Deliver products to site under provisions of Division 1.
- B. Store, protect, and handle products under provisions of Division 23.
- C. Accept controllers on site in original packing. Inspect for damage.
- D. Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.
- E. Handle in accordance with manufacturer's written instructions. Lift only with lugs provided for the purpose. Handle carefully to avoid damage to components, enclosure, and finish.

1.9 FIELD MEASUREMENTS

- A. Verify that field measurements are as on Shop Drawings.

1.10 MAINTENANCE SERVICE

- A. Furnish service and maintenance of controller for 2 years from Date of Substantial Completion.

1.11 EXTRA MATERIALS

- A. Provide 2 of each air filter.
- B. Provide 3 of each fuse size and type.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

- A. All VFDs provided for this project shall be of a single manufacturer.
- B. Approved Manufacturers:
 - 1. Asea Brown Boveri (ABB)
 - 2. Robicon
 - 3. Danfoss
 - 4. Siemens
 - 5. Toshiba
 - 6. Cutler-Hammer

2.2 GENERAL

- A. The VFD shall convert incoming 3-phase 60 Hz AC power to a variable frequency, variable voltage AC output suitable for control of a standard NEMA Design B induction motor over a 10:1 speed range.
- B. The VFD shall consist of a 3-phase full-wave converter section to rectify the incoming AC source, a filtered DC bus section, and a sinusoidal PWM output section utilizing IGBT type output transistors, and utilizing sensorless torque vector control logic, as specified below.
- C. The VFD shall maintain a near unity power factor regardless of speed or load (0.95 or better for drives larger than 5 HP).
- D. Inverter section shall utilize insulated gate bipolar transistors (IGBTs) with a minimum rating of 1200 VDC, and have an adjustable carrier frequency range of 1 to 6 kHz through 100 HP, and 1 to 3 kHz above 100 HP.
- E. The VFD and options shall be tested to ANSI/UL Standard 508 and listed by either UL or ETL.
- F. Power line noise shall be limited to a 5 percent voltage distortion factor and total demand distortion factor (TDD) as defined in IEEE Standard 519-1992, Guide for Harmonic Control and Reactive Compensation of Static Power Converters. Submittal data shall include calculations to show TDD based on available short circuit current. The point of common coupling (PCC) shall be at the power wiring immediately downstream of the Building Transformer.
- G. The VFD torque characteristic shall match the driven load.
- H. The VFD shall include an integral disconnect to isolate the VFD from input power.
- I. Voltage Tolerance: ± 10 percent; Frequency tolerance ± 3 percent.
- J. The VFD output shall be rated for continuous duty with full load amp ratings that meet or exceed NEC Table 430-150. The VFD shall have overload capability of 110 percent rated current for 60 seconds. Output voltage range shall not exceed input rated voltage.
- K. Ambient Operating Conditions: Temperature, 0-40 degrees C; Relative Humidity, 0-95 percent, non-condensing, 5600 feet elevation, without deration.

- L. All printed circuit boards and power subassemblies shall be burned in at elevated temperature (50 degrees C minimum) for 48 hours minimum. The completed, assembled VFD shall be functionally tested under motor load before shipment to ensure proper operation. The manufacturer shall provide certification that these tests have been completed.

2.3 BASIC FEATURES

- A. Control power transformer with fused primary and 24V or 120V fused secondary.
- B. VFD AC line input high-speed semi-conductor type current-limiting fuses rated 200,000 AIC minimum.
- C. Operator Controls:
 - 1. "HAND-OFF-AUTO" Selector Switch. In "AUTO" position, drive starts and stops motor from remote contact closure, and motor speed shall be proportional to a remote speed control signal. In "HAND" position, motor is started and stopped from VFD Keypad/Display Module, and the motor speed shall be as set through the VFD Keypad/Display Module.
 - 2. Pilot Lights: LED Type. 22.5mm IEC Style, Red "VFD On", White "Control Power On", and Amber "VFD Fault".
- D. Keypad/Display Module:
 - 1. A multi-line alpha-numeric backlit display capable of displaying at minimum motor speed (Hz), motor current (A), motor voltage (V), elapsed time meter (Hrs.), inverter load (percent) and all drive programming parameters.
- E. Programmable Relay Outputs (three minimum) capable of indicating the following:
 - 1. VFD in Run Mode
 - 2. VFD at Zero Speed
 - 3. VFD Fault
- F. Terminals for field-installed external safeties.
- G. Field-selectable Auto Restart on power source failure.
- H. Adjustable voltage boost for starting high torque loads.
- I. Drive shall be capable of starting into a spinning motor by matching frequency and phase angle to the motor back EMF.
- J. Critical Speed Avoidance: Drive shall allow the User to avoid operation at resonant speeds. Selected speeds shall be stepped over. Four (4) critical speeds shall be capable of being avoided, with an adjustable bandwidth for each critical speed.
- K. Signal Follower: In Auto Speed mode, motor speed shall be proportional to an external 4-20 ma or 0-10 vdc speed control signal. Verify with Control CONTRACTOR whether the control signal is 4-20 ma or 0-10 vdc. Provide control signal consistent throughout the facility. Loss of reference signal shall cause drive to go to programmable preset speed.
- L. BACnet interface.

2.4 INPUT POWER HARMONIC REDUCTION

- A. All VFDs of 3 HP and larger shall have as a minimum; positive and negative DC link reactors, or AC line input reactors to reduce input power harmonics. If the total harmonics exceed that allowed as defined in paragraph 2.2-F, above, at the PCC; provided additional AC line input reactors, input isolation transformers, or line input filters as required to meet the provisions paragraph 2.2-F.

2.5 MOTOR PROTECTION

- A. For all installations where the conductors from the VFD to the motor exceed 100 feet in length, provide a minimum 3 percent reactance motor protecting dv/dt filter at the VFD output terminals.

2.6 ADJUSTMENTS

- A. Acceleration Time: 2 to 20 Second minimum range.
- B. Deceleration Time: 2 to 20 Second minimum range.
- C. Volts/Hz Ratio: Programmable.
- D. Voltage Boost: Programmable.
- E. Critical Speed Lockout: Four (4) critical speeds with adjustable bandwidth.
- F. Current Limit: 30 to 110 percent sine wave current rating.
- G. Carrier Frequency Range: 1 to 6 kHz through 100 HP and 1 to 3 kHz above 100 HP.
- H. Output Frequency Range: 0 to 80 Hz minimum range.
- I. All drive parameters shall be stored in non-volatile memory (EEPROM).

2.7 PROTECTIVE FEATURES

- A. VFD shall have built-in protection for power source transients, over-voltage, under-voltage, and phase loss. VFD shall not require an input isolation transformer for transient protection.
- B. DC bus over-voltage protection.
- C. Instantaneous shutdown when load current exceeds 150 percent.
- D. Adjustable electronic Class 20 inverse time characteristic over-current overload protection for the motor.
- E. The VFD shall be capable of withstanding randomly applied short circuit current applied across the output terminals without damage.
- F. Protection of VFD for any external disconnects between the drive and the motor. Provide control terminals for connection of disconnect switch auxiliary contacts, which will immediately stop the drive when opened.
- G. Troubleshooting Diagnostic Features:
 - 1. Indicator lights on inverter power module to indicate correct operation (or failure) of individual power switching devices.

2. Indicator lights to show drive fault/ready states, and reason for fault shutdown, including instantaneous overload, motor overload, output or DC bus over-voltage, or source over-voltage, under-voltage, or phase loss. The VFD shall store in memory at minimum the previous 5 alarms.

2.8 FABRICATION

- A. Wiring Terminations: Match conductor materials and sizes indicated.
- B. Enclosure:
 1. For Dry, Indoor Applications: NEMA 250, Type 12.
 2. For Wet, Indoor, Temperature Controlled Applications, NEMA 250, Type 4, with ventilation provisions, or closed loop heat exchanger, as required for adequate VFD cooling. Any powered enclosure ventilation or heat exchanger shall be configured to operate from a single point of electrical connection, common with the VFD.
- C. Finish: Manufacturer's standard enamel.

2.9 SOURCE QUALITY CONTROL

- A. Inspect and production-test each product specified in this section.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify that surface is suitable for controller installation.
- B. Do not install controller until building environment can be maintained within the service conditions required by the manufacturer.

3.2 INSTALLATION

- A. Install controller where indicated, in accordance with manufacturer's written instructions and NEMA ICS 3.1.
- B. Tighten accessible connections and mechanical fasteners after placing controller.
- C. Install fuses in fusible switches.
- D. Provide engraved plastic nameplates under the provisions of Division 26.
- E. Provide neatly typed label inside each motor controller door identifying motor served, nameplate horsepower, full load amperes, code letter, service factor, and voltage/phase rating.
- F. Provide dry contacts for protection of VFD with external disconnect between VFD and motor.
 1. If a Disconnect Switch is installed between the VFD and the motor, it must be a non-fused type switch, and must include a control interlock kit with a control contact which opens prior to the main contacts.

3.3 FIELD QUALITY CONTROL

- A. Inspect completed installation for physical damage, proper alignment, anchorage, and grounding.

3.4 START-UP SERVICE

- A. Provide minimum 2 hours of start-up service for each VFD. Service shall be performed by factory-trained service technicians.
- B. Technician shall verify correct installation, start-up the drive, adjust all required operating parameters, and verify proper operation in all operating modes.
- C. OWNER Training: Provide minimum 8 hours training in operation and trouble-shooting procedures for the installed drives.

3.5 ADJUSTING

- A. Make final adjustments to installed drive to assure proper operation of fan system. Obtain performance requirements from installer of driven loads.

3.6 CLEANING

- A. Touch up scratched or marred surfaces to match original finish.

3.7 DEMONSTRATION

- A. Provide systems demonstration under provisions of Division 26.
- B. Demonstrate operation of controllers in automatic and manual modes.

END OF SECTION

SECTION 23 05 29
SUPPORTS AND ANCHORS

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

- A. Extent of Supports and Anchors required by this section is indicated on drawings and/or specified in other Division 23 sections.
- B. Types of Supports and Anchors specified in this section include the following:
 - 1. Piping Hangers and Supports
 - 2. Vertical-Piping Clamps
 - 3. Hanger-Rod Attachments
 - 4. Building Attachments
 - 5. Saddles and Shields
 - 6. Miscellaneous Materials
 - 7. Anchors
 - 8. Equipment Supports
- C. Supports and anchors furnished as part of factory-fabricated equipment are specified as part of equipment assembly in other Division 23 sections.

1.2 QUALITY ASSURANCE

- A. Manufacturer's Qualifications: Firms regularly engaged in the manufacture of supports and anchors, of types and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.
- B. Codes and Standards:
 - 1. Regulatory Requirements: Comply with applicable Mechanical Codes pertaining to product materials and installation of supports and anchors.
 - 2. Duct Hangers: SMACNA Duct Manuals.
 - 3. MSS Standard Compliance:
 - a. Provide pipe hangers and supports of which materials, design, and manufacture comply with MSS SP-58.

1.3 SUBMITTALS

- A. Product Data: Submit manufacturer's technical product data, including installation instructions for each type of support and anchor. Submit pipe hanger and support schedule showing manufacturer's figure number, size, location, and features for each required pipe hanger and support.
- B. Shop Drawings: Submit manufacturer's assembly-type shop drawings for each type of support and anchor, indicating dimensions, weights, required clearances, and methods of assembly of components.
- C. Product certificates signed by the manufacturer of hangers and supports certifying that their products meet the specified requirements.

- D. Maintenance Data: Submit maintenance data and parts list for each type of support and anchor. Include this data, product data, and shop drawings in maintenance manual; in accordance with requirements of Division 1.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturer: Subject to compliance with requirements, provide products by one of the following:
 - 1. Pipe Hangers and Supports:
 - a. B-Line Systems Inc.
 - b. Carpenter and Patterson, Inc.
 - c. Mason Industries, Inc.
 - d. PHD Manufacturing, Inc.
 - e. Elcen Metal Products Company
 - f. Erico/Caddy
 - g. Unistrut Metal Framing Systems
 - h. Hilti USA.
 - i. Advanced Thermal Systems
 - j. Anvil

2.2 PIPE HANGERS AND SUPPORTS

- A. Hangers and support components shall be factory fabricated of materials, design, and manufacturer complying with MSS SP-58.
 - 1. Components shall be stainless steel where installed for piping and equipment that will not have field-applied finish.
 - 2. Pipe attachments shall have nonmetallic coating for electrolytic protection where attachments are in direct contact with copper tubing.
- B. Hanger Rods: Continuous threaded steel, sizes as specified.

2.3 UPPER ATTACHMENTS

- A. Beam Clamps
 - 1. All thread rod sized 3/8-inch and 1/2-inch: B-Line B3034
 - 2. All thread rod sizes 5/8- inch: B-Line B3033
 - 3. All thread rod sizes 3/4-inch and up: B-Line B3055

2.4 MISCELLANEOUS MATERIALS

- A. Steel Plates, Shapes, and Bars: ASTM A 36.
- B. Cement Grout: Portland cement (ASTM C 150, Type I or Type III) and clean uniformly graded, natural sand (ASTM C 404, Size No. 2). Mix ratio shall be 1.0-part cement to 3.0 parts sand, by volume, with minimum amount of water required for placement and hydration.
- C. Heavy-Duty Steel Trapezes: Fabricate from steel shapes selected for loads required; weld steel in accordance with AWS Standards.
- D. Duct strap materials shall match duct material.

PART 3 - EXECUTION

3.1 INSPECTION

- A. Examine areas and conditions under which supports, and anchors are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.2 PREPARATION

- A. Proceed with installation of hangers, supports and anchors only after required building structural work has been completed in areas where the work is to be installed. Correct inadequacies including (but not limited to) proper placement of inserts, anchors, and other building structural attachments. Review Structural Drawings to obtain structural support limitations.
- B. Prior to installation of hangers, supports, anchors and associated work, Installer shall meet at Project Site with CONTRACTOR, installer of each component of associated work, inspection, and testing agency representatives (if any), installers of other work requiring coordination with work of this section and Architect/ ENGINEER for purpose of reviewing material selections and procedures to be followed in performing the work in compliance with requirements specified. Provide Shop Drawing showing method and support locations from structure.

3.3 INSTALLATION OF BUILDING ATTACHMENTS

- A. Install building attachments within concrete or on structural steel. Space attachments within maximum piping span length indicated in MSS SP-69 and tables this section. Install additional attachments at concentrated loads, including valves, flanges, guides, strainers, expansion joints, and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten insert to forms. Where concrete with compressive strength less than 2,500 psi is indicated, install reinforcing bars through openings at top of inserts.
- B. New Construction:
 - 1. Use inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams wherever practicable.
 - 2. Set inserts in position in advance of concrete work. Provide reinforcement rod in concrete for inserts carrying pipe over 4-inch or ducts over 60-inch wide.
 - 3. Where concrete slabs form finished ceiling, finish inserts flush with slab surface.
 - 4. Use drop-in anchors for concrete structures.
 - 5. Use beam clamps for steel structures.

3.4 INSTALLATION OF HANGERS AND SUPPORTS

- A. Install hangers, supports, clamps and attachments to support piping properly from building structure; comply with MSS SP-69 and SP-89. Arrange for grouping of parallel runs of horizontal piping to be supported together on field fabricated, heavy-duty trapeze hangers where possible. Install supports with maximum spacings complying with MSS SP-69 and tables this section. Where piping of various sizes is supported together by trapeze hangers, space hangers for smallest pipe size or install intermediate supports for smaller diameter pipe. Do not use wire or perforated metal to support piping, and do not support piping from other piping.

- B. Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers, and other accessories.
- C. Load Distribution: Install hangers and supports so that live and dead loading and stresses from movement will not be transmitted to connected equipment.
- D. Install anchors and fasteners in accordance with manufacturer's recommendations and the following:
 - 1. In the event a self-drilling expansion shield or machine bolt expansion shield is considered to have been installed improperly, the CONTRACTOR shall make an acceptable replacement or demonstrate the stability of the anchor by performing an on-site test under which the anchor will be subjected to a load equal to twice the actual load.
 - 2. Powder-driven fasteners may be used only where they will be concealed after the construction is complete. Where an occasional fastener appears to be improperly installed, additional fastener(s) shall be driven nearby (not closer than 6 inches) in undisturbed concrete. Where it is considered that many fasteners are improperly installed, the CONTRACTOR shall test load any 50 successively driven fasteners. If 10 percent or more of these fasteners fail, the CONTRACTOR shall utilize other fastening means as approved and at no additional cost to the OWNER.
 - 3. Hangers for ducts shall be attached to cellular steel floor decks with steel plates and bolted rod conforming to the steel deck manufacturer's requirements. Where the individual hanger load exceeds the capacity of a single floor deck attachment, steel angles, beams or channels shall be provided to span the number of floor deck attachments required.
 - 4. Welding may be used for securing hangers to steel structural members. Welded attachments shall be designed so that the fiber stress at any point of the weld or attachment will not exceed the fiber stress in the hanger rod.

3.5 SHEET METAL DUCT HANGERS AND SUPPORTS

- A. Install ductwork hangers and supports in accordance with SMACNA and the details on the drawings.
- B. Gripple hangers are not to be used on this project.
- C. Provide sway bracing on all ductwork in accordance with local codes and regulations.

3.6 EQUIPMENT SUPPORTS

- A. Fabricate structural steel stands to suspend equipment from structure above or support equipment above floor.
- B. Grouting: Place grout under supports for piping and equipment.
- C. Concrete bases for the mechanical equipment indoors or outdoors will be provided by the General CONTRACTOR only if shown on the Architectural or Structural Drawings. Otherwise, all bases shall be provided by this CONTRACTOR.
- D. Housekeeping bases shall be 4-inch-thick minimum, extended 4-inch beyond machinery bedplates.

- E. This CONTRACTOR shall be responsible for the proper size and location of all bases and shall furnish all required anchor bolts and sleeves. If bases are provided by the General CONTRACTOR, furnish him with templates showing the bolt locations.
- F. Equipment shall be secured to the bases with anchor bolts of ample size. Bolts shall have bottom plates and pipe sleeves and shall be securely imbedded in the concrete. All machinery shall be grouted under the entire bearing surface. After grout has set, all wedges, shims and jack bolts shall be removed, and the space filled with non-shrinking grout. This CONTRACTOR shall provide washers at all equipment anchor bolts.
- G. Construct equipment supports mounted above floor of structural steel members or steel pipe and fittings. Brace and fasten with flanges bolted to structure.
- H. Provide rigid anchors for ducts and pipes immediately after vibration connections to equipment. See also Section 23 05 48.

3.7 METAL FABRICATION

- A. Cut, drill, and fit miscellaneous metal fabrications for pipe anchors and equipment supports. Install and align fabricated anchors in indicated locations.
- B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.
- C. Field Welding: Comply with AWS D1.1 for procedures of manual shielded metal-arc welding, appearance and quality of welds made, methods used in correcting welding work, and the following:
 - 1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
 - 2. Obtain fusion without undercut or overlap.
 - 3. Remove welding flux immediately.
 - 4. Finish welds at exposed connections so that no roughness shows after finishing.

3.8 ADJUSTING

- A. Hanger Adjustment: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.
- B. Touch-Up Painting: Immediately after erection of anchors and supports, clean field welds and abraded areas of shop paint and paint exposed areas with same material as used for shop painting to comply with SSPC-PA-1 requirements for touch-up of field-painted surfaces.
 - 1. Apply by brush or spray to provide a minimum dry film thickness of 2.0 mils.
- C. For galvanized surfaces, clean welds, bolted connections, and abraded areas and apply galvanizing repair paint to comply with ASTM A 780.

END OF SECTION

SECTION 23 05 48
VIBRATION CONTROL

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

- A. Extent of Vibration Control Work required by this section is indicated on Drawings and Schedules, and/or specified in other Division 23 sections.
- B. Types of Vibration Control Products specified in this section include the following:
 - 1. Fiberglass Pads and Shapes
 - 2. Vibration Isolation Springs
 - 3. All-Directional Anchors
 - 4. Neoprene Mountings
 - 5. Spring Isolators, Free-Standing
 - 6. Spring Isolators, Vertically Restrained
 - 7. Isolation Hangers
 - 8. Flexible Pipe Connectors
- C. Vibration Control Products furnished as integral part of factory-fabricated equipment, are specified as part of equipment assembly in other Division 23 sections.
- D. Refer to other Division 23 sections for equipment foundations; Hangers; Sealants; Gaskets; requirements of electrical connections to equipment isolated on vibration control products; requirements of duct connections to air handling equipment isolated on vibration control products.

1.2 QUALITY ASSURANCE

- A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of vibration control products, of type, size, and capacity required, whose products have been in satisfactory use in similar service for not less than 5 years.
 - 1. Except as otherwise indicated, obtain Vibration Control Products from single manufacturer.
 - 2. Engage Manufacturer to provide technical supervision of installation of support isolation units produced, and of associated inertia bases (if any).

1.3 SUBMITTALS

- A. Product Data: Submit manufacturer's technical product data and installation instructions for each type of vibration control product. Submit schedule showing size, type, deflection, and location for each product furnished.
 - 1. Include data for each type and size of unit, showing isolation efficiency, stiffness, natural frequency, and transmissibility at lowest operating speed of equipment.
 - 2. For spring units, show wire size, spring diameter, free height, solid-compression height, operating height, fatigue characteristics, ratio of horizontal to vertical stiffness and bases of spring-rated selection for range of loading weights.
 - 3. Include performance certifications from manufacturers.

- B. Shop Drawings: Submit manufacturer's assembly-type shop drawings indicating dimensions, weights, required clearances, and method of assembly of components. Detail bases and show location of equipment anchoring points coordinated with equipment manufacturer's shop drawings.
 - 1. Shop drawings showing structural design and details of inertia bases, steel beam bases and other custom-fabricated work not covered by manufacturer's submitted data.
 - a. Furnish templates, anchor bolts and sleeve for equipment bases, foundations, and other support systems for coordination of vibration isolation units with other work.
 - 2. Submit shop drawings indicating scope of vibration isolation work and locations of units and flexible connections. Include support isolation points for piping and ductwork including risers, air housings and inertia bases.
 - a. Include schedule of units, showing size or manufacturer's part number, and weight supported and resulting deflection of each unit.
- C. Maintenance Data: Submit maintenance data for each type of vibration control product. Include this data, product data and shop drawings in maintenance manual; in accordance with requirements of Division 1.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

- A. Manufacturer: Subject to compliance with requirements, provide products by one of the following:
 - 1. Vibration Control Products:
 - a. Mason Industries, Inc.
 - b. Kinetics Noise Control.
 - c. Vibration Eliminator
 - d. Senior Flexonics
 - e. Amber Booth

2.2 VIBRATION CONTROL MATERIALS AND SUPPORT UNITS

- A. Fiberglass Pads and Shapes: Glassfiber of not more than 0.18 mil diameter, produced by multiple-flame attenuation process, molded with manufacturer's standard fillers and binders through 10 compression cycles at 3 times rated load bearing capacity, to achieve natural frequency of not more than 12 Hertz, in thicknesses and shapes required for use in vibration isolation units.
- B. Vibration Isolation Springs: Wound-steel compression springs, of high-strength, heat-treated, spring alloy steel with outside diameter not less than 0.8 times operating height; with lateral stiffness not less than vertical stiffness and designed to reach solid height before exceeding rated fatigue point of steel.
 - 1. Color coated springs for ease of identification.
 - 2. Spring shall have a minimum of 50 percent additional travel to solid.
 - 3. Mason Industries Type SLF

- C. Spring Isolators, Free-Standing: Except as otherwise indicated, provide vibration isolation spring Type C between top and bottom loading plates, and with pad-type Type B isolator bonded to bottom of bottom loading plate. Include studs or cups to ensure centering of spring on plates. Include leveling bolt with lock nuts and washers, centered in top plate, arranged for leveling and anchoring supported equipment as indicated.
 - 1. Include holes in bottom plate for bolting unit to substrate as indicated.
 - 2. Mason Industries Type SLFH
- D. Spring Isolators, Vertically Restrained: Provide spring isolators Type C in housing that includes vertical limit stops. Design housing to act as blocking during erection, and with installed height and operating height being equal. Maintain 1/2-inch minimum clearance around restraining bolts, and between housing and springs. Design so limit stops are out of contact during normal operation.
 - 1. Mounting used outdoors shall be hot dipped galvanized, spring shall be cadmium plated.
 - 2. Mounting used outdoors shall have certified calculation by a registered professional ENGINEER showing ability to withstand 109 MPH wind load in 3 principal axis.
 - 3. Mason Industries Type SLRS or Type SLR
- E. Isolation Hangers: Hanger units formed with brackets and including manufacturer's standard compression isolators of type indicated. Design brackets for 5 times rated loading of units. Fabricate units to accept misalignment of 15 degrees off center in any direction before contacting hanger box, and for use with either rod or strap type members and including acoustical washers to prevent metal-to-metal contacts.
 - 1. Provide vibration isolation spring Type C with cap in lower pad-type isolator rubber hanger element in bottom, securely retained in unit.
 - 2. Provide neoprene element, with minimum deflection of 0.35-inch, securely retained in hanger box.
 - 3. Mason Industries Type 30N

PART 3 - EXECUTION

3.1 INSPECTION

- A. Examine areas and conditions under which vibration control units are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to OWNER or his representative.

3.2 PERFORMANCE OF ISOLATORS

- A. General: Comply with minimum static deflections recommended by ASHRAE, for selection and application of vibration isolation materials and units as indicated.
- B. Manufacturer's Recommendations: Except as otherwise indicated, comply with manufacturer's recommendations for selection and application of vibration isolation materials and units to achieve minimum static deflection and displacement requirements.

3.3 APPLICATIONS

- A. General: Except as otherwise indicated, select vibration control products in accordance with ASHRAE Handbook, 2011 HVAC Applications Volume, Chapter 48 "Sound and Vibration Control", Table 47.
- B. Fan Sets: All fan sets should have thrust restraints when operating over 2-inches W.C. S.P. unless they are mounted on a concrete inertia base, in which case the inertia base will not allow fan movement. The fan position at operating and stop positions should not move more than 1/4-inch displacement at these 2 conditions.

3.4 INSTALLATION

- A. General: Except as otherwise indicated, comply with manufacturer's instructions for installation and load application to vibration isolation materials and units. Adjust to ensure that units do not exceed rated operating deflections or bottom out under loading and are not short-circuited by other contacts or bearing points. Remove space blocks and similar devices (if any) intended for temporary protection against overloading during installation.
- B. Install units between substrate and equipment as required for secure operation and to prevent displacement by normal forces.
- C. Adjust leveling devices as required to distribute loading uniformly onto isolators. Shim units as required where substrate is not level.
- D. Locate isolation hangers as near overhead support structure as possible.
- E. Weld riser isolator units in place as required to prevent displacement from loading and operations.

3.5 EXAMINATION OF RELATED WORK

- A. Installer of vibration isolation work shall observe installation of other work related to vibration isolation work, including work connected to vibration isolation work; and, after completion of other related work (but before equipment start-up), shall furnish written report to ENGINEER listing observed inadequacies for proper operation and performance of vibration isolation work. Report shall cover, but not necessarily be limited to the following:
 - 1. Equipment installations (performed as work of other sections) on vibration isolators.
 - 2. Ductwork connections, including provisions for flexible connections.
 - 3. Passage of piping and ductwork, which is to be isolated through walls and floors.
- B. Do not start-up equipment until inadequacies have been corrected in manner acceptable to vibration isolation installer.

3.6 ADJUSTING AND CLEANING

- A. Clean each vibration control unit, and verify that each is working freely, and that there is no dirt or debris in immediate vicinity of unit that could possibly short-circuit unit isolation.

3.7 DEFLECTION MEASUREMENTS

- A. Upon completion of vibration isolation work, prepare report showing measured equipment deflections theoretical floor deflection and isolation efficiency for each major item of equipment.

END OF SECTION

SECTION 23 05 53
MECHANICAL IDENTIFICATION

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

- A. Extent of Mechanical Identification Work required by this section is indicated on drawings and/or specified in other Division 23 sections.
- B. Types of Identification Devices specified in this section include the following:
 - 1. Painted Identification Materials
 - 2. Plastic Duct Markers
 - 3. Plastic Tape
 - 4. Engraved Plastic-Laminate Signs
 - 5. Plasticized Tags
 - 6. Lettering and Graphics
- C. Refer to other Division 23 sections for Identification Requirements at Central-Station Mechanical Control Center; not work of this section.
- D. Refer to Division 26 sections for Identification Requirements of Electrical Work; not work of this section.

1.2 QUALITY ASSURANCE

- A. Manufacturer's Qualifications: Firms regularly engaged in manufacturer of identification devices of types and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.
- B. Codes and Standards:
 - 1. ANSI Standards: Comply with ANSI A13.1 for lettering size, length of color field, colors, and viewing angles of identification devices.

1.3 SUBMITTALS

- A. Product Data: Submit manufacturer's technical product data and installation instructions for each identification material and device required.
- B. Schedules: Submit valve schedule for each piping system, typewritten and reproduced on 8-1/2-inch x 11 inch bond paper. Tabulate valve number, piping system, system abbreviation (as shown on tag), location of valve (room or space), size of valve, and variations for identification (if any). Only tag valves which are intended for emergency shutoff and similar special uses, such as valve to isolate individual system risers, individual floor branches or building system shut-off valves. Include in Operation & Maintenance Manuals as specified in Division 1.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturer: Subject to compliance with requirements, provide products by one of the following:
 - 1. Brady (W.H.) Co.; Signmark Division
 - 2. Brimar Industries, Inc.
 - 3. Industrial Safety Supply Co., Inc.
 - 4. Seton Name Plate Corp.
 - 5. Holbi.

2.2 MECHANICAL IDENTIFICATION MATERIALS

- A. General: Provide manufacturer's standard products of categories and types required for each application as referenced in other Division 23 sections. Where more than single type is specified for application, selection is Installer's option, but provide single selection for each product category.

2.3 PAINTED IDENTIFICATION MATERIALS

- A. Stencils: Standard fiberboard stencils, prepared for required applications with letter sizes generally complying with recommendations of ANSI A13.1 for piping or to match existing size in existing building, but not less than 1-1/4-inch-high letters for ductwork and not less than 3/4-inch-high letters for access door signs and similar operational instructions.
- B. Stencil Paint: Standard exterior type stenciling enamel; Black, except as otherwise indicated; either brushing grade or pressurized spray-can form and grade.
- C. Identification Paint: Standard identification enamel of colors indicated or, if not otherwise indicated, comply with ANSI A13.1 for colors or to match existing building standard identification.

2.4 PLASTIC DUCT MARKERS

- A. General: Provide manufacturer's standard laminated plastic, duct markers.
- B. For Hazardous Exhausts, use colors and designs recommended by ANSI A13.1.
- C. Nomenclature: Include the following:
 - 1. Direction of air flow
 - 2. Duct service (supply, return, exhaust, etc.)
 - 3. Duct origin (from)
 - 4. Duct destination (to)
 - 5. Design CFM

2.5 PLASTIC TAPE

- A. General: Provide manufacturer's standard color-coded pressure-sensitive (self-adhesive) vinyl tape, not less than 3 mils thick.
- B. Width: Provide 1-1/2-inch-wide tape markers on pipes with outside diameters (including insulation, if any) of less than 6-inch, 2-1/2-inch-wide tape for larger pipes.

- C. Color: Comply with ANSI A13.1, except where another color selection is indicated.

2.6 ENGRAVED PLASTIC-LAMINATE SIGNS

- A. General: Provide engraving stock melamine plastic laminate, complying with FS L-P-387, in the sizes and thicknesses indicated, engraved with engraver's standard letter style of the sizes and wording indicated, Black with White core (letter color) except as otherwise indicated, punched for mechanical fastening except where adhesive mounting is necessary because of substrate.
- B. Thickness: 1/8-Inch, except as otherwise indicated.
- C. Fasteners: Self-tapping stainless-steel screws, except contact-type permanent adhesive where screws cannot or should not penetrate the substrate.

2.7 PLASTICIZED TAGS

- A. General: Manufacturer's standard pre-printed or partially pre-printed accident-prevention tags, of plasticized card stock with matt finish suitable for writing, approximately 3-1/4-inch x 5-5/8 inch, with brass grommets and wire fasteners, and with appropriate pre-printed wording including large-size primary wording (As examples; DANGER, CAUTION, DO NOT OPERATE).

2.8 LETTERING AND GRAPHICS

- A. General: Coordinate names, abbreviations and other designations used in mechanical identification work, with corresponding designations shown, specified, scheduled, and approved by the OWNER/ ENGINEER. Provide numbers, lettering and wording as indicated and approved by the OWNER/ ENGINEER for proper identification and operation/maintenance of mechanical systems and equipment.
- B. Multiple Systems: Where multiple systems of same generic name are shown and specified, provide identification which indicates individual system number as designated on the drawings or schedule as well as service.

PART 3 - EXECUTION

3.1 GENERAL INSTALLATION REQUIREMENTS

- A. Coordination: Where identification is to be applied to surfaces which require insulation, painting or other covering or finish, including valve tags in finished mechanical spaces, install identification after completion of covering and painting. Install identification prior to installation of acoustical ceilings and similar removable concealment.

3.2 DUCTWORK IDENTIFICATION

- A. General: Identify air supply, return, exhaust, intake and relief ductwork and duct access doors with duct markers; or provide stenciled signs and arrows, showing ductwork service and direction of flow, in Black or White (whichever provides most contrast with ductwork color). Existing building identification shall match the existing method which exists in the building.
- B. Location: In each space where ductwork is exposed, or concealed only by removable ceiling

system, locate signs near points where ductwork originates or continues into concealed enclosures (shaft, underground or similar concealment), and at 50-foot spacings along exposed runs.

- C. Access Doors: Provide duct markers or stenciled signs on each access door in ductwork and housings, indicating purpose of access (to what equipment), other maintenance and operating instructions, and appropriate safety and procedural information.
- D. Concealed Doors: Where access doors are concealed above acoustical ceilings or similar concealment, plasticized tags may be installed for identification in lieu of specified signs, at Installer's option.

3.3 MECHANICAL EQUIPMENT IDENTIFICATION

- A. General: Install minimum 2-inch x 4-inch engraved plastic laminate equipment marker on each individual items of mechanical equipment. Provide signs for the following general categories of equipment.
 - 1. Main building systems control and operating valves, including safety devices and hazardous units such as gas outlets.
 - 2. Room thermostats, except gun tag labels are acceptable for room thermostats.
 - 3. Fuel-burning units including boilers, furnaces, heaters, stills and absorption chillers.
 - 4. Pumps, compressors, chillers, condensers, and similar motor-driven units.
 - 5. Heat exchangers, cooling towers, heat recovery units and similar equipment.
 - 6. Fans and blowers.
 - 7. HVAC units.
 - 8. Tanks and pressure vessels.
 - 9. Water treatment systems and similar equipment.
- B. Lettering Size: Minimum 1/4-inch-high lettering for name of unit.
- C. Text of Signs: In addition to the identified unit, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations.

3.4 ADJUSTING AND CLEANING

- A. Adjusting: Relocate any mechanical identification device which has become visually blocked by work of this division or other divisions.
- B. Cleaning: Clean face of identification devices, and glass frames of valve charts.

END OF SECTION

SECTION 23 05 93
TESTING, ADJUSTING & BALANCING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Divisions 1 and 23 Specification sections, apply to work of this section.

1.2 DESCRIPTION OF WORK

- A. This section covers Testing and Balancing of Environmental Systems including but not limited to air distribution systems, and the equipment and apparatus connected thereto. The testing and balancing of all environmental systems shall be the responsibility of 1 testing, balancing, and adjusting firm.
 - 1. Test, Adjust, and Balance all of the following mechanical systems:
 - a. Supply Air Systems.
 - b. Return Air Systems.
 - c. Exhaust Air Systems.
 - d. Refrigeration Equipment.
 - e. Temperature Control System.
 - f. Heat Generating Equipment.
 - g. Engine Generator System.
 - 2. Report any systems for excessive sound and vibration levels.

1.3 QUALIFICATIONS OF CONTRACTOR

- A. Procure the services of an independent testing and balancing Agency specializing in the testing, adjusting and balancing of environmental systems to perform the above mentioned work. An independent agency is defined as an organization that is not engaged in engineering design or is not a division of a mechanical CONTRACTOR entity that installs mechanical systems. It shall be an agency certified by NEBB or TABB. Testing and balancing work shall be directly supervised by a NEBB certified Supervisor or Professional ENGINEER on the Testing and Balancing Agency's staff. The Supervisor shall represent the Testing and Balancing Agency in progress meetings as requested and shall be available for interpreting all material found in the Balance Report.
 - 1. All field work shall be performed by qualified technicians who are currently certified by either NEBB or TABB Test and Balance Certification Agencies.
- B. The Testing and Balancing Agency shall have a minimum of 3 years experience in testing and balancing mechanical systems.

1.4 CONTRACTOR QUALIFICATIONS REVIEW

- A. The Mechanical CONTRACTOR shall submit the name of the Testing and Balancing Agency to the Architect within 30 days of contract award to ensure that the Testing and Balancing Agency is on the project from the outset of construction.

- B. Any testing and balancing agency desiring to offer their services for this Work shall submit their qualifications to the Architect, not less than 7 working days before the bid date. Review and recommendations to OWNER will be given on each request and action on the recommendation will be given in writing prior to bidding the work. Agencies meeting the qualifications of the Specification are those Agencies approved by the OWNER.
- C. Acceptable TAB Agencies are:
 - 1. Griffith Engineering Service
 - 2. JPG Engineering, Inc.
 - 3. TAB Services
 - 4. L.H. Finn & Assoc.
 - 5. Complete Mechanical Balancing, Inc.
 - 6. Double T Balancing Company
 - 7. Superior Balance and Commissioning, Inc.
 - 8. Elite Balancing, Inc.

1.5 CODES AND STANDARDS

- A. ASHRAE: ASHRAE Handbook 2011, Applications Volume, Chapter 36, Testing, Adjusting, and Balancing.
- B. NEBB: "Procedural Standards for Testing, Adjusting and Balancing of Environmental Systems."
- C. SMACNA: "Tab Procedure Guidelines".

1.6 SUBMITTALS

- A. Upon award of the Contract, the CONTRACTOR shall submit the name of the Test and Balance Agency who will be performing the work. The submittal shall include a complete list of all technicians who will be performing the field work and include a photocopy of their current certification by either NEBB or TABB Certification Agencies.
- B. Only those technicians included in the submittal shall perform the work. Any personnel or staff used to perform the work who are not included in the submittal shall be grounds for rejecting the Test and Balance Report and the Project in whole.

1.7 PROJECT CONDITIONS

- A. Air and water testing and balancing shall not begin until the system has been completed and is in full working order.
- B. Put all heating, ventilating and air conditioning systems and equipment into full operation and continue operation of same during each working day of testing and balancing. Preliminary Testing and Balancing requirements shall be ascertained prior to the commencement of work through a review of the project plans and specifications. In addition, visual observations at the site during construction shall be made to determine the location of required balancing devices, that they are being installed properly, and in an accessible location for the need. Report in writing any deficiencies to the CONTRACTOR and Mechanical ENGINEER immediately.

- C. Before any air balance work is done, the system shall be checked for duct leakage, assure filters are installed, see that filters are changed if they are dirty, check for correct fan rotation, equipment vibration, and check automatic dampers for proper operation. All volume control dampers and outlets shall be wide open at this time.

1.8 SEQUENCING AND SCHEDULING

- A. Coordinate scheduling of Work with the CONTRACTOR.
 - 1. Schedule TABB work to coincide with testing and verification of the temperature control systems where practical.
 - 2. Coordinate system start-up and performance verification with the ENGINEER as TABB work is in progress.
- B. Provide written notification to the Project Manager 5 working days prior to commencing TABB and a schedule for completing the work.
- C. Provide written notification to the CONTRACTOR within 24 hours of an equipment failure preventing TABB work from proceeding.

PART 2 - PRODUCTS

2.1 INSTRUMENTS

- A. Calibration and maintenance of instruments shall be in accordance with manufacturer's standards.
- B. Calibration histories for each instrument shall be available for examination.
- C. Use a true RMS amp and harmonic distortion electrical test meter to test and record operating and performance measurements for all motors operating with variable frequency drives.

PART 3 - EXECUTION

3.1 TEMPERATURE CONTROLS

- A. Operate all temperature control systems with the Temperature Control CONTRACTOR's representative for proper sequence of operation and calibration. Report in writing any deficiencies to the ENGINEER immediately.

3.2 REQUIREMENTS OF WORK

- A. Provide all necessary fan belts and sheaves to balance all fans to the specified air delivery for the actual field conditions.
 - 1. Test and Balance Agency shall provide motor sheave replacement and fan belt and sheave replacement necessary for final balance condition for specified air quantity when the VFD is operating at design conditions. Motor sheaves shall be replaced so motors operate at rated rpm at 60HZ, then fan sheaves shall be replaced to meet design requirements at 60HZ, without placing the motor over its nameplate amp rating.
 - 2. The Test and Balance report shall include voltage readings, both into the VFD, with concurrent motor amp readings.

- B. Balance all air and water flows at terminals within plus 5 percent to minus 5 percent of design flow quantities for individual terminals. And plus 10 percent to minus 5 percent of individual air outlets or inlets. Measure and record the following data:
- C. Air Balance:
1. Air supply, return and exhaust systems with air quantities for each air device; air handling units including supply, return, mixed, and outside temperatures and fan data including CFM, static pressure, fan RPM, voltage, rated motor amperage, motor running amperage before and after final balance, listed motor power factor and motor running power factor reading. Air diffusion patterns shall be set to minimize objectionable drafts, noise, and local smoke detection device ratings.
 2. The supply, return and exhaust fan static pressure shall be set by the balancing firm and the Control CONTRACTOR if the systems have fan volume control. The duct static shall be confirmed both through the instrumentation installed on the job and by the Balancing Agency. The system shall be tested in all operating modes (including minimum outside air with full return air, full outside air, modulated damper position, and full cooling with the design diversity). System static pressure and fan motor amperages shall be recorded in all modes. The fan speed resulting in satisfactory system performance shall be determined at full design delivery, inlet, or outlet fan. Volume control dampers shall be in the wide-open position and variable frequency drive is at 100 percent of design RPM and 1 path presenting the greatest resistance to flow shall be fully open and unobstructed.
 3. Provide full pitot traverse and CFM measurements at each fan in addition to terminal device measurements.
 4. Air volume and air temperature rise or drop across each coil, filter, dampers, etc., of air handling section.
 5. Measure, adjust, set, balance and record outside air, return air and exhaust/relief air quantities for all air handling systems and supply fans.
- Air quantities shall be determined by direct airflow measuring procedures wherever possible, where duct/inlet conditions do not allow for accurate direct measurement of outside air the following method shall be used:
- $$\text{Outside Air CFM} = \text{Supply Fan Total CFM} - \text{Return Fan Total CFM}$$
- In addition to the direct measuring of airflow quantities, measure, and record outside air, return air and mixed air temperatures, determine thermal/mass energy balance and provide calculations to verify measured airflow quantities. Adjusting and setting the outside air quantity as a percentage of damper position will not be acceptable.
- D. Final adjustments shall include but not be limited to the following:

ITEM

Fan: Belt Drive

ADJUSTMENT

RPM. Include sheave and belt exchange to deliver air flow within limits of installed motor horsepower and mechanical stress limits of the fan. Determine the limiting fan tip speed before increasing RPM. Final fan speed setting shall allow for predicted filter loading and shall establish proper duct pressures for operation of zone CFM regulators.

ITEM	ADJUSTMENT
Fan: Direct Drive	RPM with speed taps. Set fan speed on tap which most closely approaches design CFM. Report tap setting on equipment data sheet as high, medium, or low. RPM with speed control rheostat. Set output of fan at design CFM by adjusting the SCR. After adjustment, check fans ability to re-start after powering down. Increase setting if required for proper starting. CFM with variable pitch blades. Variable fixed pitch fan blades and variable in motion pitch fan blades shall be adjusted by the manufacturer at pitch required to provide design output. Pitch angle adjustment shall not exceed recommended maximum to prevent "stall."
Air Devices	All diffusers and registers shall be measured and balanced.
Motor Starter Thermal Heaters	Division 23 Furnished Magnetic and Manual Starters. Furnish and exchange thermals as required for proper motor protection. Division 26 Furnished Motor Control Center Magnetic Starters. Check for correct sizing. Notify Electrical CONTRACTOR of discrepancies. Existing Magnetic and Manual Starters. Furnish and exchange thermals as required for motor protection.
Variable Frequency Drives	Test, measure and record true RMS amperage, THD for voltage and amperage for each variable frequency drive at both the input power to the drive and the output power to the motor in both the drive mode and through the across the line by-pass mode.
E. Electric Heat:	1. Full load amperage and voltage of all electric heating elements. 2. The Testing and Balancing Agency shall check staging of heating devices and reset if required for proper operation.
F.	When necessary, as determined by the Mechanical ENGINEER, the Test and Balance Agency shall provide additional testing and measurements as required by the Mechanical ENGINEER including, but not limited to, the following: 1. Static pressure gradient profiles throughout ductwork and/or piping systems. 2. Temperature gradient profiles throughout ductwork and/or piping system. 3. Miscellaneous electrical measurements. 4. Smoke tests of room pressure relationships. 5. This work shall be done immediately upon request with complete cooperation and in an expedient schedule at no additional cost to any other party.

3.3 REPORT OF WORK

- A. The Testing and Balancing Agency shall submit 6 bound copies of the final Testing and Balancing Report at least 5 calendar days prior to the CONTRACTOR's request for final inspection. All data shall be recorded on applicable reporting forms. The report shall include all operating data as listed in Paragraph 3.2 above, a list of all equipment used in the testing and balancing work and shall be signed by the Supervising Registered Professional ENGINEER and affixed with their registration stamp, signed, and dated in accordance with State Law. Final acceptance of this project will not take place until a satisfactory report is received.
- B. When deemed necessary by the Mechanical Consulting ENGINEER, the Testing and Balancing Agency shall run temperature and/or humidity recordings and shall read any of the report quantities in the presence of the ENGINEER for verification purposes.
- C. When all air balancing is done and all dampers are set, all test holes shall be plugged, and all dampers shall be marked with paint. The following information shall be recorded for each fan system in the final report: Design fan and air device inlet or outlet size, actual inlet or outlet size, design and actual CFM and velocity through the orifice, for each terminal in the system. The pitot tube traverse method used and location of pitot tube traverse for determining CFM shall be recorded.
- D. After all balancing is complete and all coordination with the CONTRACTOR and the ENGINEER is complete, the balancing firm shall furnish aforementioned bound report which shall contain the following information:
 - 1. RPM, drive sheave information (as installed and as changed), fan nameplate information, motor nameplate information, motor amperage, motor voltage and power factor to all motors (in all operating modes).
 - 2. Static pressure across all components of the system.
 - 3. Required and final balanced CFM at each system terminal. Include the terminal size, reading orifice size, and velocities read to attain the CFM.
 - 4. Indicate on which terminal (on each system) has been balanced 100 percent open as required in the previous sections for air balancing.
 - 5. Pump and motor nameplate information, amperage and voltage to all motors, pressure drop across all system terminals, pressure rise across the pump in PSI and feet of head.
 - 6. Thermal protection for all motors shall be recorded; also, power factor for all motors drawing 1,000 watts or more. Starter brand, model, enclosure type, installed thermal heaters and the rating of the heaters, required thermal heaters and the rating of the heaters if different than installed shall be recorded. Starter heaters shall be changed to the correct size and so noted in the report. If the starters were furnished by the Division 26, the correct heater sizes shall be noted in the report and the CONTRACTOR shall be advised.
 - 7. The report shall include a sheet which shall report the method of balance, project altitude, and any correction factors.
 - 8. A **complete** reduced set of the **Black-line** Mechanical Contract Drawings which shall be included in the report with all equipment, flow measuring devices, terminals (VAV boxes, outlets, inlets, coils, unit heaters, fintube loops, radiant panel loops, schedules, etc.) clearly marked and all equipment designated.

9. Include in the report all variable frequency drive electrical performance test characteristics for each motor as described in this specification section. Include photocopies of all meter chart recorded <measured data> and/or computer printed output.
- E. The Testing and Balancing Agency shall respond and correct all deficiencies within 7 days of receiving the ENGINEER 's written review of the Balancing Report. Failure to comply will result in holding retainage of the final payment until all items have been corrected to the satisfaction of the ENGINEER.

3.4 GUARANTEE OF WORK

- A. The Testing and Balancing Agency shall guarantee the accuracy of the tests and balance for a period of 90 days from date of final acceptance of the Test and Balance Report. During this period, the Testing and Balancing Agency shall make personnel available at no cost to the OWNER to correct deficiencies that may become apparent in the system balance.

3.5 COMPLETION SERVICES

- A. Final Check: Make final checks and do any rebalancing as directed.
- B. Report: Submit Balancing Report as specified above, to the OWNER. Submit preliminary copy of report to ENGINEER for spot-checking as described below.
- C. Acceptance: Notify ENGINEER and OWNER that work is complete and submit preliminary copy of Balancing Report. Schedule time to meet the OWNER and ENGINEER at the site to perform spot-checking and verification as directed. Test and Balance Agency shall furnish personnel and equipment and spot check:
 1. The TAB representative shall be a member of the same team used during the original testing.
 2. Equipment used during the random testing shall be the same equipment used during the original testing.
 3. The system or equipment being verified shall be in the same operating mode as during the original TAB test.
 4. Up to 10 percent of the air readings shall be re-tested. Ninety percent (90%) of the re-tested readings must be within tolerances of the specifications.
 5. Whenever system verifications do not meet specifications, the entire system shall be re-balanced and rechecked.

END OF SECTION

**SECTION 23 07 00
MECHANICAL INSULATION**

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

- A. This Section includes:
 - 1. Ductwork Insulation and Jackets
- B. Refer to other Division 23 sections for Shields, Inserts, and Mechanical Identification.

1.2 QUALITY ASSURANCE

- A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of mechanical insulation products, of types and sizes required, whose products have been in satisfactory use in similar service for not less than three (3) years.
- B. Installer's Qualifications: Firm with at least five (5) years successful installation experience on projects with mechanical insulations similar to that required for this project.
- C. Maintain ambient temperatures and conditions required by manufacturers of adhesives, mastics and insulating cements.

1.3 SUBMITTALS

- A. Product Data: Submit manufacturer's installation instructions and schedule listing materials, thickness, K-value, density, and furnished accessories for each service or equipment specified.

1.4 DELIVERY, STORAGE, AND HANDLING

- A. Deliver insulation, coverings, cements, adhesives, and coatings to site in containers with manufacturer's stamp or label, affixed showing fire hazard ratings of the products, name of manufacturer, and brand.
- B. Protect insulation against dirt, water, chemical, and mechanical damage.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturer: Subject to compliance with requirements, provide product by one of the following:
 - 1. Insulation:
 - a. Armaflex
 - b. Johns-Manville Products Corp. (fiberglass, calcium silicate)
 - c. Knauf Fiber Glass (fiberglass)
 - d. Manson Insulation Co. (fiberglass, calcium silicate)
 - e. Owens-Corning Fiberglas Corp. (fiberglass)

- f. Rubatex Corp. (flexible elastomeric)
- g. Aeroflex (flexible elastomeric)
- h. Roxul (Mineral Wool)
- 2. Jacketing, Coatings, Adhesives, Sealants and Covering Products:
 - a. Childers
 - b. Foster
 - c. Johns-Manville Products Corp.
 - d. Knauf Fiber Glass
 - e. 3M Company Venture Tape
 - f. Design Polymetrics
 - g. PIC Plastics

2.2 DUCTWORK INSULATION

- A. Rigid Fiberglass Board: ASTM C 612, Type IA and IB, 3 lb/cu ft density, 0.23 "K" value at 75 degree F mean temperature, maximum service temperature 450 degree F, moisture sorption less than 5.0% by weight, aluminum foil facing reinforced with fiberglass scrim laminated to UL rated Kraft paper. Composite 25/50-flame spread/smoke developed rating (ASTM E 84, UL 723, and NFPA 90A).
 - 1. Secure with UL listed pressure sensitive tape and/or outward clinched expanded staples and vapor barrier mastic as needed.
- B. Flexible Fiberglass Blanket: ASTM C 553, Type II, 3/4 lb/cu ft density, 0.25 "K" value at 75 degree F mean temperature at compressed thickness, maximum service temperature 250 degree F, moisture sorption less than 0.2% by volume, aluminum foil facing reinforced with fiberglass scrim laminated to UL rated Kraft paper. Composite 25/50-flame spread/smoke developed rating (ASTM E 84, UL 40, and NFPA 90A).
 - 1. Secure with UL Listed pressure sensitive tape and/or outward clinched expanded staples and vapor barrier mastic as needed.
- C. Flexible Elastomeric Foam: ASTM C 534, Type I, flexible, cellular elastomeric, molded, 0.27 "K" value at 75 degree F mean temperature, maximum service temperature 220 degree F, water vapor permeability of 0.10 perm-inch, 25/50-flame spread/smoke developed rating (ASTM E 84, UL 723, and NFPA 255).
- D. Ductwork Insulation Accessories: Provide staples, bands, wires, tape, anchors, corner angles and similar accessories as recommended by insulation manufacturer for applications indicated.
- E. Ductwork Insulation Coating, Mastics, Adhesives and Sealants:
 - 1. Vapor Barrier Coating (Store and apply between 40°F and 100°F, protect from freezing until dry): Used on below ambient piping/duct to prevent moisture ingress. Permeance shall be 0.013 perms or less at 43 mils dry per ASTM E 96, Procedure B.
 - a. Foster 30-80
 - b. Childers CP-38
 - c. Vimasco 749
 - 2. Weather Barrier Mastic (Store and apply between 40° F and 100° F, protect from freezing until dry): Used on above ambient piping/duct outdoors.
 - a. Fosters 46-50

- b. Childers CP-10/11
 - c. Vimasco WC-5
- 3. Lagging Adhesive/Coating (Store and apply between 40° F and 100° F, protect from freezing until dry): Comply with MIL-A-3316C, Class 1, Grade A.
 - a. Foster 30-36
 - b. Childers CP-50AHV2
 - c. Vimasco 713
- 4. Fiberglass Adhesive (Store and apply between 40° F and 100° F, protect from freezing until dry): Comply with ASTM C916, Type II.
 - a. Foster 85-60
 - b. Childers CP-127
 - c. Vimasco 795
- 5. Reinforcing Mesh: Used in conjunction with coatings and mastics.
 - a. Foster Mast a Fab
 - b. Childers Chil Glas #10
 - c. Vimasco Elast a Fab

PART 3 - EXECUTION

3.1 INSPECTION

- A. Examine areas and conditions where mechanical insulation is to be installed. Do not proceed until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.2 DUCTWORK INSULATION

- A. See Ductwork Construction Table on the drawings or as noted below.
- B. Flexible Fiberglass Blanket:
 - 1. Unit housings that are not factory insulated: 1-1/2 Inch thickness.

3.3 INSTALLATION OF DUCTWORK INSULATION

- A. Install insulation products according to manufacturer's written instructions, building codes, and recognized industry standards.
- B. Do not insulate fiberglass ductwork or lined ductwork.
- C. Clean ductwork to remove foreign substances and moisture prior to applying insulation.
- D. Apply insulation to ductwork with all joints tightly fitted to eliminate voids
- E. Seal all vapor retardant jacket seams and penetrations with UL listed tapes or vapor retardant adhesive as recommended by the manufacturer. Coat all seams, breaks, tape patches and penetrations with vapor barrier coating.
- F. Secure insulation to the underside of duct 24-inches or greater with mechanical fasteners or speed clips spaced 18-inches on center. Cut off protruding ends of fasteners after speed clips are installed and seal penetration of vapor barrier.

- G. Extend ductwork insulation without interruption through walls, floors and similar penetrations, except where fire-stopping materials are required.
- H. Install corner angles on all external corners of insulation in exposed finished spaces before covering with jacketing.
- I. Adhere flexible elastomeric sheets to ductwork by compression fit and full coverage of adhesive. Seal butt joints with same adhesive. Apply the same sheet thickness on standing metal duct seams as installed on the duct surface.

END OF SECTION

SECTION 23 09 10
ELECTRONIC CONTROL SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

- A. Extent of Electronic Control Systems Work required by this section is indicated on drawings and schedules, and by requirements of this section.
 - 1. Control sequences are specified in Division 23, "Sequence of Operation".
- B. Refer to other Division 23 sections for installation of instrument wells, valve bodies, and dampers in mechanical systems.
- C. Provide electrical work as required, complying with requirements of Division 26 sections. Work in addition to that shown in Division 26 drawings includes, but is not limited to, the following:
 - 1. Interlock and control wiring between field-installed controls, indicating devices, and unit control panels.
 - 2. The Contractor shall be responsible for all additional electrical and other costs involved to accommodate the temperature control system panel, motors and electrical devices requiring power which differs from the power requirements shown on the Electrical Drawings.
 - 3. Refer to Division 26 for Mechanical/Electrical Coordination.

1.2 QUALITY ASSURANCE

- A. Manufacturer's Qualifications: Firms regularly engaged in manufacturer of electronic control equipment, of types and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.
- B. Installer's Qualifications: Firms specializing and experienced in electronic control system installations for not less than 5 years.
- C. Bids by Wholesalers, Contractors, Franchised Dealers, or any firm whose principal business is not that of manufacturing and installing automatic temperature control systems shall not be acceptable.
- D. Codes and Standards:
 - 1. Electrical Standards: Provide electrical products which have been tested, listed, and labeled by UL and comply with NEMA standards.
 - 2. NEMA Compliance: Comply with NEMA standards pertaining to components and devices for electronic control systems.
 - 3. NFPA Compliance: Comply with NFPA 90A "Standard for the Installation of Air Conditioning and Ventilating Systems" where applicable to controls and control sequences.

1.3 SUBMITTALS

- A. Product Data: Submit manufacturer's technical product data for each control device furnished, indicating dimensions, capacities, performance characteristics, electrical characteristics, finishes of materials, and including installation instructions and start-up instructions.
- B. Shop Drawings: Submit shop drawings for each electronic control system, containing, but not limited to, the following information:
 - 1. Schematic flow diagram of system showing fans, pumps, coils, dampers, valves, and control devices.
 - 2. Label each control device with setting or adjustable range of control.
 - 3. Indicate all required electrical wiring. Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed.
 - 4. Provide details of faces of control panels, including controls, instruments, and labeling.
 - 5. Include verbal description of Sequence of Operation.
- C. Record Drawings: At project closeout, submit record drawings of installed systems products, in accordance with requirements of Division 1.
- D. Maintenance Data: Submit maintenance instructions and spare parts lists. Include this data, product data, and shop drawings in maintenance manuals; in accordance with requirements of Division 1.

1.4 DELIVERY, STORAGE, AND HANDLING

- A. Provide factory shipping cartons for each piece of equipment, and control device. Maintain cartons through shipping, storage and handling as required to prevent equipment damage, and to eliminate dirt and moisture from equipment. Store equipment and materials inside and protected from weather.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturer: Subject to compliance with requirements, provide products by one of the following:
 - 1. Electric Control Systems:
 - a. American Auto-Matrix
 - b. Honeywell, Inc.
 - c. Johnson Controls, Inc.
 - d. Siebe Environmental Controls
 - e. Staefa Control Systems, Inc.
 - f. Landis and Gyr Powers, Inc.

2.2 MATERIALS AND EQUIPMENT

- A. General: Provide electronic control products in sizes and capacities indicated, consisting of valves, dampers, thermostats, clocks, sensors, controllers, and other components as required for complete installation. Except as otherwise indicated, provide manufacturer's standard control system components as indicated by published product information, designed, and constructed as recommended by manufacturer. Provide electronic control systems with the following functional and construction features as indicated.
- B. Dampers: Provide automatic control dampers as indicated, with damper frames not less than formed 13-gauge galvanized steel. Provide mounting holes for enclosed duct mounting. Provide damper blades not less than formed 16-gauge galvanized steel, with maximum blade width of 6-inches. Equip dampers with motors, with proper rating for each application.
 - 1. Secure blades to 1/2-inch diameter zinc-plated axles using zinc-plated hardware. Seal off against spring stainless steel blade bearings. Provide blade bearings of nylon and provide thrust bearings at each end of every blade. Construct blade linkage hardware of zinc-plated steel and brass. Submit leakage and flow characteristics, plus size schedule for controlled dampers.
 - 2. Operating Temperature Range: From negative 20 to 200 degrees F (negative 29 to 93 degrees C).
 - 3. For standard applications provide parallel or opposed blade design unless otherwise indicated on the drawings with optional closed-cell neoprene edging.
 - 4. Provide low-leakage applications at outside air intakes and exhaust air outlets, provide opposed blade design unless otherwise indicated on the drawings with inflatable seal blade edging, or replaceable rubber seals, rated for leakage at less than 5 CFM/sq. ft. of damper area, at differential pressure of 4-inches w.g. when damper is being held by torque of 50 inch-pounds.
 - 5. Dampers shall be Greenheck SEVCD or approved equivalent.
 - 6. Provide unit ventilator outside air dampers with adjustable minimum settings so that ventilation can be adjusted for each space or room.
- C. Damper Motors: Size each motor to operate dampers or valves with sufficient reserve power to provide smooth modulating action or 2-position action as specified.
 - 1. Provide permanent split-capacitor or shaded pole type motors with gear trains completely oil-immersed and sealed. Equip spring-return motors, where indicated on drawings or in operational sequence, with integral spiral-spring mechanism. Furnish entire spring mechanism in housings designed for easy removal for service or adjustment of limit switches, auxiliary switches, or feedback potentiometer.
 - 2. Equip motors for outdoor locations and for outside air intakes with "O ring" gaskets designed to make motors completely weatherproof, and equip with internal heaters to permit normal operation at negative 40 degrees F.
 - 3. Furnish non-spring return motors for dampers larger than 25 sq. ft., and for valves larger than 2-1/2 inches, sized for running torque rating of 150 inch-pounds, and breakaway torque rating of 300 inch-pounds. Size spring-return motors for running torque rating of 150 inch-pounds, and breakaway torque rating of 150 inch-pounds.

- D. Room Thermostats: Provide room thermostats with locking covers, and with concealed or readily accessible adjustment devices and dead band, as indicated.
1. Provide thermostats with red-reading glass or spiral bi-metallic thermometers.
 2. Where indicated, provide heavy duty "asylum type", clear plastic, or wire tamper-proof guards.
 3. Line-Voltage On-Off Thermostats: Provide thermostats of bi-metal actuated open contact, or bellows actuated enclosed snap-switch type, or equivalent solid-state type; UL listed at electrical rating comparable with application. Provide bimetal thermostats which employ heat anticipation. Equip thermostats which control electric heating loads directly, with Off position on dial wired to break ungrounded conductors.
 4. Combination Thermostat and Fan Switches: Comply with requirements for line-voltage thermostats. In addition, include as integral part of each thermostat, 2-, 3-, or 4-position pushbutton or lever operated manual switch for control of fan in each unit with type of control as indicated.
 - a. Label switches "FAN ON-OFF" "FAN HIGH-LOW-OFF", "FAN HIGH-MED-LOW-OFF". Provide factory-fabricated unit, capable of being mounted on 2-gang switch box or mud ring.
 5. Low-Voltage On-Off Thermostats: Comply with general requirement indicated for line-voltage thermostats. Provide thermostats of bimetal operated mercury-switch type, with either adjustable or fixed universal anticipation heater.
 6. Low-Voltage Modulating Thermostats: Provide potentiometer type, operated by vapor-filled bellows.
- E. Remote-Bulb Thermostats: Provide remote-bulb thermostats of on-off or modulating type, as required by sequence of operation. Provide liquid-filled units designed to compensate for changes in ambient temperature at instrument case. Provide capillary and bulb of copper unless otherwise indicated. Equip bulbs in water lines with separate wells of same material as bulb. Support bulbs installed in air ducts securely, to prevent damage and noise from vibrations. Provide averaging bulbs where shown or specified in sequence of operation, consisting of copper tubing not less than 8'-0" in length with either single or multiple-unit elements. Extend tubing to cover full width of duct or unit, and support adequately.
1. Provide scale settings and differential settings where applicable, which are clearly visible and adjustable from front of instrument.
 2. Equip on-off remote-bulb thermostats with precision snap switches, and with electrical ratings as required by application.
 3. Provide modulating remote-bulb thermostats of potentiometer type constructed so that complete potentiometer coil and wiper assembly is removable for inspection or replacement without disturbing calibration of instrument.
- F. Low-Temperature Protection Thermostats: Provide low-temperature protection thermostats of manual-reset type, with sensing elements of the proper length but, in no case less than 20'-0" in length. Provide thermostat designed to operate in response to coldest 1'-0" length of sensing element, regardless of temperature at other parts of element. Support element properly to cover entire duct width. Provide separate thermostats for each 25 sq. ft. of coil face area or fraction thereof.

- G. Clocks: Provide time clocks specified as part of temperature control sequences, of (seven) 7-day, (twenty-four) 24-hour type, with weekend or skip-a-day features. Equip time clocks with (ten) 10-hour spring carryover to maintain clock movement in case of power failure.
- H. Step Controllers: Provide step controllers for control sequencing or for control of electric heat power loads, of 6- or 10-stage type, with heavy-duty switching rated to handle loads, UL-listed and operated by electric motors of quality specified for valve and damper actuation.
- I. Electronic Sensors: Provide electronic temperature and relative humidity sensors of supersensitive resistance type, which are vibration and corrosion-resistant, and of wall mounted immersion, duct mounting, averaging or bulb type as required for application.
- J. Electronic Controllers: Provide electronic controllers of "Wheatstone Bridge" amplifier type, designed as individual components and fully protected by steel enclosures. Provide individual controllers of multiple-input type with provisions for remote resistance type readjustment. Identify adjustments clearly on controllers, including proportional band, authority, etc.
 - 1. Where single electronic controller is required for specific application, it can be built-in as integral part of control motor, but only where provided with easily accessible control readjustment potentiometer.
 - 2. Provide 2-position proportional electric controller power output as required by specified sequence of operations.
- K. Fan Speed Controllers: Provide solid-state fan speed controllers, to maintain room temperature by varying fan speed on fan units, in response to room temperature changes. Provide proportioning control of motor speed, from maximum down to minimum of 55 percent (field adjustable). Equip controller to provide on-off action below demand for minimum fan speed, to prevent low-speed operation and ensure normal motor life. Design controller to apply full-voltage for brief period each time motor is started, to bring motor up to minimum speed rapidly. Equip controller with filter circuit to eliminate objectionable radio interference.
- L. Electric Heat Current Controllers: Accomplish switching of load current with semiconductor devices located in load circuit of operation controller, and not by mechanical or mercury relays. Provide controllers which operate on zero-voltage switching principle, to minimize radio frequency interference; do not substitute devices incorporating phase control firing. Arrange power controllers, for loads of 10-Kw or larger, for 3-phase operation. Incorporate solid-state switch for loads of 48-Amps per phase or larger, in each ungrounded line of load circuit.
 - 1. Refer to heating equipment specifications for integral high temperature limit controllers.

- M. Electric Contactors: Provide contactors for operating or limit-control of electric heating loads which are UL-listed for 100,000 cycles of resistive loads. Equip with replaceable molded coils and replaceable silver cadmium oxide contacts. Coat core laminations with heat-resistant inorganic film to reduce core losses. Provide line and load terminals on contactors with higher-than-35-Amp rating, or provide one-piece formed-and-welded pressure type. Provide screw-type contactors for 35-Amp-or-lower rating. Equip field-mounted contactors with suitable steel enclosures; and provide open-type mounting for those installed in factory-fabricated panels.
- N. Local Control Panels: Provide control panels with suitable brackets for either wall or floor mounting, for each supply fan and miscellaneous control systems. Locate panel adjacent to systems served.
 - 1. Fabricate panels of 14 gauge furniture-quality steel, or 6063-T5 extruded aluminum alloy, totally enclosed, with hinged doors and keyed lock, with manufacturer's standard shop-painted finish and color. Provide UL-listed cabinets for use with line voltage devices.
 - 2. Panel Mounted Equipment: Include temperature and humidity controllers, relays and automatic switches, except exclude low-temperature protection thermostats, firestats, and other devices excluded in sequence of operation. Fasten devices with adjustments accessible through front of panels.
 - 3. Door-Mounted Equipment: Flush-mount (on hinged door) manual switches, including damper "minimum-off" positioning switches, "summer-winter" switches, and "manual-automatic" switches; and including dial thermometers.
 - 4. Graphics: Where specified, provide color-coded graphic laminated plastic displays on doors, to schematically show system being controlled. Provide protective sheet of clear plastic bonded to entire door to prevent damage to symbols.
 - 5. Provide standard steel cabinets as required to contain temperature controllers, relays, switches, and similar devices, except limit controllers and other devices excluded in sequence of operations. Provide full-enclosure cabinets, with painted gray finish.
- O. Central (Master) Control Panels: Provide central control panels of fully-enclosed steel cubical type, with locking doors and/or locking removable backs. Match finish of panels and provide multi-color graphic displays, schematically showing system being controlled.

2.3 ELECTRICAL MATERIALS

- A. Conduit: Types as indicated in Division 26 sized per Division 26 except for low-voltage twisted pair or single jacketed cable (1/2-inch minimum).
- B. Fittings per Division 26. Bushings or nylon insulated throats are not required for jacketed cables.
- C. All J-boxes shall be identified and labeled per Division 26.
- D. All conductors and cables shall be labeled per Division 26.
- E. Conduit and box supports shall be per Division 26.
- F. Junction boxes shall be of types and sizes as indicated in Division 26.
- G. All wiring shall be installed in conduit.
- H. Conduits shall not exceed 40 percent maximum fill for single conductor and jacketed cables.

PART 3 - EXECUTION

3.1 INSPECTION

- A. Examine areas and conditions under which electronic control systems are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.
- B. Check and verify location of thermostats and other exposed control sensors with plans and room details before installation. Locate thermostats 42-inches above floor.

3.2 INSTALLATION OF ELECTRIC CONTROL SYSTEMS

- A. General: Install systems and materials in accordance with manufacturer's instructions and roughing-in drawings, and details on drawings. Install electrical components and use electrical products complying with requirements of applicable Division 26 sections of these specifications. Mount controllers at convenient locations and heights.
- B. Control Wiring: The term "control wiring" is defined to include providing of wire, conduit and miscellaneous materials as required for mounting and connecting electronic control devices.
- C. Wiring System: Install complete control wiring system for electronic control systems. Conceal wiring, except in mechanical rooms and areas where other conduit and piping are exposed. Provide multi-conductor instrument harness (bundle) in place of single conductors where number of conductors can be run along common path. Fasten flexible conductors bridging cabinets and doors, neatly along hinge side, and protect against abrasion. Tie and support conductors neatly.
- D. Number-code or color-code conductors, excluding those used for local individual room controls, appropriately for future identification and servicing of control system.
- E. Reset Limit Controls: Install manual-reset limit controls to be independent of power controllers; automatic duct heater resets may, at Contractor's option, be installed in interlock circuit of power controllers.
- F. Unit-Mounted Equipment: Where control devices are indicated to be unit-mounted, ship electric relays, electric switches, valves, dampers, and damper motors to unit manufacturer for mounting and wiring at factory.

3.3 ADJUSTING AND CLEANING

- A. Start-Up: Start-up, test, and adjust electric control systems in presence of manufacturer's authorized representative. Demonstrate compliance with requirements. Replace damaged or malfunctioning controls and equipment.
- B. Cleaning: Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.
- C. Final Adjustment: After completion of installation, adjust thermostats, control valves, motors and similar equipment provided as work of this section.
- D. Final adjustment shall be performed by specially trained personnel in direct employ of manufacturer of primary Temperature Control System.

3.4 POST INSTALLATION INSPECTION AND REPORT

- A. Upon completion of the temperature control installation, the complete system shall be checked by an engineer of the Control Contractor and certified by him in a report to the Architect/Engineer that the system is performing as specified.

3.5 CLOSEOUT PROCEDURES

- A. Owner's Instructions: Provide services of manufacturer's technical representative for one (1) 8-hour day to instruct Owner's personnel in operation and maintenance of electric control systems.
 - 1. Schedule instruction with Owner, provide at least seven (7) day notice to Contractor and Engineer of training date.

END OF SECTION

SECTION 23 31 13
METAL DUCTWORK

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

- A. Extent of Metal Ductwork is indicated on the drawings, schedules, and by requirements of this section.

1.2 QUALITY ASSURANCE

- A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of metal ductwork products of types, materials, and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.
- B. Installer's Qualifications: Firm with at least 3 years of successful installation experience on projects with metal ductwork systems similar to that required for project.
- C. References to SMACNA, ASHRAE and NFPA are minimum requirements, the Contractor shall fabricate, construct, install, seal all ductwork as described in this specification and as shown on the drawings, in addition to these minimum standard references.
- D. Codes and Standards:
 - 1. SMACNA "HVAC Duct Construction Standards, Metal and Flexible".
 - 2. SMACNA "HVAC Air Duct Leakage Test Manual".
 - 3. ASHRAE "Systems and Equipment Handbook", Chapter 16, Duct Construction.
 - 4. NFPA 90A "Standard for the Installation of Air Conditioning and Ventilating Systems".
 - 5. SMACNA Industrial Construction Standards.

1.3 SUBMITTALS

- A. Product Data: Submit manufacturer's technical product data and installation instructions.
- B. Shop Drawings: Submit scale drawings of ductwork and fittings including, but not limited to, duct sizes, locations, elevations, and slopes of horizontal runs, wall and floor penetrations, and connections. Show interface and spatial relationship between ductwork and equipment. Show modifications of indicated requirements, made to conform to local shop practice, and how those modifications ensure that free area, materials, and rigidity are not reduced. Refer also to specification for 3D coordination drawing requirement.
- C. Record Drawings: At project closeout, submit record drawings of installed systems, in accordance with requirements of Divisions 1 and 23.
- D. Maintenance Data: Submit maintenance data and parts lists for metal ductwork materials and products. Include maintenance data and shop drawings in maintenance manual.

1.4 DELIVERY, STORAGE, AND HANDLING

- A. Protection: Protect ductwork and accessories from damage during shipping, storage, and handling. Prevent dirt and moisture from entering ducts and fittings.
- B. Storage: Where possible, store ductwork inside. Where necessary to store outside, enclose with waterproof wrapping.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Spin-In Fittings:
 - a. Flexmaster
 - b. Thermaflex
 - c. Ominair
 - d. Hercules Industries
 - 2. Duct Sealants
 - a. Duct Mate Pro Seal
 - b. Foster 32-19/32-17
 - c. Childers CP-146/CP-148

2.2 DUCTWORK MATERIALS

- A. Exposed Ductwork: Where ductwork is exposed to view in occupied spaces, provide mill phosphatized finish that is free from visual imperfections, including pitting, seam marks, roller marks, stains, dents, discolorations, and other imperfections, including those that would impair painting.
- B. Stainless Steel Sheet: ASTM A 167; Type 304 or 316; with No. 4 finish where exposed to view in occupied spaces, No. 1 finish elsewhere. Protect finished surfaces with factory applied adhesive protective paper, maintained through fabrication and installation.
- C. Aluminum Sheet: ASTM B 209, Alloy 3003, Temper H14.

2.3 MISCELLANEOUS DUCTWORK MATERIALS

- A. General: Provide materials of types and sizes required to comply with ductwork system requirements.
- B. Fittings: Provide radius type fittings fabricated of multiple sections with maximum 15-degree change of direction per section. Unless specifically detailed otherwise, use 45-degree laterals and 45-degree elbows for branch takeoff connections. Where 90-degree branches are indicated, provide conical type tees.
- C. Duct Sealant: UL 181 Listed, Class 1, flame spread 0, fuel contributed 0, smoke developed 0, water-based sealant, non-toxic, non-combustible, and non-flammable. Non-hardening, non-migrating mastic, or liquid elastic sealant, type applicable for fabrication/installation detail, as compounded, and recommended by manufacturer specifically for sealing joints and seams in ductwork. Sealant shall meet LEED IEQ 4.1 (meeting VOC tables published by SCAQMD #1168 Criteria for Low Emitting Materials).
 - 1. Service temperature -20 degrees F to 200 degrees F.
 - 2. Mold and Mildew resistant
 - 3. VOC: Maximum 50g/l (less water and exempt solvents).

- D. Ductwork Support Materials: Except as otherwise indicated, provide hot-dipped galvanized steel fasteners, anchors, rods, straps, trim, and angles for support of ductwork.
 - 1. For exposed stainless-steel ductwork, provide matching stainless steel support materials.
 - 2. For aluminum ductwork, provide aluminum support materials.
- E. Spin-in Fittings: Provide spin-in fittings between flexible and round sheet metal duct takeoffs and air devices from main ducts. Spin-in fittings shall include bell mouth and butterfly type manual volume damper with bearings, regulator and locking device.
- F. Rectangular-to-Round Taps: Where the round branch take-off will not permit a spin-in fitting, provide a rectangular to round tap. Include manual volume damper with locking devices.
- G. All fasteners and hardware for stainless steel ductwork shall be made of stainless steel.

2.4 FABRICATION

- A. Fabricate ductwork of gauges and reinforcement complying with SMACNA "HVAC Duct Construction Standards" and ASHRAE "Systems and Equipment Handbook", Chapter 16, Duct Construction.
- B. Elbows – Rectangular
 - 1. For low pressure systems use 1.0 radius smooth elbows. (From focal point to centerline of duct).
 - 2. For medium pressure systems use 1.5 radius smooth elbows. (From focal point to centerline of duct).
 - 3. If radius elbows cannot fit, use mitered elbows with turning vanes.
- C. Limit angular tapers to 30 degree for contracting tapers and 20 degree for expanding tapers.
- D. Refer to Division 23, Section 23 33 00 "Ductwork Accessories" for accessory requirements. All stainless steel or aluminum ductwork shall have stainless steel accessories construction.

PART 3 - EXECUTION

3.1 INSPECTION

- A. General: Examine areas and conditions under which metal ductwork is to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.2 INSTALLATION OF METAL DUCTWORK

- A. General: Assemble and install ductwork in accordance with recognized industry practices that will achieve airtight and noiseless (no objectionable noise) systems. Install each run with minimum number of joints. Align ductwork accurately at connections, within 1/8-inch misalignment tolerance and with internal surfaces smooth. Support ducts rigidly with suitable ties, braces, hangers, and anchors of type that will hold ducts true-to-shape and prevent buckling, popping, or compressing. Support vertical ducts at every floor.
- B. Inserts: Install concrete inserts for support of ductwork in coordination with formwork, as required to avoid delays in work.

- C. Routing: Locate ductwork runs vertically and horizontally and avoid diagonal runs wherever possible. Locate runs as indicated by drawings, 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. Hold ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building. Limit clearance to 1/2-inch where furring is shown for enclosure or concealment of ducts, but allow for insulation thickness, if any. Where possible, locate insulated ductwork for 1-inch 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. Do not encase horizontal runs in solid partitions, except as specifically shown. Coordinate layout with suspended ceiling and lighting layouts and similar finished work.
- D. Electrical Equipment Spaces: Do not route ductwork through transformer vaults and electrical equipment spaces and enclosures.
- E. Penetrations: Where ducts pass through interior partitions and exterior walls, and are exposed to view, conceal space between construction opening and duct or duct insulation with sheet metal flanges of same gauge as duct. Overlap opening on all 4 sides by at least 1-1/2 inch. Fasten to duct only.
- F. Coordination: Coordinate duct installations with installation of accessories, dampers, coil frames, equipment, controls, and other associated work of ductwork system.
- G. Installation: Install metal ductwork in accordance with SMACNA HVAC Duct Construction Standards and Industrial Construction Standards.
- H. Temporary Closure: At ends of ducts that are not connected to equipment or air distribution devices at time of ductwork installation, provide temporary closure of polyethylene film or other covering that will prevent entrance of dust and debris until time connections are to be completed.

3.3 ADJUSTING AND CLEANING

- A. Clean ductwork internally, unit by unit as it is installed, of dust and debris. Clean external surfaces of foreign substances. Where ductwork is to be painted, clean and prepare surface for painting.
- B. Strip protective paper from stainless ductwork surfaces, and repair finish wherever it has been damaged.
- C. Balancing: Seal any leaks in ductwork that become apparent in balancing process.

END OF SECTION

SECTION 23 33 00
DUCTWORK ACCESSORIES

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

- A. Types of Ductwork Accessories required for project include the following:
 - 1. Manual Volume Dampers
 - 2. Turning Vanes
 - 3. Duct Hardware
 - 4. Duct Access Doors
 - 5. Flexible Connections

1.2 QUALITY ASSURANCE

- A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of ductwork accessories, of types and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.
- B. Industry Standards: Comply with ASHRAE recommendations pertaining to construction of ductwork accessories, except as otherwise indicated.
- C. UL Compliance: Construct, test, and label fire dampers in accordance with UL Standard 555 "Fire Dampers and Ceiling Dampers" and UL Standard 555S "Motor-Driven Fire/Smoke Dampers".
- D. NFPA Compliance: Comply with applicable provisions of NFPA 90A "Air Conditioning and Ventilating Systems", pertaining to installation of ductwork accessories.
- E. SMACNA Compliance: Comply with "Fire Damper and Heat Stop Guide" for the installation of fire, smoke, and fire/smoke dampers.
- F. All fire dampers, smoke dampers, fire/smoke dampers and radiation dampers shall meet the latest local building code requirements.

1.3 SUBMITTALS

- A. Product Data: Submit manufacturer's technical product data for each type of ductwork accessory, including dimensions, capacities, and materials of construction, and installation instructions.
- B. Shop Drawings: Submit manufacturer's assembly-type shop drawings for each type of ductwork accessory showing interfacing requirements with ductwork, method of fastening or support, and methods of assembly of components. Include details of construction equipment and accessories being provided.
- C. Submittals for all damper types specified in this section shall include a schedule for each damper indicating net free area, actual face velocity and pressure drop (at sea level) based on net free area and the maximum air quantity which will be passing through the damper. Submittals without this information will be rejected.
- D. Record Drawings: At project closeout, submit record drawings of installed systems products, in accordance with requirements of Division 1.

- E. Maintenance Data: Submit manufacturer's maintenance data including parts lists for each type of duct accessory. Include this data, product data, and shop drawings in maintenance manual; in accordance with requirements of Division 1.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturer: Subject to compliance with requirements, provide products by one of the following:
 - 1. Dampers:
 - a. American Warming and Ventilating
 - b. Air Balance, Inc.
 - c. Arrow Louver & Damper; Division of Arrow United Industries, Inc.
 - d. Louvers & Dampers, Inc.
 - e. Penn Ventilator Co.
 - f. SafeAir Dowco
 - g. Cesco-Advanced Air
 - h. Ruskin
 - i. Vent Products Inc.
 - j. Greenheck
 - k. Pottorff
 - l. NCA, Industries, Inc.
 - 2. Turning Vanes:
 - a. Aero Dyne Co.
 - b. Airsan Corp.
 - c. Duro Dyne Corp.
 - d. Hart & Cooley Mfg. Co.
 - e. Hercules
 - 3. Duct Hardware:
 - a. Ventfabrics, Inc.
 - b. Young Regulator Co.
 - 4. Duct Access Doors:
 - a. Flexmaster (Inspector Series)
 - b. Cesco-Advanced Air
 - c. Duro Dyne Corp.
 - d. Ventfabrics, Inc.
 - 5. Flexible Connections:
 - a. Duro Dyne Corp.
 - b. Ventfabrics, Inc.
 - c. General Rubber Corp. (Process and Exhaust Only)

2.2 DAMPERS

- A. Material type shall match duct construction, use stainless steel in aluminum ductwork

- B. Low Pressure Rectangular Dampers (Less than 2,000 FPM and Under 4-Inch W.C. S.P. Differential):
1. For 12-inches in height or larger, use multiple opposed blade type and close fitted to ducts. Dampers smaller than 12-inches in height may have a single blade. 16 Gauge galvanized steel frame and blades with carbon steel shaft mounted with stainless steel bearings, stainless steel jamb seals and silicone blade edge seals. Linkage shall be in-jamb fixed type located outside the airstream made of plated steel tie bar and crank plates, with stainless steel pivots. Maximum damper panel width is 48-inch. Provide jack shafting when duct size required is greater than 48-inch wide. Provide notched shaft end indicating damper position, locking quadrant to fix damper position and handle. For flat oval and round ductwork, provide Type C housing.
 2. Aluminum frame with stainless steel bearings.
- C. Low Pressure Round Dampers (Less than 1,500 FPM and Under 1-Inch W.C. S.P. Differential):
1. For Dampers 4-inch diameter through 18-inch diameter use 18-gauge galvanized steel frame and the following blade construction:

4-Inch thru 12-inch diameter	22-gauge galvanized steel
13-Inch thru 18-inch diameter	20-gauge galvanized steel
 2. Carbon steel axle shaft with retainers mounted on stainless steel bearings with notched end shaft indicating damper position, locking quadrant and handle.
- D. Medium High Pressure Rectangular Dampers (Less than 4,000 FPM and Under 6-Inch W.C. (48-Inch Wide or Less) S.P. or 8-Inch W.C. S.P. (36-Inch Wide or Less)):
1. Use opposed blade dampers for volume control and parallel blade for isolation/shutoff service.
 2. 16 Gauge galvanized steel frame with welded corners. 1/8 inch thick 6063-T5 alloy aluminum frame. Double skin galvanized steel blades with single-lock seam, .081-inch thick 6060-T5 extruded aluminum blades, airfoil shape. Double durometer vinyl blade edge seals and metallic compression seals at the jambs. Solid carbon steel axles mounted on stainless steel bearings. In-jamb type linkage located outside the air stream. 48-Inch wide and 60-inch-high maximum damper size. For fixed position balancing damper, delete blades to maintain 30 percent free area with all other damper blades are 100 percent closed. For isolation or shutoff duty, damper leakage shall not exceed 9.5 CFM/square foot at 4-inch W.C. S.P. differential. Provide extended shaft with notched end indicating damper position, locking quadrant and handle.
- Air Balance Model AC-525/AC-526 (Aluminum)
- E. Medium/High Pressure Round and Flat Oval Dampers (Less than 3,000 FPM and Under 4-Inch W.C. S.P. Differential):
1. Galvanized steel damper frame construction as follows:

ROUND	
Under 6-inch diameter	12 gauge
6-Inch to 18-inch diameter	14 gauge
20-Inch to 30-inch diameter	2 x 1/2 x 1/8 channel
32-Inch to 42-inch diameter	2 x 1 x 1/8 channel

2. Galvanized steel damper blades as follows:

ROUND

- | | |
|-----------------------------|----------|
| 4-Inch to 12-inch diameter | 14 gauge |
| 14-Inch to 18-inch diameter | 12 gauge |
| 20-Inch to 42-inch diameter | 10 gauge |
3. 1/2-Inch diameter galvanized steel axles up to 18-inch diameter and 18-inch-wide flat oval, and 3/4-inch diameter plated steel sleeve pressed in to the frame with stainless steel thrust washers with stainless steel bearings.
 4. Provide notched end shaft to indicate damper position, locking quadrant and lever handle.
 5. For isolation or shutoff service, dampers shall be provided with EPT edge seals with a leakage rate not to exceed 7 CFM/square foot at 1-inch W.C. S.P. differential (based on 18-inch diameter).

2.3 TURNING VANES

- A. Fabricated Turning Vanes: Provide fabricated 22-gauge, single blade 4-1/2-inch radius, 3-1/4 inch spacing turning vanes and Type 2, 4-1/2-inch-wide runners, constructed in accordance with SMACNA "HVAC Duct Construction Standards" Fig 2.3.
- B. Turning vanes material shall match the material of the duct.
- C. Do not use trailing edge turning vanes.

2.4 DUCT HARDWARE

- A. General: Provide duct hardware, manufactured by one manufacturer for all items on project, for the following:
 1. Test Holes: Provide in ductwork at fan inlet and outlet, and elsewhere as indicated, duct test holes, consisting of slot and cover, for instrument tests.
 2. Quadrant Locks: Provide for each manual volume damper, quadrant lock device on 1 end of shaft; and end bearing plate on other end for damper lengths over 12-inch. Provide extended quadrant locks and end extended bearing plates for externally insulated ductwork.

2.5 DUCT ACCESS DOORS

- A. General: Provide access doors, whether shown or not, at all fire dampers, smoke dampers, temperature control dampers, branch balancing dampers, outside air plenums, inlet of fans, upstream of all duct smoke detectors and all other equipment requiring service and/or access.
- B. Construction: Construct of same or greater gauge as ductwork served, provide insulated doors for insulated ductwork. Provide flush frames for uninsulated ductwork, extended frames for externally insulated duct. All access doors shall have gasket and will be air tight. Provide 1 side hinged, other side with 1 handle-type latch for doors 12-inch high and smaller, 2 handle-type latches for larger doors. For spiral ductwork, use United McGill combination access section type ARF-SD for non-insulated duct systems and type ARF-ID double wall insulated door for insulated ducted systems (all supply ductwork).

2.6 FLEXIBLE CONNECTIONS

- A. General: Provide flexible duct connections wherever ductwork connects to vibration isolated equipment. Construct flexible connections of neoprene-coated flameproof fabric crimped into duct flanges for attachment to duct and equipment. Make air-tight joint. Provide adequate joint flexibility to allow for thermal, axial, transverse, and torsional movement, and also capable of absorbing vibrations of connected equipment. Shelf life shall be verified to not exceed 6 months. Any sign of cracking on interior or exterior shall be cause for replacement immediately.
- B. Use the following product types for each application accordingly:
 - 1. Indoor Equipment Non-Corrosive Air Systems: Heavy glass fabric, double-coated with DuPont's NEOPRENE, non-combustible fabric, fire retardant coating with good resistance to abrasion and flexing. Fabric shall be 30 ounce per square yard, capable of operating at –10-degrees F to 200 degrees F, waterproof, air tight, 6-inches wide, complies with NFPA 90 and UL Standard #214. "Ventglas" Model as manufactured by VentFabric, Inc.
 - 2. High Temperature Non-Corrosive Air Systems: Heavy glass fabric coated with silicone rubber, non-combustible fabric, fire retardant coating, capable of operating and maintaining flexibility between temperatures of –25-degrees F to 500 degrees F. Fabric shall be 16 ounce per square yard, waterproof, air tight, 6-inches wide, complies with NFPA 90, UL Standard #214. "Ventsil" Model as manufactured by VentFabrics, Inc.
 - 3. Indoor Corrosive Air System: Heavy glass fabric coated with DuPont's teflon fluorocarbon resins, capable of operating between temperatures of –20-degrees F and 500 degrees F. Fabric shall be 14 ounce per square yard, water tight, air tight, chemically resistant to most chemicals including but not limited to sulfuric acid, acetic acid, chlorine, dimethyl ether, xylene, hexane, ozone, nitric acid, butyl acetate, ammonia gas and liquid, acetone, mercury, cyclohexane, methanol, 6-inches wide "Ventel" model as manufactured by VentFabrics, Inc.

PART 3 - EXECUTION

3.1 INSPECTION

- A. Examine areas and conditions under which ductwork accessories will be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to the ENGINEER.

3.2 INSTALLATION OF DUCTWORK ACCESSORIES

- A. Install ductwork accessories in accordance with manufacturer's installation instructions, with applicable portions of details of construction as shown in SMACNA standards, and in accordance with recognized industry practices to ensure that products serve intended function.
- B. Install turning vanes in square or rectangular 90-degree elbows in supply, return and exhaust air systems, and elsewhere as indicated.
- C. Install access doors to open against system air pressure, with latches operable from either side, except outside only where duct is too small for person to enter.

- D. Coordinate with other work, including ductwork, as necessary to interface installation of ductwork accessories properly with other work.
- E. Provide duct access doors whether shown or not for inspection and cleaning before and after all filters, coils, fans, automatic dampers, at fire dampers (minimum 16-inch x 24-inch in ducts larger than 18-inch), fire/smoke dampers, upstream side of airturns in all return and exhaust air ductwork, upstream of duct smoke detectors and elsewhere as indicated. Review locations prior to fabrication. Provide multiple access doors for large ductwork to provide adequate reach to equipment.
- F. Provide 4-inch x 4-inch (104 x 104 mm) quick opening access doors for inspection at balancing dampers, except conical taps with manual balancing damper.
- G. Provide fire dampers and smoke dampers at locations shown, where ducts and outlets pass through fire rated components, and where required by Authorities Having Jurisdiction.
- H. Provide balancing dampers at points on low pressure supply, return, and exhaust systems where branches are taken from larger ducts and as required for air balancing.
- I. Provide balancing dampers on high pressure systems where indicated. Use splitter dampers only where indicated on Drawings.
- J. Provide flexible connections immediately adjacent to equipment in ducts associated with fans and equipment subject to forced vibration. Provide matching flanged backing frame with flexible connector where flanged fan connections are provided.
- K. Where fire and smoke dampers are installed in fire and smoke rated construction, provide firestopping between fire and fire smoke damper sleeve and substrate.

3.3 FIELD QUALITY CONTROL

- A. Operate installed ductwork accessories to demonstrate compliance with requirements. Test for air leakage while system is operating. Repair or replace faulty accessories, as required to obtain proper operation and leakproof performance.
- B. Test every fire and fire/smoke damper for proper operation, provide letter to the Architect/ENGINEER certifying this work is complete and all dampers are functioning properly.

3.4 ADJUSTING AND CLEANING

- A. Adjusting: Adjust ductwork accessories for proper settings, install fusible links in fire dampers and adjust for proper action.
- B. Label access doors in accordance with Division 23 Section "Mechanical Identification".
- C. Final positioning of manual dampers is specified in Division 23 Section "Testing, Adjusting, and Balancing".
- D. Cleaning: Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.

3.5 EXTRA STOCK

- A. Furnish extra fusible links to OWNER, 1 link for every 10 installed of each temperature range; obtain receipt.

END OF SECTION

SECTION 23 34 13
AIR HANDLING FANS

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

- A. Extent of Air Handling Equipment Work required by this section is indicated on drawings and schedules, and by requirements of this section.
- B. This Section includes the following types of Air-Handling Equipment:
 - 1. Inline Centrifugal Fans
- C. Refer to other Division 23 sections for vibration control; control system; sequence of operation; testing, adjusting, and balancing.
- D. Refer to Division 26 section for the following work; not work of this section.
 - 1. Power supply wiring from power source to power connections at air handling units.
- E. Refer to Division 23 section "Mechanical/Electrical Requirements for Mechanical Equipment".

1.2 QUALITY ASSURANCE

- A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of air handling equipment of types and sizes required, whose products have been in satisfactory use in similar service for not less than 3 years.
- B. Codes and Standards:
 - 1. Fans Performance Ratings: Establish flow rate, pressure, power air density, speed of rotation, and efficiency by factory tests and ratings in accordance with AMCA Standard 210/ASHRAE Standard 51 - Laboratory Methods of Testing Fans for Rating.
 - 2. UL Compliance: Provide air handling equipment which are listed by UL and have UL label affixed.
 - 3. UL Compliance: Provide air handling equipment which are designed, manufactured, and tested in accordance with UL 805 "Power Ventilators".
 - 4. NEMA Compliance: Provide motors and electrical accessories complying with NEMA Standards.
 - 5. Sound Power Level Ratings: Comply with AMCA Standard 301 "Method for Calculating Fan Sound Ratings from Laboratory Test Data". Test fans in accordance with AMCA Standard 300 "Test Code for Sound Rating". Fans shall be licensed to bear the AMCA Certified Sound Ratings Seal.
 - 6. Nationally Recognized Testing Laboratory and NEMA Compliance (NRTL): Fans and components shall be NRTL listed and labeled. The term "NRTL" shall be defined in OSHA Regulation 1910.7.
 - 7. Electrical Component Standards: Components and installation shall comply with NFPA 70 "National Electrical Code".

1.3 SUBMITTALS

- A. Product Data: Submit manufacturer's technical data for air handling equipment including specifications, capacity ratings, sound data, dimensions, weights, materials, operating and service/access clearance accessories furnished, and installation instructions.
- B. Shop Drawings: Submit assembly-type shop drawings showing unit dimensions, construction details, methods of assembly of components, and field connection details.
- C. Wiring Diagrams: Submit manufacturer's electrical requirements for power supply wiring to air-handling units. Submit manufacturer's ladder-type wiring diagrams for interlock and control wiring. Clearly differentiate between portions of wiring that are manufacturer-installed and portions to be field-installed.
- D. Record Drawings: At project closeout, submit record drawings of installed systems products; in accordance with requirements of Division 1.
- E. Maintenance Data: Submit maintenance data and parts list for each type of power and gravity ventilator, accessory, and control. Include this data, product data, shop drawings, and wiring diagrams in maintenance manuals in accordance with requirements of Division 1.

1.4 DELIVERY, STORAGE, AND HANDLING

- A. Lift and support units with the manufacturer's designated lifting or supporting points.
- B. Disassemble and reassemble units as required for movement into the final location following manufacturer's written instructions.
- C. Deliver fan units as a factory-assembled unit to the extent allowable by shipping limitations, with protective crating and covering.

1.5 SEQUENCING AND SCHEDULING

- A. Coordinate the size and location of concrete equipment pads. Cast anchor bolt inserts into pad.
- B. Coordinate the installation of roof curbs, equipment supports, and roof penetrations.
- C. Coordinate the size and location of structural steel support members.

1.6 EXTRA MATERIALS

- A. Furnish 1 additional complete set of belts for each belt-driven fan.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Inline Centrifugal Fans:
 - a. Acme Engineering & Manufacturing Corp.
 - b. Loren Cook Co.
 - c. Penn Barry.

- d. Greenheck
- e. Twin City Fan and Blower Co (TCF)
- 2. Centrifugal Roof Ventilator (Wall Mounted):
 - a. Acme Engineering & Manufacturing Corp.
 - b. Loren Cook Co.
 - c. Penn Barry.
 - d. Greenheck
 - e. Twin City Fan and Blower Co (TCF)

2.2 FANS, GENERAL

- A. General: Provide fans that are factory fabricated and assembled, factory tested, and factory finished, with indicated capacities and characteristics.
- B. Fans and Shafts: Statically and dynamically balanced and designed for continuous operation at the maximum rated fan speed and motor horsepower.
 - 1. Fan Shaft: Turned, ground, and polished steel designed to operate at no more than 70 percent of the first critical speed at the top of the speed range of the fan's class.
- C. Belt Drives: Factory mounted, with final alignment and belt adjustment made after installation.
 - 1. Service Factor: 1.4.
- D. Belts: Oil-resistant, non-sparking, and non-static.
- E. Motors and Fan Wheel Pulleys: Adjustable pitch for use with motors through 15 HP; fixed pitch for use with motors larger than 15 HP. Select pulley so that pitch adjustment is at the middle of the adjustment range at fan design conditions. Provide premium energy efficient motor.
 - 1. Belt Guards: Provide steel belt guards for motors mounted on the outside of the fan cabinet.
- F. Shaft Bearings: Provide type indicated, having a median life "Rating Life" AFBMA L10 of 100,000 hrs calculated in accordance with AFBMA Standard 9 for ball bearings and AFBMA Standard 11 for roller bearings.
- G. Factory Finish: The following finishes are required:
 - 1. Sheet Metal Parts: Prime coating prior to final assembly or as noted in equipment schedule.
 - 2. Exterior Surfaces: Baked-enamel finish coat after assembly or as noted in equipment schedule.
- H. Vibration: Provide vibration isolators as scheduled and specified in other Division 23 sections.

2.3 INLINE CENTRIFUGAL FANS

- A. General Description: Inline, belt-driven, centrifugal fans consisting of housing, wheel, outlet guide vanes, fan shaft, bearings, drive assembly, motor and disconnect switch, mounting brackets, and accessories.
- B. Housing: Split, spun-aluminum housing, with aluminum straightening vanes, inlet and outlet flanges, and support bracket adaptable to floor, side wall, or ceiling mounting.

- C. Direct-Drive Units: Motor encased in housing out of air stream, factory-wired to disconnect located on outside of fan housing.
- D. Belt-Drive Units: Motor mounted on adjustable base, with adjustable sheaves, enclosure around belts within fan housing, and lubricating tubes from fan bearings extended to outside of fan housing.
- E. Wheel: Aluminum, airfoil blades welded to aluminum hub.
- F. Bearings: Grease lubricated ball or roller anti-friction type with extended lubrication lines to outside fan housing.
- G. Accessories: The following accessories are required as indicated:
 - 1. Volume Control Damper: Manual operated with quadrant lock, located in fan outlet.
 - 2. Companion Flanges: For inlet and outlet duct connections.
 - 3. Fan Guards: Expanded metal in removable frame.
 - 4. Speed Control: Variable speed switch with On-Off control and speed control for 100 to 50 percent of fan air delivery.

2.4 CENTRIFUGAL ROOF VENTILATORS

- A. General Description: Belt-driven or direct-drive as indicated, centrifugal consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, curb base, and accessories.
- B. Housing: Heavy-gauge, removable, spun-aluminum, dome top and outlet baffle; square, one-piece, hinged, aluminum base with venturi inlet cone.
 - 1. Upblast Units: Provide spun-aluminum discharge baffle to direct discharge air upward, with rain and snow drains.
- C. Fan Wheel: Aluminum hub and wheel with backward-inclined blades.
- D. Belt-Driven Drive Assembly: Resiliently mounted to the housing, with the following features:
 - 1. Pulleys: Cast iron, adjustable-pitch.
 - 2. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
 - 3. Fan Shaft: Turned, ground, and polished steel drive shaft keyed to wheel hub.
 - 4. Fan and motor isolated from exhaust air stream.
- E. Accessories: The following items are required as indicated:
 - 1. Fan configured for wall mounting.
 - 2. Disconnect Switch: Non-fusible type, with thermal overload protection mounted inside fan housing, factory-wired through an internal aluminum conduit.
 - 3. Bird Screens: Removable 1/2-inch mesh, 16 gauge, aluminum or brass wire.
 - 4. Dampers: Motor-operated, parallel-blade, volume control dampers mounted in curb base.
 - a. Blades: Die-formed sheet aluminum.
 - b. Frame: Extruded aluminum, with waterproof, felt blade seals.

- c. Linkage: Nonferrous metals, connecting blades to counter weight or operator.
 - d. Operators: Manufacturer's standard electric motor.
- 5. Roof Curbs: Prefabricated, heavy-gauge, galvanized steel; mitered and welded corners; 2-inch thick, rigid, fiberglass insulation adhered to inside walls; built-in cant and mounting flange for flat roof decks; and 2-inch wood nailer. Size as required to suit roof opening and fan base.
 - a. Overall Height: 8-Inches.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances, housekeeping pads, and other conditions affecting performance of fans.
- B. Do not proceed until unsatisfactory conditions have been corrected.

3.2 INSTALLATION, GENERAL

- A. Install fans level and plumb, in accordance with manufacturer's written instructions. Support units using vibration control devices as indicated. Vibration control devices are specified in Division 23 Section "Vibration Controls".
 - 1. Secure roof-mounted fans to roof curbs with cadmium-plated hardware.
 - a. Installation of roof curbs is specified in Division 7.
 - 2. Suspended Units: Suspend units from structural steel support frame using threaded steel rods and vibration isolation springs.
- B. Arrange installation of units to provide access space around air-handling units for service and maintenance.

3.3 CONNECTIONS

- A. Duct installations and connections are specified in other Division 23 sections. Make final duct connections on inlet and outlet duct connections with flexible connections.
- B. Electrical Wiring: Install electrical devices furnished by manufacturer but not specified to be factory mounted. Furnish copy of manufacturer's wiring diagram submittal to Electrical Installer.
 - 1. Verify that electrical wiring installation is in accordance with manufacturer's submittal and installation requirements of Division 26 sections. Ensure that rotation is in direction indicated and intended for proper performance. Do not proceed with centrifugal fan start-up until wiring installation is acceptable to Centrifugal Fan Installer.
 - 2. Temperature control wiring and interlock wiring are specified in Division 23.
 - 3. Grounding: Connect unit components to ground in accordance with the National Electrical Code.

3.4 FIELD QUALITY CONTROL

- A. Upon completion of installation of air handling equipment, and after motor has been energized with normal power source, test equipment to demonstrate compliance with requirements. Where possible, field correct malfunctioning equipment, then retest to demonstrate compliance. Replace equipment which cannot be satisfactorily corrected.
- B. Manufacturer's Field Inspection: Arrange and pay for a factory-authorized service representative to perform the following:
 - 1. Inspect the field assembly of components and installation of fans including ductwork and electrical connections.
 - 2. Prepare a written report on findings and recommended corrective actions.

3.5 ADJUSTING, CLEANING, AND PROTECTING

- A. Start-up, test and adjust air handling equipment in presence of manufacturer's authorized representative.
- B. Adjust damper linkages for proper damper operation.
- C. Clean unit cabinet interiors to remove foreign material and construction dirt and dust. Vacuum clean fan wheel and cabinet.

3.6 SPARE PARTS

- A. General: Furnish to OWNER with receipt 1 spare set of belts for each belt driven air handling equipment.

3.7 PRE-STARTUP CHECK

- A. Final Checks Before Start-Up: Perform the following operations and checks before start-up:
 - 1. Remove shipping blocking and bracing.
 - 2. Verify unit is secure on mountings and supporting devices and that connections for piping, ductwork, and electrical are complete. Verify proper thermal overload protection is installed in motors, starters, and disconnects.
 - 3. Perform cleaning and adjusting specified in this Section.
 - 4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearings operations. Reconnect fan drive system, align belts, and install belt guards.
 - 5. Lubricate bearings, pulleys, belts, and other moving parts with factory-recommended lubricants.
 - 6. Verify manual and automatic volume control and that fire and smoke dampers in connected ductwork systems are in the full-open position.
 - 7. Disable automatic temperature control operators.
- B. Starting Procedures for Fans:
 - 1. Energize motor; verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated RPM.
 - 2. Replace fan and motor pulleys as required to achieve design conditions.
 - 3. Measure and record motor electrical values for voltage and amperage.
- C. Shut unit down and reconnect automatic temperature control operators.

- D. Refer to Division 23 Section "Testing, Adjusting, and Balancing" for procedures for air-handling-system testing, adjusting, and balancing.

3.8 DEMONSTRATION

- A. Demonstration Services: Arrange and pay for a factory-authorized service representative to train OWNER's maintenance personnel on the following:
 - 1. Procedures and schedules related to start-up and shutdown, troubleshooting, servicing, preventative maintenance, and how to obtain replacement parts.
 - 2. Familiarization with contents of Operating and Maintenance Manuals specified in Division 1 Section "Project Closeout" and Division 23 Section "Basic Mechanical Requirements".
- B. Schedule training with at least 7 days' advance notice.

END OF SECTION

SECTION 23 37 13
AIR OUTLETS & INLETS

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

- A. Extent of Air Outlets and Inlets Work is indicated by drawings and schedules, and by requirements of this section.
- B. Types of Air Outlets and Inlets required for project include the following:
 - 1. Registers and Grilles
 - 2. Louvers
- C. Refer to other Division 23 sections for ductwork, duct accessories; testing and balancing; not work of this section.

1.2 QUALITY ASSURANCE

- A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of air outlets and inlets of types and capacities required, whose products have been in satisfactory use in similar service for not less than 5 years.
- B. Codes and Standards:
 - 1. ARI Compliance: Test and rate air outlets and inlets in accordance with ARI 650 "Standard for Air Outlets and Inlets".
 - 2. ASHRAE Compliance: Test and rate air outlets and inlets in accordance with ASHRAE 70 "Method of Testing for Rating the Air Flow Performance of Outlets and Inlets".
 - 3. ADC Compliance: Test and rate air outlets and inlets in certified laboratories under requirements of ADC 1062 "Certification, Rating and Test Manual".
 - 4. ADC Seal: Provide air outlets and inlets bearing ADC Certified Rating Seal.
 - 5. AMCA Compliance: Test and rate louvers in accordance with AMCA 500L-99 "Laboratory Method of Testing Louvers for Rating".
 - 6. AMCA Seal: Provide louvers bearing AMCA Certified Rating Seal.
 - 7. NFPA Compliance: Install air outlets and inlets in accordance with NFPA 90A "Standard for the Installation of Air Conditioning and Ventilating Systems".

1.3 SUBMITTALS

- A. Product Data: Submit manufacturer's technical product data for air outlets and inlets including the following:
 - 1. Schedule of air outlets and inlets indicating drawing designation, room location, number furnished, model number, size, and accessories furnished.
 - 2. Data sheet for each type of air outlet and inlet, and accessory furnished; indicating construction, finish, and mounting details.
 - 3. Performance data for each type of air outlet and inlet furnished, including aspiration ability, temperature, and velocity traverses, throw and drop, and noise criteria ratings. Indicate selections on data.

- B. Shop Drawings: Submit manufacturer's assembly-type shop drawing for each type of air outlet and inlet, indicating materials and methods of assembly of components.
- C. Record Drawings: At project closeout, submit record drawings of installed systems products, in accordance with requirements of Division 1.
- D. Maintenance Data: Submit maintenance data, including cleaning instructions for finishes, and spare parts lists. Include this data, product data, and shop drawings in maintenance manuals; in accordance with requirements of Division 1.

1.4 DELIVERY, STORAGE AND HANDLING

- A. Deliver air outlets and inlets wrapped in factory-fabricated fiber-board type containers. Identify on outside of container type of outlet or inlet and location to be installed. Avoid crushing or bending and prevent dirt and debris from entering and settling in devices.
- B. Store air outlets and inlets in original cartons and protect from weather and construction work traffic. Where possible, store indoors; when necessary to store outdoors, store above grade and enclose with waterproof wrapping.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturer: Subject to compliance with requirements, provide products by one of the following:
 - 1. Diffusers, Registers and Grilles:
 - a. Krueger; Division of Philips Industries, Inc.
 - b. Titus Products Division; Philips Industries, Inc.
 - c. Metal-Aire
 - d. E.H. Price.
 - 2. Louvers:
 - a. Louvers & Dampers, Inc.
 - b. Ruskin
 - c. Pottorff
 - d. Greenheck

2.2 REGISTERS AND GRILLES

- A. General: Except as otherwise indicated, provide manufacturer's standard registers and grilles where shown; of size, shape, capacity, and type indicated; constructed of materials and components as indicated, and as required for complete installation.
- B. Performance: Provide registers and grilles that have, as minimum, temperature and velocity traverses, throw and drop, and noise criteria ratings for each size device as listed in manufacturer's current data.

- C. Wall Compatibility: Provide registers and grilles with border styles that are compatible with adjacent wall systems, and that are specifically manufactured to fit into wall construction with accurate fit and adequate support. Refer to general construction drawings and specifications for types of wall construction which will contain each type of wall register and grille.
- D. Types: Provide registers and grilles of type, capacity, and with accessories and finishes as listed on air device schedule.

2.3 LOUVERS

- A. General: Provide stationary extruded aluminum louvers in sizes and locations indicated on the Drawings.
- B. Performance: Provide beginning of water penetration (0.01 oz. per sq.ft.) at a free area velocity of no less than 900 fpm at standard air conditions based on mill finish, 48-inch x 48-inch test size per AMCA Standard 511.
- C. Frame: 4-Inch-deep channel, 0.081-inch thick 6063-T5 extruded aluminum alloy. Coordinate with wall construction shown on the Architectural Drawings and provide frame and sill style necessary to provide a weatherproof installation.
- D. Blades: K-Design, drainable blade design 0.081-inch thick, 6063-T5 extruded aluminum alloy.
- E. Mullions: Provide exposed vertical mullions along horizontal dimension of louver opening when louver exceeds manufacturer recommended single section size.
- F. Louver Screens: On inside face of louvers, provide removable 1/2-inch expanded mesh framed aluminum bird screen.
- G. Finish: Kynar, provide standard color chart for color selection by Architect.

PART 3 - EXECUTION

3.1 INSPECTION

- A. Examine areas and conditions under which air outlets and inlets are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. General: Install air outlets and inlets in accordance with manufacturer's written instructions and in accordance with recognized industry practices to insure that products serve intended functions.
- B. Coordinate with other work, including ductwork and duct accessories, as necessary to interface installation of air outlets and inlets with other work.
- C. Locate ceiling air diffusers, registers, and grilles, as indicated on general construction "Reflected Ceiling Plans". Unless otherwise indicated, locate units in center of acoustical ceiling modules.

3.3 SPARE PARTS

- A. Furnish to OWNER, with receipt, 3 operating keys for each type of air outlet and inlet that require them.

END OF SECTION

SECTION 23 82 00
TERMINAL HEAT UNITS

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

- A. Extent of Terminal Unit Work is indicated on drawings and schedules, and by requirements of this section.
- B. Types of Terminal Units required for project include the following:
 - 1. Electric Unit Heaters
- C. Refer to other Division 23 sections for piping; ductwork; testing, adjusting, and balancing of terminal units; not work of this section.
- D. Refer to Division 26 section for the following work; not work of this section.
 - 1. Power supply wiring from power source to power connection on terminal units.
 - 2. Provide the following electrical work as work of this section, complying with requirements of Division 26 sections:
 - a. Control wiring between field-installed controls, indicating devices, and terminal unit control panels.
 - 1) Control wiring specified as work of Division 23 for Automatic Temperature Controls is work of that section.
- E. Refer to other Division 23 sections for automatic temperature controls not factory installed, required in conjunction with terminal units; not work of this section.

1.2 QUALITY ASSURANCE

- A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of terminal units, of types and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.
- B. Codes and Standards:
 - 1. ARI Compliance: Provide coil ratings in accordance with ARI Standard 410 "Forced-Circulation Air-Cooling and Air-Heating Coils".
 - 2. ASHRAE Compliance: Test coils in accordance with ASHRAE Standard 33 "Methods of Testing Forced Circulation Air Cooling and Heating Coils".
 - 3. UL Compliance: Provide electrical components for terminal units which have been listed and labeled by UL.
 - 4. ARI Compliance: Test and rate ventilators in accordance with ARI Standard 330 "Unit Ventilators".

5. Electric Heating Equipment: All equipment with a heating coil capacity exceeding a 48-amp rating shall have the heating elements subdivided and protected by an overcurrent protection device rated at not more than 60 amps. Equipment not exceeding 48 amps shall also have overcurrent protection. Overcurrent protection devices shall be factory wired and installed in accordance with the National Electric Code. All equipment shall be factory assembled and wired in accordance with the National Fire Protection Association and shall be listed by Underwriters' Laboratories.

1.3 SUBMITTALS

- A. Product Data: Submit manufacturer's technical product data, for terminal units showing dimensions, capacities, ratings, performance characteristics, gauges and finishes of materials, and installation-startup instructions.
- B. Shop Drawings: Submit manufacturer's assembly-type shop drawings indicating terminal unit dimensions, weight loading, required clearances, construction details, field connection details and methods of assembly of components.
- C. Wiring Diagrams: Submit manufacturer's electrical requirements for power supply wiring to terminal units. Submit manufacturer's ladder-type wiring diagrams for interlock and control wiring. Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed.
- D. Record Drawings: At project closeout, submit record drawings of installed systems products in accordance with requirements of Division 1.
- E. Maintenance Data: Submit maintenance instructions, including lubrication instructions, filter replacement, motor and drive replacement, control, accessories, "trouble-shooting" maintenance guide, and spare parts lists. Include this data, product data, and shop drawings in maintenance manuals; in accordance with requirements of Division 1.

1.4 DELIVERY, STORAGE, AND HANDLING

- A. Handle terminal units and components carefully to prevent damage, breaking, denting, and scoring. Do not install damaged terminal units or components; replace with new.
- B. Store terminal units and components in clean dry place. Protect from weather, dirt, fumes, water, construction debris, and physical damage.
- C. Comply with Manufacturer's rigging and installation instructions for unloading terminal units and moving them to final location.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturer: Subject to compliance with requirements, provide products by one of the following:
 1. Electric Unit Heaters:
 - a. Q Mark
 - b. Trane (The) Co.
 - c. Brasch

- d. Indeeco
- e. Berko
- f. Markel
- g. Modine
- h. Chromalox

2.2 ELECTRIC UNIT HEATERS

- A. General: Provide electric unit heaters in locations as indicated, and of capacities, style, and having accessories as scheduled.
- B. Horizontal Unit Heaters:
 - 1. Casings: Construct of steel, phosphatized inside and out, and finished with standard color baked enamel finish. Provide motor-mounted panel, minimum of 18-gauge steel. Fabricate casing to enclose coil, louvers, and fan blades. Provide louvers for two-way air diffusion.
 - 2. Fans: Construct of aluminum, and factory-balance. Provide fan inlet orifice, smooth, and drawn into casing back panel.
- C. Elements: Unit shall include electric resistance element with manual-reset thermal overload protection, unit mounted contactors and transformer.
- D. Motors: Provide totally enclosed motors, with built-in overload protection, having electrical characteristics as scheduled.

PART 3 - EXECUTION

3.1 INSPECTION

- A. Examine areas and conditions under which terminal units are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.2 INSTALLATION OF UNIT HEATERS

- A. General: Install unit heaters as indicated, and in accordance with manufacturer's installation instructions.
- B. Uncrate units and inspect for damage. Verify that nameplate data corresponds with unit designation.
- C. Hang units from building substrate, not from piping. Mount as high as possible to maintain greatest headroom possible unless otherwise indicated.
- D. Support units with rod-type hangers anchored to building substrate.
- E. Protect units with protective covers during balance of construction.

3.3 ELECTRICAL WIRING

- A. General: Install electrical devices furnished by manufacturer but not specified to be factory mounted. Furnish copy of manufacturer's wiring diagram submittal to Electrical Installer.
 - 1. Verify that electrical wiring installation is in accordance with manufacturer's submittal and installation requirements of Division 26 sections. Do not proceed with equipment start-up until wiring installation is acceptable to equipment Installer.

3.4 ADJUSTING AND CLEANING

- A. General: After construction is completed, including painting, clean unit exposed surfaces, vacuum clean terminal coils and inside of cabinets.
- B. Retouch any marred or scratched surfaces of factory-finished cabinets, using finish materials furnished by manufacturer.

3.5 START-UP

- A. Start-up, test, and adjust terminal units in accordance with manufacturer's published start-up instructions. Adjust for proper air flow where applicable.

END OF SECTION

SECTION 26 00 00
ELECTRICAL GENERAL PROVISIONS

PART 1 - GENERAL

1.1 SUMMARY

- A. The work includes, but is not limited to, the following principal systems and equipment:
1. Motors.
 2. Grounding and Lightning Protection.
 3. 208/120 V distribution.
 4. Panelboards.
 5. Raceways.
 6. Transformers.
 7. Lighting fixtures and lamps.
 8. 480-V distribution.
 9. Miscellaneous control.

1.2 REFERENCES

- A. Perform work, furnish and install materials and equipment in full accordance with the latest issue of the applicable rules, regulations, requirements, and specifications of the following:
1. Local laws and ordinances.
 2. State and Federal Laws.
 3. National Electrical Code (NEC).
 4. State Fire Marshal.
 5. Underwriters' Laboratories (UL).
 6. National Electrical Safety Code (NESC).
 7. American National Standards Institute (ANSI).
 8. National Electrical Manufacturer's Association (NEMA).
 9. National Electrical Contractor's Association (NECA) Standard of Installation.
 10. Institute of Electrical and Electronics Engineers (IEEE).
 11. Insulated Cable Engineers Association (ICEA).
 12. Occupational Safety and Health Act (OSHA).
 13. National Electrical Testing Association (NETA).
 14. American Society for Testing and Materials (ASTM).
- B. Wherever the requirements of the Specifications or Drawings exceed those of the above items, the requirements of the Specifications or Drawings govern. Code compliance is mandatory.
- C. Product Quality: All electrical items shall be new and unused. Items such as cables, transformers, motors, control centers, etc., shall be newly manufactured for this project. Proof of purchase documents shall be provided upon request. Utilize products of a single MANUFACTURER for each item.

1.3 ADMINISTRATIVE REQUIREMENTS - NOT USED

1.4 SUBMITTALS

A. Action Submittals:

1. Product Data:

- a. Submit manufacturer's descriptive literature and product specifications for each product.
- b. Submittal data must show MANUFACTURER's name, published ratings or capacity data, detailed equipment drawing for fabricated items, panel diagrams, wiring diagrams, installation instructions and other pertinent data.
- c. Where literature is submitted covering a group or series of similar items, the applicable items must be clearly indicated.

2. Shop Drawings:

- a. Indicate typical layout including dimensions.
- b. Submittals are required on all products and items to be installed on this project.
- c. Submit detail drawings of special accessory components not included in the manufacturer's product data.

3. Terminal Connection Diagrams:

- a. Submit terminal connection diagrams for approval prior to any wire installation.
- b. Submit finalized terminal connection diagrams at the end of the Contract.

B. Informational Submittals:

1. Source Quality Control Submittals:

2. Field / Site Quality Control Submittals:

3. Sustainable Design Submittals:

4. Special Procedure Submittals:

5. Qualification Statements:

6. Previous Installations List:

7. Samples:

8. Certificates:

- a. Supplier Certificates – Refer to Item 3.10 in this Section.

9. Manufacturer's Instructions / Reports:

C. Closeout Submittals:

1. Maintenance Contracts:

2. Operation and Maintenance Data:

3. Bonds:

4. Warranty Documentation:

5. Record Documentation: Prepare and maintain Project Record Documents in accordance with Division 1 Section 01 78 10 - Project Record Documents and the following:

- a. At the job site, maintain a set of white prints of the contract drawings.

- b. At the job site, maintain a set of equipment terminal connection diagrams.
 - c. On the prints, record field changes and diagrams of those portions of work in which actual construction is at variance with the contract drawings.
 - d. Mark the drawings with a colored pencil. Record installed feeder conduits, dimensioning the exact location and elevation of the conduit.
 - e. Delivery: Submit Project Record Documents in accordance with Division 1 Section 01 78 10 - Project Record Documents.
- 6. Sustainable Design Closeout Documentation:
- 7. Software:
- D. Maintenance Material Submittals:
 - 1. Spare Parts / Extra Stock Materials:
 - 2. Tools and Software:

1.5 QUALITY ASSURANCE

- A. Regulatory Agency Sustainability Approvals:
 - 1. Refer to Section 01 40 00 - Quality Requirements.
 - 2. Regulations: Work, materials and equipment must comply with the latest rules and regulations of the following:
 - a. National Electrical Code (NEC).
 - b. National Electrical Safety Code (NESC).
 - c. Occupational Safety and Health Act (OSHA).
 - d. State and federal codes, ordinances and regulations.
 - e. Local Electrical Code.
 - 3. Discrepancies:
 - a. The Plans and Specifications are intended to comply with listed codes, ordinances, regulations and standards.
 - b. Where discrepancies occur, immediately notify the ENGINEER in writing and ask for an interpretation.
 - c. Should installed materials or workmanship fail to comply, the CONTRACTOR is responsible for correcting the improper installation.
 - 4. Additionally, where sizes, capacities, or other such features are required in excess of minimum code or standards requirement, provide those specified or shown.
- B. Qualifications:
 - 1. Suppliers:
 - a. Company specializing in supplying products specified in this Section with minimum 5 years documented experience.
 - b. All equipment of each type specified in this section shall be supplied by a single SUPPLIER who is fully experienced, reputable, and qualified in the manufacture of the equipment to be furnished. The equipment shall be designed, constructed, and installed in accordance with the best practices and methods.
 - c. SUPPLIER shall maintain a complete stock of spare parts commonly needed for the equipment specified and shall be capable of shipping spare parts within 48

- hours of request.
- d. SUPPLIER shall furnish all equipment with a stainless steel nameplate securely affixed in a conspicuous place on the equipment showing the equipment ratings, serial number, model number, equipment supplier name, and other pertinent nameplate data.
- 2. An acceptable CONTRACTOR for the work under this division must have personnel with experience, training, and skill to provide a practical working system. The CONTRACTOR shall have previous water and wastewater experience with at least five years in business.
 - a. The CONTRACTOR shall be required to furnish acceptable evidence of having installed not less than three systems of size and type comparable to this project.
 - b. The systems must have served satisfactorily for not less than three years.
 - c. The superintendent must have had experience in installing not less than three systems.
 - d. The CONTRACTOR shall submit qualifications of his firm and resumes of his personnel who will work on this project.
 - 3. Field Representative:
 - a. The SUPPLIER shall furnish a qualified field representative for the time indicated in this Section. Field representatives shall be factory-employed personnel and have a minimum of 2 years' experience with the operation of and training on this type of equipment. Sales representatives will only be considered acceptable service technicians if they have 3 years' experience with the operation of and training on this type of equipment from the SUPPLIER being supplied and have started up 15 units of a similar size and type from the SUPPLIER. The field representative shall submit a resume for approval before startup assistance can be provided. For each training event two separate pre-startup training sessions shall be performed, one in the early morning and one in the late afternoon. Two separate post-startup training sessions shall be performed, one in the early morning and one in the late afternoon. CONTRACTOR shall coordinate the scheduling of such training and startup assistance with OWNER'S personnel. A typed outline shall be handed out at each training session and, at a minimum, will include normal operating parameters, alarms, and maintenance.
 - 4. Testing Agencies:
 - 5. Licensed Professionals:
- C. All electrical work shall be performed by workers skilled in the electrical trade and licensed for the work by the local authority.
 - D. A licensed Master Electrician will be required for constructing, installing, altering, maintaining, repairing or replacing any electrical wiring, apparatus, or equipment on any voltage level. A licensed Master Electrician or a licensed Journeyman Electrician is required to be on the job site during the performance of any electrical work.
 - E. All cable splicing methods and materials shall be of the type recommended by the splicing materials MANUFACTURER for the cable to be spliced and shall be approved by the ENGINEER prior to installation.
 - F. All materials and equipment shall be installed in accordance with the approved

recommendations of the MANUFACTURER and the best practices of the trade, and in conformance with the Contract Documents. The CONTRACTOR shall promptly notify the OWNER in writing of any conflict between any requirements of the Contract Documents and MANUFACTURER's directions and shall obtain written instructions from the OWNER before proceeding with the work. Should the CONTRACTOR perform any work that does not comply with the MANUFACTURER's directions or such written instructions from the OWNER, he shall bear all costs incurred in correcting deficiencies.

- G. All equipment and materials shall be new, unless specifically noted otherwise, and shall bear the MANUFACTURER's name, trademark and ASME, UL, or other labels in every case where a standard has been established for the particular item. Equipment shall be the latest approved design of a standard product of a MANUFACTURER regularly engaged in the production of the required type of equipment and shall be supported by a service organization that is, in the opinion of the OWNER, reasonably convenient to the site.
- H. It is the responsibility of the CONTRACTOR to ensure that items furnished fit the space available with adequate room for proper operation and maintenance. He shall make measurements to ascertain space requirements, including those for connections, and shall furnish and install such sizes and shapes of equipment that, in the final inspection, will suit the true intent and meaning of the Plans, Specifications and Contract Documents.
- I. The CONTRACTOR shall furnish and install all equipment, accessories, connections and incidental items necessary to complete the work, ready for use and operation by the OWNER.
- J. When the ENGINEER has reviewed equipment submittals and given instructions to proceed with the installation of items of equipment that require arrangements or connections different from those shown on the drawings, it shall be the responsibility of the CONTRACTOR to install the equipment to operate properly and in accordance with the intent of the Plans and Specifications, and he shall provide any additional equipment and materials that may be required. The CONTRACTOR shall be responsible for the proper location of roughing-in and connections by other trades. All changes shall be made at no increase in the Contract Amount or additional costs to other trades.
- K. The CONTRACTOR shall support the installation of all equipment, plumb, rigid and true to line. The CONTRACTOR shall determine how equipment, fixtures, conduit, etc., are to be installed, and shall provide foundations, bolts, inserts, stands, hangers, brackets and accessories for proper support whether or not shown on the drawings.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Deliver, handle, and store all components to be installed under this section in accordance with the SUPPLIER'S written Pre-Installation Delivery, Storage, and Handling Instructions and the requirements of Section 01 60 00 - Product Requirements.

1.7 SITE CONDITIONS

- A. Environmental Conditions:
 - 1. All equipment including controls and drives specified herein shall be specifically designed to be installed for this service and the environment encountered in this installation, unless noted otherwise.

B. Existing Conditions:

1. CONTRACTOR shall verify actual dimensions of openings, adjacent facilities and equipment, utilities, and related items by field measurements before fabrication, as applicable.

1.8 WARRANTY

A. Manufacturer Warranty:

1. Refer to Section 01 78 26 - Warranties for Special Equipment Warranty.

1.9 CONTRACT DOCUMENTS

A. Intent:

1. The intent of the contract drawings or Plans is to establish the types of systems and functions; the drawings will not specifically indicate each item essential to the functioning of the system.
2. Electrical drawings are generally diagrammatic and show approximate location and extent of work.
3. Install the work complete, including minor details necessary to perform the function indicated.
4. In case of doubt as to work intended, or if amplification or clarification is needed, request instructions from the ENGINEER.
5. It is also the intent of these Contract Documents that the electrical and process system CONTRACTOR coordinate with each other in order to provide a complete and workable system with all wiring, conduit and accessories required which may not be shown on the Plans.

B. Discrepancies:

1. Review pertinent drawings and adjust the work to conditions shown.
2. Where discrepancies occur between Plans, Specifications, and actual field conditions, immediately notify the ENGINEER for his interpretation.
3. Dimensions on electrical drawings shall be verified with structural, architectural and mechanical drawings.

C. Outlet and Equipment Locations:

1. Coordinate the actual locations of electrical outlets and equipment with building features and mechanical equipment as indicated on architectural, structural and mechanical drawings.
2. Review with the ENGINEER any proposed changes in outlet or equipment location.
3. Relocation of outlets before installation, up to 3 feet from the position indicated, may be directed by OWNER without additional cost.
4. Remove and relocate outlets placed in an unsuitable location, when so requested by the ENGINEER.

1.10 SYSTEM RESPONSIBILITY

A. The ELECTRICAL CONTRACTOR shall be responsible for:

1. Complete systems in accordance with the intent of these Contract Documents.

2. Coordinating the details of facility equipment and construction for all Specification Sections which affect the work covered under Division 26, Electrical.
3. Furnishing and installing incidental items not actually shown or specified, but which are required by good practice to provide complete functional systems.
4. Coordinate the work with the PLANT CONTROL SYSTEM INTEGRATOR.
 - a. The PLANT CONTROL SYSTEM INTEGRATOR shall furnish and install the primary and secondary instruments, i.e., level element and level indicating transmitter, flow transmitter (flow tube by others), headloss transmitters, etc. Refer to Loop Drawings.
 - b. The conduit and wiring to and from the instruments shall be furnished and installed by the ELECTRICAL CONTRACTOR. Termination in the instrument shall be by PLANT CONTROL SYSTEM INTEGRATOR.
 - c. All terminations in the control panel shall be by PLANT CONTROL SYSTEM INTEGRATOR.
 - d. ELECTRICAL CONTRACTOR shall:
 - 1) Provide termination drawings for PLANT CONTROL SYSTEM INTEGRATOR.
 - 2) Provide equipment pad for control panels, consoles and instrument panels shall be furnished by the Electrical CONTRACTOR.
 - 3) Coordinate testing of the electrical system being furnished and shall be responsible for the equipment supplied.
 - 4) Present at time of the instrument system testing and start-up and responsible for the coordination of the facility testing with the PLANT CONTROL SYSTEM INTEGRATOR.
 - 5) Coordinate the interface requirement between each starter and control panel furnished under this Contract with the PLANT CONTROL SYSTEM INTEGRATOR.
 - e. Written proof shall be furnished to verify a clear understanding has been reached between the ELECTRICAL CONTRACTOR and the PLANT CONTROL SYSTEM INTEGRATOR for each control loop requirement, i.e., type of contacts (momentary, maintained), interface relay requirement, number of wires, terminal marking, control schematic information, and wiring diagrams.
- B. Electrical Drawings showed only general locations of equipment, devices, and raceway, unless specifically dimensioned. The CONTRACTOR shall be responsible for the proper routing of raceway, subject to the approval of the ENGINEER.
- C. Submit to the ENGINEER in writing details of any necessary, proposed departures from these Contract Documents. Submit such request as soon as practicable, and within ten (10) days after award of the Contract. Make no such departures without written approval of the ENGINEER.
- D. Dimensions on electrical drawings shall be verified with structural, architectural, and mechanical drawings.
- E. Where the CONTRACTOR is submitting a packaged system; the system shall comply with the requirements of the electrical specifications, including field cables, conduits, junction boxes, circuit breakers, combination starters, pushbuttons, pilot lights, and motors. Deviations shall

not be accepted, unless pre-approved. Control centers and special control cabinets wired to terminal blocks shall include the MANUFACTURER's standard quality, unless specifically mentioned to the contrary on the drawings or in the specifications.

- F. Maintain continuity of electric service to functioning portions of the process or buildings during hours they are normally in use. Temporary outages will be permitted during cutover work at such times and places as can be pre-arranged with the ENGINEER and OWNER. Such outages shall be kept to a minimum number and minimum length of time. Make no outages without prior written authorization of the ENGINEER. Include costs for temporary wiring and overtime work required in the Contract price. Remove temporary wiring at the completion of the work.

PART 2 - PRODUCTS

2.1 PRODUCT REQUIREMENTS

- A. Condition: Materials and equipment provided under these Specifications shall be new products of MANUFACTURERS regularly engaged in production of such equipment. Provide the MANUFACTURER's latest standard design for the type of equipment specified.
- B. NEC and UL: Products must conform to requirements of the National Electrical Code. Where Underwriters' Laboratories have set standards, listed products, and issued labels, products used must be listed and labeled by UL.
- C. Space Limitations: Equipment selected must conform to the building features and must be coordinated with them. Do not provide equipment which will not suit arrangement and space limitations.
- D. Factory Finish: Equipment must be delivered with a hard surface, factory-applied finish so that no additional field painting is required.
- E. Field Installation: All field installed equipment, conduit, etc., shall require Type 316 stainless steel nuts, bolts, washers, and rigid aluminum or Type 316 stainless steel metal framing and supports, and other items as indicated on the Plans.

2.2 SUBSTITUTIONS

- A. Refer to Division 1 General Requirements for substitution requirements.

PART 3 - EXECUTION

3.1 INSTALLER - NOT USED

3.2 EXAMINATION - NOT USED

3.3 PREPARATION

- A. Protection of Equipment
 - 1. Moisture:
 - a. During construction, provide heaters to protect switchgear, transformers, motors, control equipment, and other items from moisture absorption and corrosion.
 - b. Apply protection immediately on receiving the products and provide continuous

- protection.
- c. Store all equipment indoors in dry, well ventilated and heated space.
- 2. Clean: Keep products clean by elevating above ground or floor and by using suitable coverings.
- 3. Damage: Take such precautions as are necessary to protect apparatus and materials from damage. Failure to protect materials is sufficient cause for rejection of the apparatus or material in question.
- 4. Finish: Protect factory finish from damage during construction operations and until final acceptance of the project.

3.4 INSTALLATION

- A. Refer to Section 01 70 00 - Execution Requirements.
- B. Cooperation with Other Trades:
 - 1. Cooperation with trades of adjacent, related or affected materials or operations, and of trades performing continuations of this work under subsequent contracts, is considered a part of this work to effect timely and accurate placing of work and to bring together, in proper and correct sequence, the work of such trades.
 - 2. Coordinated equipment layout in sufficient time to be coordinated with work of others, provide drawings and layout work showing exact size and location of sleeves, openings or inserts for electrical equipment in slabs, walls, partitions and chases.
- C. Workmanship: Work must be performed by workers skilled in their trade. The installation must be complete whether the work is concealed or exposed.
- D. Concrete Equipment Pads:
 - 1. Install minimal 4-inch thick concrete foundation pads for indoor floor mounted equipment, except where direct floor mounting is permitted by the ENGINEER.
 - 2. Pour pads on roughened floor slabs, sized so that outer edges extend a minimum of 3 inches beyond equipment.
 - 3. Trowel pads smooth and chamfer edges to a 1-inch bevel.
 - 4. Provide dowels in slab, and rebar between the dowels.
 - 5. Pads must drain away from the equipment.
 - 6. Secure equipment to pads as recommended by the MANUFACTURER.
- E. Setting of Equipment:
 - 1. Equipment must be leveled and set plumb.
 - 2. Sheet metal enclosures mounted against a wall must be separated from the wall not less than 1/2 inch by means of corrosion resistant spacers or by 3 inches of air for freestanding units.
 - 3. Use corrosion resistant bolts, nuts and washers to anchor the equipment.
- F. Sealing of Equipment:
 - 1. Permanently seal outdoor equipment at the base using grout in accordance with Section 03 60 00 - Grout, Non-Shrink.
 - 2. Seal or screen openings into equipment to prevent entrance of animals, birds and insects.

3. Use stainless steel or copper mesh with openings not larger than 1/16-inch squares for screened openings.
 4. Seal small cracks and openings from the inside with silicone sealing compound.
- G. Concealed Work: Conceal electrical work in walls, floors, chases, under floors, underground and above ceilings except:
1. Where shown or specified to be exposed. Exposed is understood to mean open to view.
 2. Where exposure is necessary to the proper function.
 3. Where size of materials and equipment precludes concealment.
- H. Application: Unless otherwise indicated, power will be utilized as follows:
1. Motors 1-2 horsepower and smaller: 120 V, single-phase.
 2. Incandescent lighting, convenience outlets, special outlets and fluorescent lighting: 120 V, single-phase.
 3. HVAC, Heaters exhaust fan: 480 V, three-phase
 4. Transformer 15 KVA: 480 V, three phase supply
- I. Equipment and Device Marking
1. Nameplates:
 - a. Externally mark electrical equipment by means of suitable nameplates identifying each and the equipment served.
 - b. Provide each piece of equipment with a black phenolic nameplate with 3/16-inch high white lettering secured to front of equipment. For nameplate size, refer to Section 26 05 53 - Identification for Electrical Systems.
 - c. Supply blank nameplates for spare units and used spaces.
 - d. Actual nameplate legend, which may consist of up to three lines, will be provided to the ENGINEER on submittals.
 2. Nameplate Fasteners: Fasten nameplates to equipment only by means of appropriate noncorroding screws and as specified in Section 26 05 53 - Identification for Electrical Systems.
 3. Nameplate Information: In general, the following information is to be provided for the types of electrical equipment as listed.
 - a. Switchgear, Motor Control Centers and Distribution Panelboards: On the mains, identify the piece of equipment, the source and voltage characteristics, i.e., 480 V, 3PH, 3 W, etc. For each branch circuit protective device, identify the load served.
 - b. Transformers: Identify the service source and load served.
 - c. Panelboards: Identify the service source, panelboard designation and voltage characteristics.
 4. Panelboards:
 - a. Prepare a neatly typed circuit directory behind clear heat-resistant plastic for each panelboard.
 - b. Identify circuits by equipment served and by room numbers, where room numbers exist.

- c. Use equipment names and room numbers selected by the ENGINEER; names and numbers may be different from those shown on Drawings.
 - d. Indicate spares and spaces with light, erasable pencil markings.
- 5. Boxes, Small Equipment and High Equipment:
 - a. Pull boxes and similar items may be marked with Dymo No. 158-4 vinyl embossing tape with adhesive back in lieu of nameplates. Use Dymo No. 7123 perma-stick liquid adhesive with the tape. Tape color, placement and spacing must be approved by the ENGINEER before starting this work. Individually mounted disconnect switches and motor starters shall be marked with phenolic nameplates attached with stainless steel.
 - b. Provide identification stencils for high voltage equipment and raceways with the legend "DANGER HIGH VOLTAGE." Mark all exposed high voltage raceways every 25 feet.
- 6. Power Receptacles: Use nameplate or engraved plate to identify power receptacles where the nominal voltage between a pair of contacts is greater than 150 V with circuit No., voltage and phases.
- 7. Wall Switches: Engrave the switch plate of the switch with the function of the switch.

3.5 SYSTEM STARTUP

- A. Startup of the facility shall be in accordance with Section 01 75 25 - Equipment Testing and Startup.

3.6 CUTTING AND PATCHING

- A. Lay out work carefully in advance. Do not cut or notch any structural member or building surface without specific approval of ENGINEER. Carefully carry out any cutting, channeling, chasing, or drilling of floors, walls, partitions, ceilings, paving, or other surfaces required for the installation, support, or anchorage of conduit, raceways, or other electrical materials and equipment. Following such work, restore surfaces neatly to original condition.

3.7 LOAD BALANCE

- A. The Drawings and Specifications indicate circuiting to electrical loads and distribution equipment. Balance electrical load between phases as nearly as possible on switchboards, panelboards, motor control centers, and related items.

3.8 MOTOR ROTATION

- A. Before and after final service connections are made, check and correct the rotation of motors.
- B. Coordinate rotation checks with the ENGINEER and the CONTRACTOR responsible for the driven equipment. Submit a written report to the ENGINEER for each motor verifying that rotation has been checked and corrected.

3.9 CLEANING AND TOUCH-UP PAINTING

- A. Touch up scratches, scrapes, or chips in interior and exterior surfaces of devices and equipment with finishes matching, as nearly as possible, the type, color, consistency, and type of surface of the original finish. If extensive damage is done to equipment paint

surfaces, refinish the entire equipment in a manner that provides finish equal to or better than the factory finish, and that meets the requirements of the Specifications and is acceptable to the ENGINEER.

3.10 CLOSEOUT ACTIVITIES

- A. Demonstration
- B. Training
- C. Equipment Supplier Certificates
 - 1. Provide Equipment Supplier Certificate(s) of installation stating the equipment is installed per the manufacturer's recommendations and in accordance with the Drawings and Specifications.
 - 2. Provide Equipment Supplier Certificate(s) of Performance stating the equipment meets or exceeds the performance requirements as defined herein.

END OF SECTION

SECTION 26 05 19
LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes the following:
 - 1. Building wires and cables rated 600 V and less.
 - 2. Connectors, splices, and terminations rated 600 V and less.
 - 3. Sleeves and sleeve seals for cables.

1.2 REFERENCES

- A. EPDM: Ethylene-propylene-diene terpolymer rubber.
- B. NBR: Acrylonitrile-butadiene rubber.

1.3 ADMINISTRATIVE REQUIREMENTS - NOT USED

1.4 SUBMITTALS

- A. Refer to Section 26 00 00 - Electrical General Provisions.

1.5 QUALITY ASSURANCE

- A. Refer to Section 26 00 00 - Electrical General Provisions.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Refer to Section 26 00 00 - Electrical General Provisions.

1.7 SITE CONDITIONS

- A. Refer to Section 26 00 00 - Electrical General Provisions.

1.8 WARRANTY

- A. Refer to Section 26 00 00 - Electrical General Provisions.

PART 2 - PRODUCTS

2.1 CONDUCTORS AND CABLES

- A. Available Manufacturers: Any Manufacturer whose product complies with specification will be acceptable.
- B. Single Conductors:
 - 1. Unless otherwise indicated, all conductors shall be copper and shall be stranded. Solid conductors shall be allowed on 120-V lighting and receptacle circuits.
 - 2. Utilize only conductors meeting applicable requirements of NEMA WC 3, WC 5, WC 7, and ICEA S-19-81, S-61-402, and S-66-524.
 - 3. Insulation Requirements:
 - a. Conductor sizes No. 6 and larger provide conductors with type RHH or RHW.

- b. Conductor sizes smaller than No. 6 provide conductors with XHHW.
 - c. For lighting and receptacles, provide conductors with THHN or THWN.
 - 4. Unless noted otherwise, conductor sizes indicated are based on copper conductors. Do not provide conductors smaller than those indicated.
 - 5. Where flexible cords and cables are specified, provide Type SO, 600 V with the number and size of copper conductors indicated.
- C. Multi-Conductor Cable:
- 1. Provide cable that is UL listed Type TC and conforms to the requirements of UL 1277 and NEC Article 340, or UL listed Power Limited Circuit Cable that conforms to the requirements of NEC Article 725. Provide cables permanently and legibly marked with the Manufacturer's name, the maximum working voltage for which the cable was tested, the type of cable, and labeled UL (or submit evidence of UL listing).
 - 2. 600 V Multi-Conductor Control Cable, Type TC:
 - a. General: Multi-conductor control circuit interconnection cable with ground. Suitable for installation in open air, in cable trays, conduit, or other approved raceways. Minimum cable temperature rating 90°C dry locations, 75°C wet locations. Passes vertical tray flame test.
 - b. Individual Conductors: No. 14 AWG, 7-strand copper.
 - c. Insulation and Jackets: Provide conductors insulated with flame retardant ethylene propylene rubber, UL rated VW-1. Conductors identified by colors per ICEA Method 1 K2 (no greens and whites) and assembled to ICEA standards. Outer jacket flame retardant, sunlight resistant and oil resistant, chlorosulfonated polyethylene (CSPE) with nominal thickness per ICEA standards.
 - 3. 600 V Multi-Conductor Power Cable, Type TC:
 - a. General: Three-conductor or 4-conductor, with ground and overall jacket suitable for installation in open air, cable trays, conduit, or other approved raceways. Minimum cable temperature rating 90°C dry locations, 75°C wet locations.
 - b. Individual Conductors: Class B stranded, coated, or uncoated copper.
 - c. Insulation and Jackets: Provide conductors insulated with flame retardant ethylene propylene rubber, UL rated VW-1. Conductors identified by colors per ICEA Method 1 K2 (no greens and whites) and assembled to ICEA standards. Outer jacket flame retardant, sunlight resistant, and oil resistant, chlorosulfonated polyethylene (CSPE) with nominal thickness per ICEA standards.
 - 4. Single Pair (600 V No. 16 AWG Twisted, shielded Pair Instrumentation Cable, Type TC):
 - a. General: Single pair instrumentation cable designed for noise rejection for process control, computer, or data log applications. Suitable for installation in cable trays, conduit, or other approved raceways. Minimum cable temperature rating shall be 90°C dry locations, 75°C wet locations.
 - b. Individual Conductors: Soft annealed copper, Class B, 7-strand concentric per ASTM B8, 20 AWG, 7-strand copper drain wire.
 - c. Insulation and Jacket: Each conductor 15-mil nominal PVC and 4-mil nylon

insulation. Pair conductors pigmented black and red. Jacket flame-retardant and sunlight and oil resistant PVC with 45-mils nominal thickness. Shield 1.35 mil aluminum, Mylar overlapped, to provide 100% coverage.

d. Dimension: 0.31 inch nominal

5. Multi-pair (600 V No. 16 AWG, Multi-twisted Shielded Pairs with a Common Overall Shield Instrumentation Cable, Type TC):

- a. General: Twisted, shielded pairs of instrument cables, grouped in a single cable with an overall shield, designed for use as instrumentation, process control, and computer cable. Suitable for installation in cable tray, conduit, or other approved raceways. Minimum cable temperature rating shall be 90°C dry locations, 75°C wet locations.
- b. Conductors: Soft annealed copper, Class B, 7-strand concentric per ASTM B8. Copper drain wires. Pair drain wire size AWG 20; group drain wire size AWG 18.
- c. Insulation and Jacket: Each conductor 25-mil flame retardant ethylene propylene pigmented black and red with red conductor numerically printed for group identification. Outer jacket flame retardant and sunlight and oil resistant chlorinated polyethylene (CPE) with nominal thickness. Individual pair shield 1.35-mil aluminum-mylar with tin plated copper drain wire. Group shield 2.35-mil aluminum-mylar, overlapped for 100% coverage.

D. Type P Four Conductor Power Cable

- 1. General: Four (4) insulated power conductors, armored and sheathed for demanding environments of offshore drilling and petroleum facilities.
 - a. Individual Conductors: Soft annealed flexible stranded tinned copper per IEEE 1580 Table 11.
 - b. Insulation: Flame retardant cross-linked polyolefin, meeting the requirements for Type P of IEEE 1580 and Type X110 of UL 1309/CSA C22.2 No. 245.
 - c. Jacket: Black, active grade, flame retardant, oil, abrasion, chemical and sunlight resistant thermosetting compound meeting UL 1309/CXS C22.2 No. 245 and IEEE 1580.
 - d. Armor: Basket weave bronze wire armor per IEEE 1580 and UL 1309/CSA C22.2 No. 245.
 - e. Sheath: Black, active grade, flame retardant, oil, abrasion, chemical and sunlight resistant thermosetting compound meeting UL 1309/CXS C22.2 No. 245 and IEEE 1580.

E. VFD Cable

- 1. Type TC-ER cable with 3 copper conductors, XLPE insulation, bare copper symmetrical segmented ground, dual tape shield with PVC jacket.
- 2. 90C temperature rating
- 3. Comply with UL 1277, UL 1685
- 4. Voltage ratings 600V.

PART 3 - EXECUTION

3.1 INSTALLATION OF CONDUCTORS AND CABLES

- A. Do not exceed cable manufacturer's recommendations for maximum pulling tensions and minimum bending radii. Pulling compound shall be used. Use only UL listed compound compatible with the cable outer jacket and with the raceway involved.
- B. Tighten screws and terminal bolts using torque type wrenches, and/or drives, to tighten to the inch-pound requirements of the NEC and UL.
- C. Where single conductors and cables in manholes, handholes, vaults, cable trays, and other indicated locations are not wrapped together by some other means such as arc and fireproofing tapes, bundle throughout their exposed length conductors entering from each conduit with nylon, self-locking, releasable, cable ties placed at intervals not exceeding 12 inches on centers.

3.2 CONDUCTOR - 600 V AND BELOW

- A. Provide conductor sizes as indicated on the drawings.
- B. Wire nuts may be used on solid conductors of 120 V and 277 V lighting and 120 V receptacle circuits only. Use King silicone filled pressure connectors or approved equal. Use crimp connectors on all stranded conductors. Place no more than one conductor in any single-barrel pressure connection.
- C. Soldered mechanical joints insulated with tape will not be acceptable.
- D. Vinyl plastic insulating tape for wire and cable splices and terminations shall be flame retardant, 7-mil thick minimum, rated for 90°C minimum meeting the requirements of UL 510.
- E. Provide terminals and connectors acceptable for the type of material used.
- F. Arrange wiring in cabinets, panels, and motor control centers neatly cut to proper length. Remove surplus wire, and braid and secure in an acceptable manner. Identify circuits entering motor control centers or other control cabinets in accordance with the conductor identification system specified herein.
- G. Terminate control and instrumentation wiring with methods consistent with terminals provided, and in accordance with terminal manufacturer's instructions. Where terminals provided will accept such lugs, terminate control and instrumentation wiring (except solid thermocouple leads) with insulated, locking-fork compression lugs, Thomas & Betts, Sta-Kon, or equal.
- H. For terminals designed to accept only bare wire compression terminations, use only stranded wire, and terminate only one wire per terminal. Tighten terminal screws with torque screwdriver to recommended torque values.
- I. Attach compression lugs with a tool specifically designed for that purpose which provides a complete, controlled, crimp where the tool will not release until the crimp is complete. Use of plier type crimpers is not acceptable.
- J. Cap spare conductors and conductors not terminated with UL listed end caps.
- K. Where conductors pass through holes or over edges in sheet metal, remove all burrs, chamfer edges, and install bushings and protective strips of insulating material to protect the conductors.
- L. For conductors that will be connected by others, provide at least 6 feet spare conductor in

freestanding panels, and at least 2 feet spare in other assemblies. Provide additional spare length in any particular assembly where it is obvious that more conductor length will be needed to reach the termination point.

3.3 CABLES

- A. Do not splice without permission of the ENGINEER. Locate splices, when permitted, only in readily accessible cabinets or junction boxes using terminal strips.
- B. Where connections of cables installed under this section are to be made to instrumentation and controls, leave pigtails of adequate length for neat bundled type connections.
- C. Maintaining the integrity of shielding of instrumentation cables is essential to the operation of the control systems. Take special care in cable installation to ensure that grounds do not occur because of damage to the jacket over the shield.

3.4 CABLE PLACEMENT:

- A. Immediately prior to the placement of each cable or cable group, inspect the raceway to determine that installation is complete and that the interior is clean and free of all materials detrimental to the cable or its placement. Group all cable assigned to a particular conduit and pulled simultaneously, using cable grips and acceptable lubricants.
- B. Provide adequately sized raceways to accommodate the number and size of cable as specified, and in compliance with Article 300 of the National Electric Code. If at any time during the progress of the work raceways appear inadequate to accommodate the assigned cable, notify the Owner at once and discontinue further work on the questionable raceway until advised by the Owner as to how to proceed.
- C. Carefully check all cable as to size and length before pulling into conduits. Remove and replace cable pulled into the wrong conduit or cut too short at no additional cost to the Owner. Do not pull cable removed from one conduit or duct into another conduit or duct without permission of the Owner.
- D. Fishing and pulling shall be performed with flexible round non-metallic tape, carbon dioxide, or forced air propelled polyethylene cord, nylon rope, or manila rope. No metallic cable or materials that may damage or scratch the inside surface shall be pulled into any conduit.
- E. Use woven wire cable grips to pull all low voltage single conductor cable, No. 2/0 and larger, and all low voltage multi-conductor cable. Use pulling loops to pull single conductor cable smaller than No. 2/0. When a cable grip is used for pulling, the arc of the cable covered by the grip plus 6 inches shall be cut off and discarded.
- F. Insert a reliable non-freezing type of swivel or swivel connection between the pulling ropes and the cable eye, or grip to prevent twisting under strain.
- G. Do not exceed the maximum pulling tension recommended by the cable manufacturer. Pulling mechanisms of both the manual and power types shall have the rated capacity in tons clearly marked on the mechanism. Whenever the capacity of the pulling mechanism exceeds the recommended pulling tension of the cable as given by the cable manufacturer, a dynamometer shall be used to show the tension on the cable, and the indicator shall be constantly watched. If any excessive strain develops, stop the pulling operation at once and determine and correct the difficulty.

3.5 CONDUCTOR ARC AND FIREPROOFING TAPES

- A. Use arc and fireproofing tapes on 600 V single conductors and cables, except those rated Type TC, throughout their entire exposed length at splices in manholes, handholes, vaults, cable trays, and other indicated locations.
- B. Wrap together as a single cable conductors entering from each conduit.
- C. Follow tape manufacturer's installation instructions. Secure the arc and fireproofing tape at frequent intervals with bands of the specified glass cloth electrical tape. Make each band of at least two wraps of tape directly over each other.

3.6 FIELD QUALITY CONTROL

- A. Perform tests and inspections and prepare test reports.
- B. Tests and Inspections:
 - 1. After installing conductors and cables and before electrical circuitry has been energized, test service entrance and feeder conductors, and conductors feeding the following critical equipment and services for compliance with requirements.
 - 2. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 - 3. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each splice in cables and conductors No. 3 AWG and larger. Remove box and equipment covers so splices are accessible to portable scanner.
 - a. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each splice 11 months after date of Substantial Completion.
 - b. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
 - c. Record of Infrared Scanning: Prepare a certified report that identifies splices checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.
- C. Test Reports: Prepare a written report to record the following:
 - 1. Test procedures used.
 - 2. Test results that comply with requirements.
 - 3. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.
- D. Remove and replace malfunctioning units and retest as specified above.

END OF SECTION

SECTION 26 05 26
GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes methods and materials for grounding systems and equipment, plus the following special applications:
 - 1. Underground distribution grounding.
 - 2. Common ground bonding with lightning protection system.

1.2 REFERENCES - NOT USED

1.3 ADMINISTRATIVE REQUIREMENTS - NOT USED

1.4 SUBMITTALS

- A. Refer to Section 26 00 00 - Electrical General Provisions.

1.5 QUALITY ASSURANCE

- A. Refer to Section 26 00 00 - Electrical General Provisions.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Refer to Section 26 00 00 - Electrical General Provisions.

1.7 SITE CONDITIONS

- A. Refer to Section 26 00 00 - Electrical General Provisions.

1.8 WARRANTY

- A. Refer to Section 26 00 00 - Electrical General Provisions.

PART 2 - PRODUCTS

2.1 CONDUCTORS

- A. Insulated Conductors: Tinned-copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.
- B. Bare Copper Conductors:
 - 1. Solid Conductors: ASTM B 3.
 - 2. Stranded Conductors: ASTM B 8.
 - 3. Tinned Conductors: ASTM B 33.
 - 4. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inches in diameter.
 - 5. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
 - 6. Bonding Jumper: Copper tape, braided conductors, terminated with copper ferrules; 1-5/8 inches wide and 1/16 inches thick.
 - 7. Tinned Bonding Jumper: Tinned-copper tape, braided conductors, terminated with copper ferrules; 1-5/8 inches wide and 1/16 inches thick.

- C. Grounding Bus: Rectangular bars of annealed copper, 1/4x2 inches in cross section, unless otherwise indicated; with insulators.

2.2 CONNECTORS

- A. Listed and labeled by a nationally recognized testing laboratory acceptable to authorities having jurisdiction for applications in which used, and for specific types, sizes, and combinations of conductors and other items connected.
- B. Bolted Connectors for Conductors and Pipes: Copper or copper alloy, bolted pressure-type, with at least two bolts.
 - 1. Pipe Connectors: Clamp type, sized for pipe.
- C. Welded Connectors: Exothermic-welding kits of types recommended by kit MANUFACTURER for materials being joined and installation conditions.

2.3 GROUNDING ELECTRODES

- A. Ground Rods: Copper-clad steel; 3/4 inch by 10 feet in diameter.

PART 3 - EXECUTION

3.1 APPLICATIONS

- A. Conductors: Install solid conductor for No. 8 AWG and smaller, and stranded conductors for No. 6 AWG and larger, unless otherwise indicated.
- B. Underground Grounding Conductors: Install bare tinned-copper conductor, No. 4/0 AWG minimum.
 - 1. Bury at least 24 inches below grade.
 - 2. Duct-Bank Grounding Conductor: Bury 12 inches above duct bank when indicated as part of duct-bank installation.
- C. Isolated Grounding Conductors: Green-colored insulation with continuous yellow stripe. On feeders with isolated ground, identify grounding conductor where visible to normal inspection, with alternating bands of green and yellow tape, with at least three bands of green and two bands of yellow.
- D. Grounding Bus: Install in electrical and telephone equipment rooms, in rooms housing service equipment, and elsewhere as indicated.
 - 1. Install bus on insulated spacers 1 inch, minimum, from wall 6 inches above finished floor, unless otherwise indicated.
 - 2. Where indicated on both sides of doorways, route bus up to top of door frame, across top of doorway, down to specified height above floor, and connect to horizontal bus.
- E. Conductor Terminations and Connections:
 - 1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
 - 2. Underground Connections: Welded connectors except at test wells and as otherwise indicated.
 - 3. Connections to Ground Rods at Test Wells: Bolted connectors.
 - 4. Connections to Structural Steel: Welded connectors.

3.2 GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS

- A. Comply with IEEE C2 grounding requirements.
- B. Grounding Manholes and Handholes: Install a driven ground rod through manhole or handhole floor, close to wall, and set rod depth so 4 inches will extend above finished floor. If necessary, install ground rod before manhole is placed and provide No. 4/0 AWG bare, tinned-copper conductor from ground rod into manhole through a waterproof sleeve in manhole wall. Protect ground rods passing through concrete floor with a double wrapping of pressure-sensitive insulating tape or heat-shrunk insulating sleeve from 2 inches above to 6 inches below concrete. Seal floor opening with waterproof, nonshrink grout.
- C. Grounding Connections to Manhole Components: Bond exposed-metal parts such as inserts, cable racks, pulling irons, ladders, and cable shields within each manhole or handhole, to ground rod or grounding conductor. Make connections with No. 4 AWG minimum, stranded, hard-drawn copper bonding conductor. Train conductors' level or plumb around corners and fasten to manhole walls. Connect to cable armor and cable shields as recommended by manufacturer of splicing and termination kits.
- D. Pad-Mounted Transformers and Switches: Install two ground rods and ground ring around the pad. Ground pad-mounted equipment and noncurrent-carrying metal items associated with substations by connecting them to underground cable and grounding electrodes. Install tinned-copper conductor not less than No. 4/0 AWG for ground ring and for taps to equipment grounding terminals. Bury ground ring not less than 6 inches from the foundation.

3.3 EQUIPMENT GROUNDING

- A. Install insulated equipment grounding conductors with all feeders and branch circuits.
- B. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:
 - 1. Feeders and branch circuits.
 - 2. Lighting circuits.
 - 3. Receptacle circuits.
 - 4. Single-phase motor and appliance branch circuits.
 - 5. Three-phase motor and appliance branch circuits.
 - 6. Flexible raceway runs.
 - 7. Armored and metal-clad cable runs.
 - 8. Busway Supply Circuits: Install insulated equipment grounding conductor from grounding bus in the switchgear, switchboard, or distribution panel to equipment grounding bar terminal on busway.
 - 9. Computer and Rack-Mounted Electronic Equipment Circuits: Install insulated equipment grounding conductor in branch-circuit runs from equipment-area power panels and power-distribution units.
- C. Water Heater, Heat-Tracing, and Antifrost Heating Cables: Install a separate insulated equipment grounding conductor to each electric water heater and heat-tracing cable. Bond conductor to heater units, piping, connected equipment, and components.

- D. Isolated Grounding Receptacle Circuits: Install an insulated equipment grounding conductor connected to the receptacle grounding terminal. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service, unless otherwise indicated.
- E. Isolated Equipment Enclosure Circuits: For designated equipment supplied by a branch circuit or feeder, isolate equipment enclosure from supply circuit raceway with a nonmetallic raceway fitting listed for the purpose. Install fitting where raceway enters enclosure and install a separate insulated equipment grounding conductor. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service, unless otherwise indicated.
- F. Signal and Communication Equipment: For telephone, alarm, voice and data, and other communication equipment, provide No. 4 AWG minimum insulated grounding conductor in raceway from grounding electrode system to each service location, terminal cabinet, wiring closet, and central equipment location.
 - 1. Service and Central Equipment Locations and Wiring Closets: Terminate grounding conductor on a 1/4x2x12-inch grounding bus.
 - 2. Terminal Cabinets: Terminate grounding conductor on cabinet grounding terminal.
- G. Metal Poles Supporting Outdoor Lighting Fixtures: Install grounding electrode and a separate insulated equipment grounding conductor in addition to grounding conductor installed with branch-circuit conductors.

3.4 INSTALLATION

- A. Grounding Conductors: Route along shortest and straightest paths possible, unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.
- B. Common Ground Bonding with Lightning Protection System: Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system. Bond electrical power system ground directly to lightning protection system grounding conductor at closest point to electrical service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor and install in conduit.
- C. Ground Rods: Drive rods until tops are 2 inches below finished floor or final grade, unless otherwise indicated.
 - 1. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating, if any.
- D. Test Wells: Ground rod driven through drilled hole in bottom of handhole. Handholes and shall be at least 12 inches deep, with cover.
 - 1. Test Wells: Install at least one test well for each service, unless otherwise indicated. Install at the ground rod electrically closest to service entrance. Set top of test well flush with finished grade or floor.
- E. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance, except where routed through short lengths of conduit.

1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
 2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install so vibration is not transmitted to rigidly mounted equipment.
 3. Use exothermic-welded connectors for outdoor locations, but if a disconnect-type connection is required, use a bolted clamp.
- F. Grounding and Bonding for Piping:
1. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes, using a bolted clamp connector or by bolting a lug-type connector to a pipe flange, using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
 2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
 3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.
- G. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install tinned bonding jumper to bond across flexible duct connections to achieve continuity.
- H. Grounding for Steel Building Structure: Install a driven ground rod at base of each corner column and at intermediate exterior columns at distances not more than 60 feet apart.
- I. Ground Ring: Install a grounding conductor, electrically connected to each building structure ground rod and to each indicated item, extending around the perimeter of area or item indicated.
1. Install tinned-copper conductor not less than No. 4/0 AWG for ground ring and for taps to building steel.
 2. Bury ground ring not less than 24 inches from building foundation.

3.5 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections and prepare test reports:
1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
 2. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, at ground test wells. Make tests at ground rods before any conductors are connected.
 - a. Measure ground resistance not less than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
 - b. Perform tests by fall-of-potential method according to IEEE 81.
 3. Prepare dimensioned drawings locating each test well, ground rod and ground rod

assembly, and other grounding electrodes. Identify each by letter in alphabetical order, and key to the record of tests and observations. Include the number of rods driven, their depth at each location, and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.

- B. Report measured ground resistances that exceed the following values:
 - 1. Power and Lighting Equipment or System with Capacity 500 kVA and Less: 10 Ω .
 - 2. Power and Lighting Equipment or System with Capacity 500-1,000 kVA: 5 Ω .
 - 3. Power and Lighting Equipment or System with Capacity More Than 1,000 kVA: 3 Ω .
 - 4. Power Distribution Units or Panelboards Serving Electronic Equipment: 5 Ω .
 - 5. Substations and Pad-Mounted Equipment: 5 Ω .
 - 6. Manhole Grounds: 10 Ω .
- C. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.

END OF SECTION

SECTION 26 05 29
HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes the following:
 - 1. Hangers and supports for electrical equipment and systems.
 - 2. Construction requirements for concrete bases.

1.2 REFERENCES

- A. Comply with NFPA 70.
- B. Comply with MFMA-4.

1.3 ADMINISTRATIVE REQUIREMENTS - NOT USED

1.4 SUBMITTALS

- A. Refer to Section 26 00 10 - Electrical General Provisions.

1.5 QUALITY ASSURANCE

- A. Refer to Section 26 00 00 - Electrical General Provisions.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Refer to Section 26 00 00 - Electrical General Provisions.

1.7 SITE CONDITIONS

- A. Refer to Section 26 00 00 - Electrical General Provisions.

1.8 WARRANTY

- A. Refer to Section 26 00 00 - Electrical General Provisions.

PART 2 - PRODUCTS

2.1 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

- A. Available Manufacturers: Any Manufacturer whose product complies with specification will be acceptable.
- B. General: Strut shall be 1-5/8 inches wide in varying heights and welded combinations as required to meet load capacities and designs i

- C. Indicated on the drawings.
- D. Materials and Finish: Material and finish specifications for each strut type are as follows:
 - 1. Stainless Steel: All fittings and hardware shall be made of AISI Type 316 stainless steel.
- E. Raceway and Cable Supports: As described in NECA 1 and NECA 101.
- F. Conduit and Cable Support Devices: AISI Type 316 stainless steel hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.
- G. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for non-armored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be malleable iron.
- H. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M, steel plates, shapes, and bars. Black and galvanized.
- I. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:
 - 1. Mechanical-Expansion Anchors: Insert-wedge-type, stainless steel, for use in hardened Portland cement concrete with tension, shear, and pullout capacities appropriate for supported loads and building materials in which used.
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) Cooper B-Line, Inc.; a division of Cooper Industries.
 - 2) Empire Tool and Manufacturing Co., Inc.
 - 3) Hilti Inc.
 - 4) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
 - 5) MKT Fastening, LLC.
 - 2. Concrete Inserts: Stainless Steel, slotted support system units similar to MSS Type 18; complying with MFMA-4 or MSS SP-58.
 - 3. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.
 - 4. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
 - 5. Toggle Bolts: Stainless steel springhead type.
 - 6. Hanger Rods: Threaded stainless steel.

2.2 ANCHOR BOLTS AND ANCHOR BOLT SLEEVES

- A. Cast-In-Place Anchor Bolts:
 - 1. Unless otherwise shown on Drawings. F 593, AISI Type 316, Condition CW
- B. Anchor Bolt Sleeves:
 - 1. Plastic:
 - a. Single unit construction with corrugated sleeve.

- b. Top of sleeve shall be self-threading to provide adjustment of threaded anchor bolt projection.
 - c. Material: High density polyethylene.
- 2. Fabricated Steel: ASTM A 36.

2.3 CONCRETE AND MASONRY DRILLED ANCHORS

A. Mechanical Expansion Anchors:

- 1. Available Manufacturers: Any Manufacturer whose product complies with specification will be acceptable.
- 2. Design Requirements: Anchor bolt and sleeve assembly shall have capability to sustain without failure, as determined by the Strength Design method when installed in cracked and uncracked concrete, in accordance with the International Building Code and as determined by testing in accordance with ASTM E 488 and AC-308.2.
- 3. Material: AISI Type 304 and Type 316 stainless steel.
- 4. Current evaluation and acceptance reports by ICC or other similar code organization and listed by UL and FM Global.
- 5. Acceptable for use in potable water structures by NSF and local health organizations.
- 6. Type:
 - a. ICC-ES Code Listed, Category 1, Cracked and Uncracked Concrete.
 - b. Self-drilling Anchors; snap-off or flush type, zinc-plated.
 - c. Non-drilling Anchors; flush type for use with zinc-plated or stainless-steel bolt, or stud type with projecting threaded stud.
- 7. Size: As shown on Drawings and required for the concrete strength specified.

B. Wedge Bolts:

- 1. Available Manufacturers: Any Manufacturer whose product complies with specification will be acceptable.
- 2. Material: Zinc plated, case hardened carbon steel.
- 3. Current evaluation and acceptance reports by ICC or other similar code organization and listed by UL and FM Global.
- 4. Type:
 - a. ICC-ES Code Listed, Category 1, Cracked and Uncracked Concrete.
 - b. Description: One-piece, heavy duty screw anchor with finished hex head suitable for cracked and uncracked concrete and grouted masonry.
- 5. Size: As shown on Drawings and required for the concrete strength specified.

C. Snake Anchors:

- 1. Available Manufacturers: Any Manufacturer whose product complies with specification will be acceptable.
- 2. Material: Zinc plated, case hardened carbon steel.
- 3. Current evaluation and acceptance reports by ICC or other similar code organization and listed by UL and FM Global.
- 4. Type:

- a. ICC-ES Code Listed, Category 1, Cracked and Uncracked Concrete.
- b. Description: Internally threaded, self-tapping screw anchor designed for performance in cracked and uncracked concrete and grouted masonry. Suitable base materials included normal-weight concrete, structural lightweight concrete, and concrete over metal deck.
- 5. Size: As shown on Drawings and required for the concrete strength specified.
- D. Adhesive Anchors:
 - 1. General: Adhesive anchoring system designed for bonding threaded anchor rod and reinforcing bar hardware into drilled holes in concrete and solid masonry base materials.
 - 2. Threaded rod:
 - a. Material: Unless otherwise specified:
 - 1) ASTM F 593 Stainless steel threaded rod, unless otherwise specified.
 - b. Diameter as shown on the Drawings or as required for the loads and conditions.
 - c. Length as required to provide minimum depth of embedment.
 - d. Clean and free of grease, oil, or other deleterious material.
 - e. For hollow-unit masonry, provide galvanized or stainless-steel wire cloth screen tube to fit threaded rod.
 - f. Anchor rods shall have rolled threads.
 - 3. Adhesive:
 - a. Available Manufacturers: Any Manufacturer whose product complies with specification will be acceptable.
 - b. Two-component, high strength adhesive anchoring system designed to be used in adverse/thaw environments, with gray color mixing.
 - 1) ICC-ES Code Listed.
 - 2) Cure Temperature, Pot Life, and Workability: Compatible for the intended use and environmental conditions.
 - 3) Non-sag, with selected viscosity base on installation temperature and overhead application where applicable.
 - 4) ASTM Compliance:
 - a) Uncracked Concrete: Meets ASTM C881, Types I, II, IV, and V, Grade 3, Class A and B.
 - b) Uncracked and Cracked Concrete: Meets ASTM C881, Types I, II, IV, and V, Grade 3, Class B and C.
 - 5) Compliant with NSF/ANSI Standard 61 for potable water applications.
- E. Concrete Inserts:
 - 1. For piping, grating and floor plate provide malleable iron inserts.
 - 2. Provide those recommended by the manufacturer for the required loading.
 - 3. Finish shall be black.
- F. Powder actuated fasteners and other types of bolts and fasteners not specified herein shall not be used unless approved by ENGINEER.

2.4 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

- A. Description: Welded or bolted, structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.

PART 3 - EXECUTION

3.1 APPLICATION

- A. Use stainless steel components unless otherwise shown on drawings.
- B. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems except if requirements in this Section are stricter.
- C. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for conduit and cable tray as scheduled in NECA 1, where Table 1 lists maximum spacing less than stated in NFPA 70. Minimum rod size shall be 1/4 inch in diameter.
- D. Multiple Raceways or Cables: Install trapeze-type supports fabricated with support system, sized so capacity can be increased by at least 25% in the future without exceeding specified design load limits.
 - 1. Secure raceways and cables to these supports with single-bolt conduit clamps.
- E. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2 inch and smaller raceways serving branch circuits and communication systems above suspended ceilings and for fastening raceways to trapeze supports.

3.2 SUPPORT INSTALLATION

- A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this Article.
- B. Raceway Support Methods: In addition to methods described in NECA 1, conduit may be supported by openings through structure members, as permitted in NFPA 70.
- C. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be the weight of supported components plus 200 lb.
- D. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:
 - 1. To Wood: Fasten with lag screws or through bolts.
 - 2. To New Concrete: Bolt to concrete inserts.
 - 3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
 - 4. To Existing Concrete: Expansion anchor fasteners.
 - 5. To Steel: Beam clamps (MSS Type 19, 21, 23, 25, or 27) complying with MSS SP-69.
 - 6. To Light Steel: Sheet metal screws.
 - 7. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction

boxes, transformers, and other devices on slotted-channel racks attached to substrate.

- E. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars.

3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

- A. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.
- B. Field Welding: Comply with AWS D1.1/D1.1M.

3.4 CONCRETE BASES

- A. Construct concrete bases of dimensions indicated but not less than 4 inches larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.
- B. Materials
 - 1. Cementitious Material: Use the following cementitious materials, of the same type, brand, and source throughout Project:
 - 2. Portland Cement: ASTM C 150, Type II or Type 1/II. Supplement with the following:
 - a. Fly Ash: ASTM C 618, Class C. Fly ash may be used for replacement of up to 15% of cement content by weight except for paving concrete.
 - 3. Normal-Weight Aggregate: ASTM C 33, graded, 1 inch nominal maximum aggregate size.
 - 4. Water: ASTM C 94; potable.
- C. Concrete Mixtures
 - 1. Comply with ACI 301 requirements for concrete mixtures.
 - 2. Provide concrete with the following mix design to result in concrete placed in the field of minimum compressive strength of 3,000 psi at 28 days based on test cylinders which are taken during concrete placement.

Unit	Measurement
Minimum Compressive Strength (7 day)	2,250 psi
Minimum Compressive Strength (28 day)	3,000 psi
Coarse Aggregate	ASTM C33, No. 467
Fine Aggregate	ASTM C33
Water/Cementitious Ratio (max.)	0.50 by weight
Air Entrainment	4-6 percent
Slump with Superplasticizer	7 inches to 9 inches
Slump without Superplasticizer	3 inches $\pm$ 1 inch
Minimum Cementitious Content	470 pounds per cubic yard

- D. Additive
 - 1. Red ferrous oxide concrete coloring pigment mixed at the rate of 1-1/2 lb. per sack of cement for electrical conduit.
- E. Anchor equipment to concrete base.

1. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
2. Install anchor bolts to elevations required for proper attachment to supported equipment.
3. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

3.5 PAINTING

- A. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A780.

END OF SECTION

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SECTION 26 05 33
RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes raceways, fittings, boxes, enclosures, and cabinets for electrical wiring.

1.2 REFERENCES - NOT USED

1.3 ADMINISTRATIVE REQUIREMENTS - NOT USED

1.4 SUBMITTALS

- A. Refer to Section 26 00 00 - Electrical General Provisions.

1.5 QUALITY ASSURANCE

- A. Refer to Section 26 00 00 - Electrical General Provisions.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Refer to Section 26 00 00 - Electrical General Provisions.

1.7 SITE CONDITIONS

- A. Refer to Section 26 00 00 - Electrical General Provisions.

1.8 WARRANTY

- A. Refer to Section 26 00 00 - Electrical General Provisions.

PART 2 - PRODUCTS

2.1 ALUMINUM CONDUIT AND FITTINGS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that comply with UL 6A, "Standard for Electrical Rigid Metal Conduit - Aluminum, Red Brass and Stainless Steel" and is manufactured to ANSI C80.5. and manufactured of 6063 alloy in temper designation T-1.
- B. Fittings for Conduit (Including all Types and Flexible and Liquidtight), and Cable: NEMA FB 1; listed for type and size raceway with which used, and for application and environment in which installed.
 - 1. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 886.

2.2 PVC COATED ALUMINUM CONDUIT AND FITTINGS

- A. Available Manufacturers: Any Manufacturer whose product complies with specification will be acceptable.
- B. PVC-Coated Aluminum Rigid Conduit:
 - 1. Alloy: Manufactured of 6063 alloy in temper designation T-1.
 - 2. Standards: UL 6A, "Standard for Electrical Rigid Metal Conduit - Aluminum, Red Brass and Stainless Steel" and is manufactured to ANSI C80.5.

3. Coating Thickness: 0.040 inch, minimum.
- C. Fittings for Conduit (Including all Types and Flexible and Liquidtight), and Cable: NEMA FB 1; listed for type and size raceway with which used, and for application and environment in which installed.
 1. Coating for Fittings for PVC-Coated Conduit: Minimum thickness of 0.040 inch with overlapping sleeves protecting threaded joints.

2.3 BOXES, ENCLOSURES, AND CABINETS

- A. Available Manufacturers: Any Manufacturer whose product complies with specification will be acceptable.
- B. Cast-Metal Outlet and Device Boxes: NEMA FB 1, aluminum, Type FD, with gasketed cover.
- C. Metal Floor Boxes: Cast metal, fully adjustable, rectangular.
- D. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.
- E. Cast-Metal Access, Pull, and Junction Boxes: NEMA FB 1, cast aluminum with gasketed cover.
- F. Hinged-Cover Enclosures: NEMA 250, Type 4X, with continuous-hinge cover with fast-operating clamp-cover junction box clamp, Type 316 stainless steel, unless otherwise indicated.
 1. Metal Enclosures: Stainless Steel Type 316.

2.4 TERMINATION CABINETS & BOXES

- A. Termination cabinets shall be NEMA 4X, Type 316 stainless steel gasketed. Cabinets shall be configured as shown on the plans, and shall be of sufficient size to adequately contain all terminals, wire-duct, and cables as determined by the CONTRACTOR. Cabinets shall have fast-operating clamp-cover junction box clamp, Type 316 stainless steel.
- B. Acceptable manufacturers: Hoffman.

2.5 WIREWAY

- A. General:
 1. Suitable for lay-in conductors.
 2. Designed for continuous grounding.
 3. Covers:
 - a. Hinged or removable in accessible areas.
 - b. Non-removable when passing through partitions.
 4. Finish: Rust inhibiting primer and manufacturer's standard paint inside and out except for stainless steel type.
 5. Standards: UL 870, NEMA 250.
- B. Watertight (NEMA 4X rated) Wireway:
 1. 14 Gauge Type 304 or 316 stainless steel bodies and covers without knockouts and 10 Gauge stainless steel flanges.
 2. Cover: Fully gasketed and held in place with captive clamp type latches.

3. Flanges: Fully gasketed and bolted.

2.6 CONDUIT BODIES AND FITTINGS AND ACCESSORIES

A. Fittings for Use with Aluminum Conduit:

1. General:
 - a. In hazardous locations listed for use in Class I, Groups C and D locations.
2. Locknuts:
 - a. Threaded stainless steel.
 - b. Gasketed or non-gasketed.
 - c. Grounding or non-grounding type.
3. Bushings:
 - a. Threaded, insulated metallic.
 - b. Grounding or non-grounding type.
4. Hubs: Threaded, insulated and gasketed metallic for raintight connection.
5. Couplings:
 - a. Threaded straight type: Same material and finish as the conduit with which they are used on.
6. Unions: Threaded copper free cast aluminum.
7. Conduit bodies (ells and tees):
 - a. Body: Cast copper free aluminum with threaded hubs.
 - b. Standard and mogul size.
 - c. Cover:
 - 1) Clip-on type with stainless steel screws.
 - 2) Gasketed or non-gasketed cast copper free aluminum.
8. Conduit bodies (round):
 - a. Body: Cast copper free aluminum with threaded hubs.
 - b. Cover: Threaded screw on type, gasketed, cast copper free aluminum.
9. Sealing fittings:
 - a. Body: Cast copper free aluminum with threaded hubs.
 - b. Standard and mogul size.
 - c. With or without drain and breather.
 - d. Fiber and sealing compound: UL listed for use with the sealing fitting.
10. Hazardous location flexible coupling (HAZ-FLEX):
 - a. Liquid tight and arc resistant.
 - b. Electrically conductive so no bonding jumper is required.
 - c. Dry and wet areas:
 - 1) Bronze braided covering over flexible brass core.
 - 2) Bronze end fittings.
 - 3) Aluminum unions and nipples.
 - d. Corrosive areas:

- 1) Stainless steel braided covering over flexible stainless steel core.
 - 2) Stainless steel end fittings.
 - 3) Aluminum unions and nipples.
11. Expansion couplings:
 - a. 2 inch nominal straight-line conduit movement in either direction.
 - b. 4 inch nominal straight-line conduit movement in either direction.
 - c. Cast copper free aluminum with insulated bushing.
 - d. Gasketed for wet locations.
 - e. Internally or externally grounded.
 12. Expansion/deflection couplings:
 - a. 3/4 IN nominal straight-line conduit movement in either direction.
 - b. 30 degree nominal deflection from the normal in all directions.
 - c. Metallic hubs, neoprene outer jacket and stainless steel jacket clamps.
 - d. Internally or externally grounded.
 - e. Watertight, raintight and concrete tight.
 13. Standards: UL 467, UL 514B, UL 886.
- B. Fittings for Use with PVC-Aluminum:
1. The same material and construction as those fittings listed under paragraph "Fittings for Use with Aluminum Conduit" and coated as defined under paragraph "PVC Coated Aluminum Conduit"

PART 3 - EXECUTION

3.1 RACEWAY APPLICATION

- A. Outdoors: Apply raceway products as specified below, unless otherwise indicated:
1. Exposed Conduit: Aluminum rigid conduit.
 2. Concealed Conduit, Above ground: Aluminum rigid conduit.
 3. Underground Conduit: RNC, Type EPC-40-PVC, concrete encased.
 4. Under concrete slab: RNC, Type EPC-40-PVC, concrete encased.
 5. Concealed in Concrete: RNC, Type EPC-40-PVC.
 6. Chemical areas: PVC-coated aluminum rigid conduit .
 7. Installed in wet-wells: PVC-coated aluminum rigid conduit.
 8. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): PVC Coated Light-tight Flexible Metal Conduit.
 9. Boxes and Enclosures, Aboveground: NEMA 250, Type 4X, stainless steel.
- B. Indoors: Apply raceway products as specified below, unless otherwise indicated:
1. Exposed Conduit: Aluminum rigid conduit.
 2. Concealed in Ceilings and Interior Walls and Partitions: Aluminum rigid conduit.
 3. Concealed in Masonry or CMU walls: RNC, Type EPC-80-PVC..

4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): PVC Coated Light-tight Flexible Metal Conduit.
 5. Damp or Wet Locations: Aluminum rigid conduit.
 6. Chemical areas: PVC-coated aluminum rigid conduit.
 7. Boxes and Enclosures: NEMA 250, Type 4, except use NEMA 250, Type 4X, stainless steel in damp, wet, or chemical locations.
- C. Minimum Raceway Size: 3/4-inch trade size. Minimum size for underground conduit shall be 1-inch trade size.
- D. Raceway Fittings: Compatible with raceways and suitable for use and location.
1. PVC Externally Coated, Aluminum Conduits: Use only fittings listed for use with that material. Patch and seal all joints, nicks, and scrapes in PVC coating after installing conduits and fittings. Use sealant recommended by fitting manufacturer.
- E. Do not install aluminum conduits in contact with concrete.

3.2 CONDUIT BODIES AND FITTINGS AND ACCESSORIES

- A. Conduit bodies and fittings shall not reduce the conduit fill area for the size of conduit to which they are installed. The next size of conduit body or fitting shall be installed if required.
- B. Conduit Seals:
1. Installed in conduit systems located in hazardous areas as required by the NFPA 70.
- C. Install Expansion Fittings:
1. Where conduits are exposed to the sun and conduit run is greater than 200 feet.
 2. Elsewhere as identified on the Drawings.
- D. Install Expansion/Deflection Fittings:
1. Where conduits enter a structure.
 - a. Except electrical manholes and handholes.
 - b. Except where the ductbank is tied to the structure with rebar.
 2. Where conduits span structural expansions joints.
 3. Elsewhere as identified on the Drawings.
- E. Threaded connections shall be made wrench-tight.
- F. Conduit joints shall be watertight:
1. Where subjected to possible submersion.
 2. In areas classified as wet.
 3. Underground.
- G. Terminate Conduits:
1. In metallic outlet boxes:
 - a. Conduit hub and locknut.
 - b. Insulated bushing and two (2) locknuts.
 - c. Use grounding type locknut or bushing when required by NFPA 70.

2. In NEMA 12 rated enclosures:
 - a. Watertight, insulated and gasketed hub and locknut.
 - b. Use grounding type locknut or bushing when required by NFPA 70.
3. In NEMA 4X rated enclosures:
 - a. Watertight, insulated and gasketed hub and locknut.
4. In NEMA 7 rated enclosures:
 - a. Into an integral threaded hub.
5. When stubbed up through the floor into floor mount equipment:
 - a. With an insulated grounding bushing on metallic conduits.
 - b. With end bells on non-metallic conduits.

3.3 OUTLET, PULL AND JUNCTION BOX INSTALLATION

A. General:

1. Install products in accordance with manufacturer's instructions.
2. See the Drawings for area classifications.
3. Fill unused punched-out, tapped, or threaded hub openings with insert plugs.
4. Size boxes to accommodate quantity of conductors enclosed and quantity of conduits connected to the box.

B. Outlet Boxes:

1. Permitted uses of metallic outlet boxes:
 - a. Housing of wiring devices:
 - 1) Recessed in all stud framed walls and ceilings.
 - 2) Recessed in poured concrete, concrete block, and brick walls of architecturally finished areas and exterior building walls.
 - b. Pull or junction box:
 - 1) Above gypsum wall board or acoustical tile ceilings.
 - 2) Above 10 feet in an architecturally finished area where there is no ceiling.
2. Permitted uses of cast outlet boxes:
 - a. Housing of wiring devices surface mounted in non-architecturally finished dry, wet corrosive, and hazardous areas.
 - b. Pull and junction box surface mounted in non-architecturally finished dry, wet, and corrosive areas.
3. Permitted uses of non-metallic outlet boxes:
 - a. Housing of wiring devices surface mounted in non-architecturally finished corrosive areas.
 - b. Pull and junction box surface mounted in non-architecturally finished corrosive areas.
4. Mount device outlet boxes where indicated on the Drawings and at heights as scheduled in Section 26 27 26 - Wiring Devices.
5. Set device outlet boxes plumb and vertical to the floor.
6. Outlet boxes recessed in walls:

- a. Install with appropriate stud wall support brackets or adjustable bar hangers so that they are flush with the face of the wall.
 - b. Locate in ungrouted cell of concrete block with bottom edge of box flush with bottom edge of block and flush with the face of the block.
- 7. Place barriers between switches in boxes with 277 V switches on opposite phases.
- 8. Back-to-back are not permitted.
- 9. When an outlet box is connected to a PVC coated conduit, the box shall also be PVC coated.
- C. Pull and Junction Boxes:
 - 1. Install pull or junction boxes in conduit runs where indicated or required to facilitate pulling of wires or making connections.
 - a. Make covers of boxes accessible.
 - 2. Permitted uses of NEMA 4X metallic enclosure:
 - a. Pull or junction box surface mounted in areas designated as wet and/or corrosive.
 - 3. Permitted uses of NEMA 4X non-metallic enclosure:
 - a. Pull or junction box surfaced mounted in areas designated as wet and/or highly corrosive.
 - 4. Permitted uses of NEMA 7 enclosure:
 - a. Pull or junction box surface mounted in areas designated as Class I hazardous.
 - 1) Provide PVC coating in corrosive areas when PVC coated conduit is used.
 - 5. Permitted uses of NEMA 12 enclosure:
 - a. Pull or junction box surface mounted in areas designated as dry.

3.4 INSTALLATION

- A. Comply with NECA 1 for installation requirements applicable to products specified in Part 2 except where requirements on Drawings or in this Article are stricter.
- B. Keep raceways at least 6 inches away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.
- C. Complete raceway installation before starting conductor installation.
- D. Arrange stub-ups so curved portions of bends are not visible above the finished slab.
- E. Install no more than the equivalent of three 90-degree bends in any conduit run except for communications conduits, for which fewer bends are allowed.
- F. Conceal conduit within finished walls, ceilings, and floors, unless otherwise indicated.
- G. Raceways Embedded or under slabs in Slabs:
 - 1. Run conduit larger than 1 inch trade size, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support.
 - 2. Arrange raceways to cross building expansion joints at right angles with expansion fittings.

3. Provide Aluminum Rigid PVC-Coated conduit bends for PVC conduits 2-inch and larger.
 4. At the transition from PVC to rigid aluminum conduit, extend PVC Coated rigid aluminum conduit a minimum of 6 inches into the concrete.
- H. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors, including conductors smaller than No. 4 AWG.
 - I. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb. tensile strength. Leave at least 12 inches of slack at each end of pull wire.
 - J. Install raceway sealing fittings at suitable, approved, and accessible locations and fill them with listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings where indicated on drawings.
 - K. Expansion-deflection Fittings for Rigid Aluminum Conduit and PVC-Coated Conduit: Install in each run of aboveground conduit crossing structural expansion joints and on exposed conduit runs of more than 100 feet or where necessary. Provide bonding jumpers across fittings.
 - L. Flexible Conduit Connections: Use maximum of 72 inches of flexible conduit for recessed and semi-recessed lighting fixtures; equipment subject to vibration, noise transmission, or movement; and for transformers and motors.
 - M. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block and install box flush with surface of wall.
 - N. Set metal floor boxes level and flush with finished floor surface.

3.5 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

- A. Coordinate sleeve selection and application with selection and application of firestopping in accordance with applicable regulations
- B. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.
- C. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
- D. Rectangular Sleeve Minimum Metal Thickness:
 1. For sleeve cross-section rectangle perimeter less than 50 inches and no side greater than 16 inches, thickness shall be 0.052 inch.
 2. For sleeve cross-section rectangle perimeter equal to, or greater than 50 inches and 1 or more sides equal to or greater than 16 inches, thickness shall be 0.138 inch.
- E. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.
- F. Cut sleeves to length for mounting flush with both surfaces of walls.
- G. Extend sleeves installed in floors 2 inches above finished floor level.
- H. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and raceway unless sleeve seal is to be installed.

- I. Seal space outside of sleeves with grout for penetrations of concrete and masonry and with approved joint compound for gypsum board assemblies.
- J. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and raceway, using joint sealant appropriate for size, depth, and location of joint.
- K. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at raceway penetrations. Install sleeves and seal with firestop materials.
- L. Roof-Penetration Sleeves: Seal penetration of individual raceways with flexible, boot-type flashing units applied in coordination with roofing work.
- M. Aboveground, Exterior-Wall Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.
- N. Underground, Exterior-Wall Penetrations: Install cast-iron "wall pipes" for sleeves. Size sleeves to allow for 1-inch annular clear space between raceway and sleeve for installing mechanical sleeve seals.

3.6 SLEEVE-SEAL INSTALLATION

- A. Install to seal underground, exterior wall penetrations.
- B. Use type and number of sealing elements recommended by manufacturer for raceway material and size. Position raceway in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.7 FIRESTOPPING

- A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly.

3.8 PROTECTION

- A. Provide final protection and maintain conditions that ensure coatings, finishes, and cabinets are without damage or deterioration at time of Substantial Completion.
 - 1. Repair damage to PVC or paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION

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SECTION 26 05 43
UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes the following:
 - 1. Conduit, ducts, and duct accessories for concrete-encased duct banks, and in single duct runs.
 - 2. Handholes and boxes.
 - 3. Manholes.

1.2 REFERENCES

- A. RNC: Rigid nonmetallic conduit.

1.3 ADMINISTRATIVE REQUIREMENTS

- A. COORDINATION
 - 1. Coordinate layout and installation of ducts, manholes, handholes, and boxes with final arrangement of other utilities, site grading, and surface features as determined in the field.
 - 2. Coordinate elevations of ducts and duct-bank entrances into manholes, handholes, and boxes with final locations and profiles of ducts and duct banks as determined by coordination with other utilities, underground obstructions, and surface features. Revise locations and elevations from those indicated as required to suit field conditions and to ensure that duct runs drain to manholes and handholes, and as approved by ENGINEER.

1.4 SUBMITTALS

- A. Refer to Section 26 00 00 - Electrical General Provisions.

1.5 QUALITY ASSURANCE

- A. Refer to Section 26 00 00 - Electrical General Provisions.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Refer to Section 26 00 00 - Electrical General Provisions.

1.7 SITE CONDITIONS

- A. Refer to Section 26 00 00 - Electrical General Provisions.

1.8 WARRANTY

- A. Refer to Section 26 00 00 - Electrical General Provisions.

PART 2 - PRODUCTS

2.1 PVC COATED ALUMINUM CONDUIT

- A. Subject to compliance with requirements, manufacturers offering products that offer PVC Coated Aluminum Conduit ETL-PVC-001.
 - B. PVC Coated Aluminum conduit:
 - 1. All PVC coated Aluminum conduit shall be ETL-PVC-001 Certified.
 - 2. Shall be ANSI C80.1 aluminum conduit with an external 0.040" minimum PVC protective coating per NEMA Standard RN1. Both ends of conduit shall be threaded and thread protectors shall be factory-installed. Fittings shall be threaded type ANSI C80.4, hot-dipped galvanized with a 0.055" minimum PVC coating to match the conduit.
 - C. Fittings for Conduit (Including all Types and Flexible and Liquidtight), and Cable: NEMA FB 1; listed for type and size raceway with which used, and for application and environment in which installed.
 - 1. Coating for Fittings for PVC-Coated Conduit: Minimum thickness of 0.040 inch with overlapping sleeves protecting threaded joints.
- 2.2 PVC CONDUIT
- A. RNC: Conforming to NEMA TC 2, Type EPC-40-PVC, UL 651, with matching fittings by same manufacturer as the conduit, complying with NEMA TC 3 and UL 514B.
- 2.3 NONMETALLIC DUCTS AND DUCT ACCESSORIES
- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. ARNCO Corp.
 - 2. Beck Manufacturing.
 - 3. Cantex, Inc.
 - 4. CertainTeed Corp.; Pipe & Plastics Group.
 - 5. Condux International, Inc.
 - 6. ElecSys, Inc.
 - 7. Electri-Flex Company.
 - 8. IPEX Inc.
 - 9. Lamson & Sessions; Carlon Electrical Products.
 - 10. Manhattan/CDT; a division of Cable Design Technologies.
 - 11. Spiraduct/AFC Cable Systems, Inc.
 - B. Duct Accessories:
 - 1. Duct Separators: Factory-fabricated rigid PVC interlocking spacers, sized for type and sizes of ducts with which used, and selected to provide minimum duct spacing indicated while supporting ducts during concreting or backfilling.
- 2.4 DETECTABLE WARNING TAPE
- A. Description: Acid- and alkali-resistant polyethylene film warning tape manufactured for marking and identifying underground utilities, a minimum of 6 inches wide and 4 mils thick,

continuously inscribed with a description of the utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 30 inches deep. Tape shall be red in color for electrical, orange in color for communication. Printed legend shall indicate type of underground line

2.5 PRECAST MANHOLES

- A. Available Manufacturers: Available Manufacturers: Any Manufacturer whose product complies with specification will be acceptable.
- B. Comply with ASTM C 858, with AASHTO H-17, H-20 structural design load rating, and with interlocking mating sections, complete with accessories, hardware, and features.
 - 1. Windows: Precast openings in walls, arranged to match dimensions and elevations of approaching ducts and duct banks plus an additional 12 inches vertically and horizontally to accommodate alignment variations.
 - a. Windows shall be located no less than 6 inches from interior surfaces of walls, floors, or roofs of manholes, but close enough to corners to facilitate racking of cables on walls.
 - b. Window opening shall have cast-in-place, welded wire fabric reinforcement for field cutting and bending to tie in to concrete envelopes of duct banks.
 - c. Window openings shall be framed with at least two additional No. 4 steel reinforcing bars in concrete around each opening.
- C. Concrete Knockout Panels: 1-1/2 to 2 inches thick for future conduit entrance and sleeve for ground rod.
- D. Joint Sealant: Asphaltic-butyl material with adhesion, cohesion, flexibility, and durability properties necessary to withstand maximum hydrostatic pressures at the installation location with the ground-water level at grade.

2.6 UTILITY STRUCTURE ACCESSORIES

- A. Available Manufacturers: Available Manufacturers: Any Manufacturer whose product complies with specification will be acceptable.
- B. Manhole Access Covers, and Chimney Components: Comply with structural design loading specified for manhole.
- C. Access Covers:
 - a. Designed for incidental H-20 Wheel Loading
 - b. Diamond Plate Surface, labeled "Electric"
 - c. Torsion Bar Assist opening with safety latch to prevent accidental closing.
 - d. Size 36x36 inches
 - e. Weatherproof steel frame, with steel cover with recessed cover hook eyes and tamper-resistant, captive, cover-securing bolts.
 - f. Similar to Jensen Precast CAA-3636
 - g. Configuration: Imbedded into top ring cover
- 2. Manhole Chimney Components: Precast concrete rings with dimensions matched to those of the manhole.

- D. Manhole Sump Frame and Grate: ASTM A 48/A 48M, Class 30B, gray cast iron.
- E. Pulling Eyes in Concrete Walls: Eyebolt with reinforcing-bar fastening insert, 2-inch diameter eye, and 1x4-inch bolt.
 - 1. Working Load Embedded in 6-Inch, 4,000-psi Concrete: 13,000 lb ft minimum tension.
- F. Pulling-In and Lifting Irons in Concrete Floors: 7/8-inch diameter, hot-dip galvanized, bent steel rod; stress relieved after forming; and fastened to reinforcing rod. Exposed triangular opening.
 - 1. Ultimate Yield Strength: 40,000 lb ft shear and 60,000 lb ft tension.
- G. Bolting Inserts for Concrete Utility Structure Cable Racks and Other Attachments: Flared, threaded inserts of noncorrosive, chemical-resistant, nonconductive thermoplastic material; 1/2x2-3/4 inches deep, flared to 1-1/4 inches minimum at base.
 - 1. Tested Ultimate Pullout Strength: 12,000 lb ft minimum.
- H. Expansion Anchors for Installation after Concrete Is Cast: Zinc-plated, carbon-steel-wedge type with stainless-steel expander clip with 1/2-inch bolt, 5,300 lb ft rated pullout strength, and minimum 6,800-lb ft rated shear strength.
- I. Cable Rack Assembly: Nonmetallic. Components fabricated from nonconductive, fiberglass-reinforced polymer.
 - 1. Stanchions: Nominal 36 inches high x4 inches wide, with a minimum of 9 holes for arm attachment.
 - 2. Arms: Arranged for secure, drop-in attachment in horizontal position at any location on cable stanchions, and capable of being locked in position. Arms shall be available in lengths ranging from 3 inches with 450 lb. minimum capacity to 20 inches with 250 lb. minimum capacity. Top of arm shall be nominally 4 inches wide, and arm shall have slots along full length for cable ties.
- J. Duct-Sealing Compound: Nonhardening, safe for contact with human skin, not deleterious to cable insulation, and workable at temperatures as low as 35°F. Capable of withstanding temperature of 300°F without slump and adhering to clean surfaces of plastic ducts, metallic conduits, conduit coatings, concrete, masonry, lead, cable sheaths, cable jackets, insulation materials, and common metals.
- K. Fixed Manhole Ladders: Arranged for attachment to roof of manhole. Ladder and mounting brackets and braces shall be fabricated from nonconductive, structural-grade, fiberglass-reinforced resin.
- L. Cover Hooks: Heavy duty, designed for lifts 60 lb ft and greater. Two required.

2.7 UNDERGROUND DUCTS STEEL REINFORCEMENT

- A. Reinforcing Bars: ASTM A 615, Grade 60, deformed.
- B. Plain-Steel Wire: ASTM A 82, as drawn.
- C. Plain-Steel Welded Wire Reinforcement: ASTM A 185, fabricated from as-drawn steel wire into flat sheets.
- D. Deformed-Steel Welded Wire Reinforcement: ASTM A 497, flat sheet.

2.8 UNDERGROUND DUCTS CONCRETE

A. Materials

1. Cementitious Material: Use the following cementitious materials, of the same type, brand, and source throughout Project:
2. Portland Cement: ASTM C 150, Type II or Type 1/II. Supplement with the following:
 - a. Fly Ash: ASTM C 618, Class C. Fly ash may be used for replacement of up to 15% of cement content by weight except for paving concrete.
3. Normal-Weight Aggregate: ASTM C 33, graded, 1 inch nominal maximum aggregate size.
4. Water: ASTM C 94; potable.

B. Concrete Mixtures

1. Comply with ACI 301 requirements for concrete mixtures.
2. Provide concrete with the following mix design to result in concrete placed in the field of minimum compressive strength of 3,000 psi at 28 days based on test cylinders which are taken during concrete placement.

Unit	Measurement
Minimum Compressive Strength (7 day)	2,250 psi
Minimum Compressive Strength (28 day)	3,000 psi
Coarse Aggregate	ASTM C33, No. 467
Fine Aggregate	ASTM C33
Water/Cementious Ratio (max.)	0.50 by weight
Air Entrainment	4-6 percent
Slump with Superplasticizer	7 inches to 9 inches
Slump without Superplasticizer	3 inches $\pm$ 1 inch
Minimum Cementious Content	470 pounds per cubic yard

C. Additive

1. Red ferrous oxide concrete coloring pigment mixed at the rate of 1-1/2 lb. per sack of cement for electrical conduit.

2.9 GROUNDING

- A. Bare Copper Conductors: Shall be tinned, stranded Conductors complying with ASTM B 8 and Tinned Conductors: ASTM B 33.
- B. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions. Listed and labeled by a nationally recognized testing laboratory acceptable to authorities having jurisdiction for applications in which used, and for specific types, sizes, and combinations of conductors and other items connected.
- C. Ground Rods: Copper-clad steel; 3/4 inch by 10 feet in length.

2.10 SOURCE QUALITY CONTROL

- A. Test and inspect precast concrete utility structures according to ASTM C 1037.
 1. Strength tests of complete boxes and covers shall be by either an independent testing agency or the manufacturer. A qualified registered professional engineer shall certify tests by manufacturer.

2. Testing machine pressure gages shall have current calibration certification complying with ISO 9000 and ISO 10012, and traceable to NIST standards.

PART 3 - EXECUTION

3.1 UNDERGROUND DUCT APPLICATION

- A. Ducts shall be RNC, NEMA Type EPC-40-PVC, in reinforced, concrete-encased duct bank, unless otherwise indicated.

3.2 EARTHWORK

- A. Excavation
 1. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by excavation for trenches.
 2. During inclement weather and where site conditions warrant, take precautions to prevent surface-water run-off from entering the excavation. Remove and dispose of water entering trench, as necessary grade trench bottom and compact subgrade. Do not place bedding, lay pipe, conduits, cables, or duct banks in water. Provide continuous control of water until trench backfill is complete.
 3. Excavate to lines, grades, depths, and dimensions shown and as necessary to accomplish Work. Allow for excavation support and protection materials, working space, bedding course, topsoil, and related materials.
 4. Excavate trenches to uniform widths to provide required clearance of each side of conduit. Trench walls shall be vertical to elevation equal to 12 inches above top of conduits or duct banks.
 5. Proceed with caution in areas of existing utilities exposing them by hand excavation or other means acceptable to utility owner. Protect, support, and maintain existing utilities.
 6. Avoid disturbing soil within branch spread of trees designated for protection. If it is necessary to excavate through roots, perform work by hand and cut roots with a sharp axe.
- B. Preparation of Trench Bottom
 1. Subgrade: Grade with hand tools, remove loose and disturbed materials, and trim off high areas left by excavating bucket teeth. Allow space for bedding material as required.
 2. Soft Subgrade: Remove any soft subgrade, replacing with trench stabilizing material.

3.3 DUCT INSTALLATION

- A. Slope: Pitch ducts a minimum slope of 1:300 down toward manholes and handholes and away from buildings and equipment. Slope ducts from a high point in runs between two manholes to drain in both directions.
- B. Curves and Bends: Use 5 degree angle couplings for small changes in direction. Use manufactured long sweep bends, both horizontally and vertically, at other locations, unless otherwise indicated.

- C. Joints: Use solvent-cemented joints in ducts and fittings and make watertight according to manufacturer's written instructions. Stagger couplings so those of adjacent ducts do not lie in same plane.
- D. Duct Entrances to Manholes and Concrete Handholes: Use end bells, spaced approximately 10 inches on center for 5-inch ducts, and vary proportionately for other duct sizes.
 - 1. Begin change from regular spacing to end-bell spacing 10 feet from the end bell without reducing duct line slope and without forming a trap in the line.
 - 2. Grout end bells into structure walls from both sides to provide watertight entrances.
 - 3. Tie duct bank reinforcing steel into dowels at manhole walls.
- E. Wall Penetrations: Make a transition from underground duct to PVC coated-aluminum conduit at least 10 feet outside the wall without reducing duct line slope away from the building, and without forming a trap in the line. Use fittings manufactured for duct-to-conduit transition. Install conduit penetrations of walls in accordance with Division 26 Section 26 05 33 - Raceway and Boxes for Electrical Systems.
- F. Sealing: Provide temporary closure at terminations of ducts that have cables pulled. Seal spare ducts at terminations. Use sealing compound and plugs to withstand at least 15 psig hydrostatic pressure.
- G. Pulling Cord: Install 100 lb ft test nylon cord in ducts, including spares.
- H. Concrete-Encased Ducts: Support ducts on duct separators.
 - 1. Separator Installation: Space separators close enough to prevent sagging and deforming of ducts, with not less than 4 spacers per 20 feet of duct. Secure separators to earth and to ducts to prevent floating during concreting. Stagger separators approximately 6 inches between tiers. Tie entire assembly together using fabric straps; do not use tie wires or reinforcing steel that may form conductive or magnetic loops around ducts or duct groups.
 - 2. Concreting Sequence: Pour each run of envelope between manholes or other terminations in one continuous operation.
 - a. Start at one end and finish at the other, allowing for expansion and contraction of ducts as their temperature changes during and after the pour. Use expansion fittings installed according to manufacturer's written recommendations or use other specific measures to prevent expansion-contraction damage.
 - 3. Pouring Concrete: Spade concrete carefully during pours to prevent voids under and between conduits and at exterior surface of envelope. Do not allow a heavy mass of concrete to fall directly onto ducts. Use a plank to direct concrete down sides of bank assembly to trench bottom. Allow concrete to flow to center of bank and rise up in middle, uniformly filling all open spaces. Do not use power-driven agitating equipment unless specifically designed for duct-bank application.
 - 4. Reinforcement: Reinforce concrete-encased duct banks as shown on Drawings.
 - 5. Forms: Use walls of trench to form sidewalls of duct bank where soil is self-supporting and concrete envelope can be poured without soil inclusions; otherwise, use forms.
 - 6. Minimum Space between Ducts: 3 inches between ducts and exterior envelope wall, 2 inches between ducts for like services, and 6 inches between power and signal ducts.

7. Depth: Install top of duct bank at least 24 inches below finished grade in areas not subject to deliberate traffic and at least 30 inches below finished grade in deliberate traffic paths for vehicles unless otherwise indicated.
 8. Stub-Ups: Use PVC coated-Aluminum conduit elbows for stub-ups at poles and equipment and at building entrances through the floor.
 - a. Couple PVC coated- Aluminum conduits to ducts with adapters designed for this purpose and encase coupling with 3 inches of concrete.
 - b. Stub-Ups to Equipment: For equipment mounted on outdoor concrete bases, extend PVC coated- Aluminum conduit horizontally a minimum of 60 inches from edge of base. Install insulated grounding bushings on terminations at equipment.
- I. Underground-Line Warning Tape
1. During backfilling of trenches install continuous underground-line warning tape directly above line at 6 to 8 inches below finished grade. Use multiple tapes where width of multiple lines installed in a common trench or concrete envelope exceeds 16 inches overall.

3.4 BACKFILL

- A. General:
1. Process excavated material to meet specified soil fill requirements. Adjust moisture as necessary to obtain specified compaction. Place and compact backfill in 8-inch loose lifts.
 2. Do not allow backfill to free-fall into the trench or allow heavy, sharps pieces of material to be placed as backfill until after 2 feet of backfill has been placed.
 3. Do not use power-driven impact type compactors until at least 4 feet of backfill is place over top of pipe.
 4. Backfill to grade with allowances for topsoil, crushed rock surfacing, pavements, or other work.
 5. Settling backfill by jetting or flooding will only be permitted as shown on the Drawings or when approved by Engineer in writing. Trenches improperly backfilled and compacted, or where settlement occurs, shall be excavated to depth required, backfilled, compacted, and surface restored to required grade.
- B. Density Control
1. Areas Subjected to or Influenced by Vehicular Traffic. Unless otherwise indicated on the Drawings, compact backfill to a minimum 100% of maximum density as determined in accordance with ASTM D698, with required moisture content within minus 2 to plus 4 of optimum.
 2. Areas Not Subjected to or Influenced by Vehicular Traffic. Unless otherwise indicated on the Drawings, compact backfill to a minimum 95% of maximum density as determined in accordance with ASTM D698, with required moisture content within minus 2 to plus 4 of optimum.

3.5 UNDERGROUND CONDUIT MARKERS

- A. Mark underground duct banks 24x24x4 inch concrete marker with etched lettering and

arrows indicating the duct bank route.

- B. Install markers at point of origin, at point of termination, at bends, and at 100-foot intervals, even if not shown on plans.

3.6 INSTALLATION OF CONCRETE MANHOLES, HANDHOLES, AND BOXES

- A. Elevations:
 - 1. Manhole Roof: Install with rooftop at least 6 inches above finished grade. In paved areas and trafficways, set manhole roofs 1 inch above finished. Set other manhole frames 1 inch above finished grade.
- B. Drainage: Install drains in bottom of manholes where indicated. Coordinate with drainage provisions indicated.
- C. Hardware: Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators as required for installation; and support of cables and conductors and as indicated.
- D. Fixed Manhole Ladders: Arrange to provide for safe entry with maximum clearance from cables and other items in manholes.
- E. Field-Installed Bolting Anchors in Manholes and Concrete Handholes: Do not drill deeper than 3-7/8 inches for manholes and 2 inches for handholes, for anchor bolts installed in the field. Use a minimum of two anchors for each cable stanchion.
- F. Warning Sign: Install "Confined Space Hazard" warning sign on the inside surface of each manhole cover.

3.7 GROUNDING

- A. Conductors: Install solid conductor for No. 8 AWG and smaller, and stranded conductors for No. 6 AWG and larger, unless otherwise indicated.
- B. Underground Grounding Conductors: Install bare tinned-copper conductor, No. 4/0 AWG minimum. Bury 12 inches above duct bank when indicated as part of duct-bank installation.
- C. Isolated Grounding Conductors: Green-colored insulation with continuous yellow stripe. On feeders with isolated ground, identify grounding conductor where visible to normal inspection, with alternating bands of green and yellow tape, with at least three bands of green and two bands of yellow.
- D. Grounding Underground Distribution System Components
 - 1. Comply with IEEE C2 grounding requirements.
 - 2. Grounding Manholes and Handholes: Install a driven ground rod through manhole or handhole floor, close to wall, and set rod depth so 4 inches will extend above finished floor. If necessary, install ground rod before manhole is placed and provide No. 4/0 AWG bare, tinned-copper conductor from ground rod into manhole through a waterproof sleeve in manhole wall. Protect ground rods passing through concrete floor with a double wrapping of pressure-sensitive insulating tape or heat-shrunk insulating sleeve from 2 inches above to 6 inches below concrete. Seal floor opening with waterproof, nonshrink grout.
 - 3. Grounding Connections to Manhole Components: Bond exposed-metal parts such as

inserts, cable racks, pulling irons, ladders, and cable shields within each manhole or handhole, to ground rod or grounding conductor. Make connections with No. 4 AWG minimum, stranded, hard-drawn copper bonding conductor. Train conductors' level or plumb around corners and fasten to manhole walls. Connect to cable armor and cable shields as recommended by manufacturer of splicing and termination kits.

E. INSTALLATION

1. Grounding Conductors: Route along shortest and straightest paths possible, unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.
2. Ground Rods: Drive rods until tops are 2 inches below finished floor or final grade, unless otherwise indicated.
3. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating, if any.

3.8 FIELD QUALITY CONTROL

A. Perform the following tests and inspections and prepare test reports:

1. Demonstrate capability and compliance with requirements on completion of installation of underground ducts and utility structures.
2. Pull aluminum or wood test mandrel through duct to prove joint integrity and test for out-of-round duct. Provide mandrel equal to 80% fill of duct. If obstructions are indicated, remove obstructions and retest.
3. Test manhole and handhole grounding to ensure electrical continuity of grounding and bonding connections

B. Correct deficiencies and retest as specified above to demonstrate compliance.

3.9 CLEANING

- A. Pull leather-washer-type duct cleaner, with graduated washer sizes, through full length of ducts. Follow with rubber duct swab for final cleaning and to assist in spreading lubricant throughout ducts.
- B. Clean internal surfaces of manholes, including sump. Remove foreign material.

END OF SECTION

SECTION 26 05 53
IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes the following:
- B. Identification for raceway.
- C. Identification for conductors and communication and control cable.
- D. Warning labels and signs.
- E. Instruction signs.
- F. Equipment identification labels.
- G. Miscellaneous identification products.

1.2 REFERENCES - NOT USED

1.3 ADMINISTRATIVE REQUIREMENTS

A. COORDINATION

- 1. Coordinate identification names, abbreviations, colors, and other features with requirements in the Contract Documents, Shop Drawings, Manufacturer's wiring diagrams, and the Operation and Maintenance Manual, and with those required by codes, standards, and 29 CFR 1910.145. Use consistent designations throughout Project.
- 2. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.
- 3. Coordinate installation of identifying devices with location of access panels and doors.
- 4. Install identifying devices before installing acoustical ceilings and similar concealment.

1.4 SUBMITTALS

- A. Refer to Section 26 00 00 - Electrical General Provisions.

1.5 QUALITY ASSURANCE

- A. Refer to Section 26 00 00 - Electrical General Provisions.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Refer to Section 26 00 00 - Electrical General Provisions.

1.7 SITE CONDITIONS

- A. Refer to Section 26 00 00 - Electrical General Provisions.

1.8 WARRANTY

- A. Refer to Section 26 00 00 - Electrical General Provisions.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Nameplates:

1. Provide a nameplate for each piece of mechanical equipment, process equipment, valve, pump, mixer, feeder, fan, air-handling unit, motor, switch, receptacle, controller, instrument transducer, instrument power supply, solenoid, motor control center, starter, panelboard, switchboard, individually mounted or plug-in type circuit protector or motor controller, disconnect switch, bus duct tap switch, time switch, relay and for any other control device or major item of electrical equipment, either located in the field or within panels.
2. Provide all nameplates of identical style, color, and material throughout the facility.
3. Device nameplates information:
 - a. Designations as indicated on the Drawings and identified on the Process and Instrumentation Drawings.
 - b. Device tag and loop number ID (#) (e.g. EDV-#).
 - c. Circuit ID (e.g. LPA-11).
 - d. Area served (e.g. Lighting Chemical Building).

B. Wire numbers:

1. Coordinate the wire numbering system with all vendors of equipment so that every field wire has a unique number associated with it for the entire system:
 - a. Wire numbers shall correspond to the wire numbers on the control drawings or the panel and circuit numbers for receptacles and lighting.
 - b. Wire numbers shall correspond to the terminal block number to which they are attached in the control panel.
 - c. Internal panel wires on a common terminal shall have the same wire number.
2. Provide the following wiring numbering schemes throughout the project for field wires between programmable logic controllers, (PLC), vendor control panels, (CP), motor control centers, (MCC), field starters, field instruments, etc.
 - a. Where:
 - 1) ORIGIN LOC. = Designation for originating panel or device
 - 2) ORIGIN TERM. = Terminal designation at originating panel or device
 - 3) DEST. LOC. = Designation for destination panel or device
 - 4) DEST. TERM. = Terminal designation at destination panel or device or PLC I/O address at destination panel
 - b. Identify equipment and field instruments as the origin.
 - c. PLCs are always identified as the destination.
 - d. Location is the panel designation for CP, LCP, or PLC. For connections to MCCs, location is the specific starter tag and loop number. Location is the tag and loop number for motor starters, field instruments, and equipment. Any hyphen in the panel designation or tag and loop number shall be omitted.
 - e. Terminal designation is the actual number on the terminal block where the

- conductor terminates at field devices and vendor control panels. For multi-conductor cables, all terminal numbers shall be shown, separated by commas.
- f. Terminal designations at motor leads shall be the motor manufacturer's standard terminal designation (e.g. T1, T2, T3, etc.).
 - g. Terminal designations at PLCs where the field conductor connects to field terminal blocks for a PLC input or output shall be the PLC address (Note: the following PLC I/O numbering scheme is typical for Allen-Bradley, the numbering scheme should be modified to match that of the actual PLC manufacturer used for the project):
 - 1) Discrete Point: W:X:Y/Z or Analog Point: W:X:Y.Z
 - a) Where:
 - i. W = I for input, O for output
 - ii. X = PLC number (1, 2, 3...)
 - iii. Y = Slot number (01, 02, 03...)
 - iv. Z = Terminal number (00, 01, 02...) for a discrete point or a word number for an analog point (1, 2, 3...)
 - h. Terminal designations at PLCs where the conductor does not connect to a PLC input point or output point shall be the terminal number with a "C" prefix (e.g. C0010). For common power after a fuse or neutrals after a switch, the subsequent points shall have and capital letter suffix starting with "A" (e.g. C0010A).
 3. Case 1: Vendor control panel (CP) to Programmable Logic Controller (PLC):
 - a. Field wire number/label: A-B/C-D
 - 1) A = Vendor control panel number without hyphen (CP#)
 - 2) B = Terminal number within CP (manufacturer's or vendor's standard terminal number)
 - 3) C = Programmable Logic Controller number without hyphen (PLC#)
 - 4) D = Either the PLC address if the field terminal is connected directly to a PLC input or output point or the terminal number with a "C" prefix if not connected directly to a PLC I/O point (C0010)
 - 5) Examples:
 - a) CP#-10/PLC#-I:1:01/01
 - b) CP#-10/PLC#-O:1:10/07
 - c) CP#-10/PLC#-C0100
 4. Case 2: Field instrument to Programmable Logic Controller (PLC):
 - a. Field wire number/label: E-F/C-D
 - 1) C = Programmable Logic Controller number without hyphen (PLC#)
 - 2) D = Either the PLC address if the field terminal is connected directly to a PLC
 - 3) Input or Output point or the terminal number with a "C" prefix if not connected directly to a PLC I/O point (C0010)
 - 4) E = Field mounted instrument tag and loop numbers without hyphen

- (EDV#)
- 5) F = Manufacturer's standard terminal number within instrument. Use both terminal numbers for analog points separated by a comma
 - 6) Examples:
 - a) TIT#-2,3/PLC#-I:1:01.1
 - b) TSH#-1/PLC#-I:2:01/00
5. Case 3: Motor control center (MCC) to Programmable Logic Controller (PLC):
- a. Field wire number/label: G-B/C-D
 - 1) B = Terminal number within Motor Control Center (manufacturer's or vendor's standard terminal number)
 - 2) C = Programmable Logic Controller without hyphen (PLC#)
 - 3) D = Either the PLC address if the field terminal is connected directly to a PLC input or output point or the terminal number with a "C" prefix if not connected directly to a PLC I/O point (C0010)
 - 4) G = Actual starter designation in the motor control center without hyphen (MMS#)
 - 5) Examples:
 - a) MMS#-10/PLC#-I:1:01/01
 - b) MMS#-10/PLC#-O:1:10/07
 - c) MMS#-10/PLC#-C0100
6. Case 4: Motor control center (MCC) to vendor control panel (CP):
- a. Field wire number/label: G-B/A-B
 - b. A = Vendor control panel number without hyphen (CP#)
 - c. B = Terminal number within motor control center or vendor control panel
 - d. (manufacturer's or vendors standard terminal number)
 - e. G = Actual starter designation in the motor control center without hyphen (MMS#)
 - f. Example:
 - 1) MMS#-X2/CP#-10
7. Case 5: Motor leads to a motor control center (MCC):
- a. Field wire number/label: H-I/G-B
 - b. B = Terminal number within motor control center (manufacturer's standard terminal number)
 - c. G = Actual starter designation in the motor control center without hyphen (MMS#)
 - d. H = Equipment tag and loop number without hyphen (PMP#)
 - e. I = Motor manufacturer's standard motor lead identification (e.g. T1, T2, T3, etc.)
 - f. Example:
 - 1) PMP#-T3/MMS#-T3
8. Case 6: Remote or separately mounted starter or variable frequency drive (VFD) to

Programmable Logic Controller (PLC):

- a. Field wire number/label: J-B/C-D
 - b. B = Terminal number within starter or variable frequency drive
 - c. (manufacturer's standard terminal number)
 - d. C = Programmable Logic Controller number without hyphen (CP#)
 - e. D = Either the PLC address if the field terminal is connected directly to a PLC input or output point or the terminal number with a "C" prefix if not connected directly to a PLC I/O point (C0010)
 - f. J = Starter or variable frequency drive tag and loop number without hyphen (MMS#)
 - g. Examples:
 - 1) MMS#-10/PLC#-I:1:01/01
 - 2) MMS#-10/PLC#-O:2:10/07
 - 3) MMS#-10/PLC#-C0010
9. Identify all spare conductors as required for other field wires with an "S" prefix:
Example: S MMS#-10/PLC#-C011

2.2 RACEWAY IDENTIFICATION MATERIALS

- A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway and cable size.
- B. Color for Printed Legend:
 - 1. Power Circuits: Black letters on an orange field.
 - 2. Legend: Indicate system or service and voltage, if applicable.
- C. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.
- D. Snap-Around Labels: Slit, pretension, flexible, preprinted, color-coded acrylic sleeves, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.
- E. Snap-Around, Color-Coding Bands: Slit, pretension, flexible, solid-colored acrylic sleeves, 2 inches long, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.
- F. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; 2 inches wide; compounded for outdoor use.

2.3 CONDUCTOR AND COMMUNICATION- AND CONTROL-CABLE IDENTIFICATION MATERIALS

- A. All markings to labels, schedules, tags on nameplates shall be machine printed only. Hand printing is prohibited. Circuits shall be tagged at terminations (both ends), in pull boxes, cabinets and enclosures as follows;
 - 1. Tags relying on adhesives or taps-on markers are not acceptable.
 - 2. Hand written tags are not acceptable.
 - 3. Provide conductor tags for conductors No. 10 AWG and below with legible permanent

sleeve of yellow or white PVC with machine printed black marking, Raychem TMS sleeves or approved equal.

4. Provide tags for cables and for conductors No. 8 AWG and larger consisting of permanent nylon marker plates with legible designations hat tamped on the plate. Attach these marker plates to conductors and calves with stainless steel wire wraps. Tags shall be Raychem TMS-CM cable markers or approved equal.
 5. Tags shall be imprinted with panelboard and panelboard position number (e.g. LA3-23) for conductors fed from panelboards. Other conductors shall have tags imprinted with the MCC which feeds the conductors (e.g. MCC 1).
 6. Switch-legs shall the designation descried above their tags, plus an "S" suffix. Travelers shall have the designation described able on their taps, plus a "T" suffix.
 7. Where more than one neutral is present with a group of conductors, a tag shall be applied to each neutral indicating which phase conductors are served by each neutral (e.g. HA-2, 4, 6).
- B. Color-Coding Conductor Tape: Colored, self-adhesive vinyl tape not less than 3 mils thick by 1-2 inches wide.

2.4 WARNING LABELS AND SIGNS

- A. Comply with NFPA 70 and 29 CFR 1910.145.
- B. Self-Adhesive Warning Labels: Factory printed, multicolor, pressure-sensitive adhesive labels, configured for display on front cover, door, or other access to equipment, unless otherwise indicated.
- C. Baked-Enamel Warning Signs: Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for application. 1/4-inch grommets in corners for mounting. Nominal size, 7x10 inches.
- D. Metal-Backed, Butyrate Warning Signs: Weather-resistant, non-fading, preprinted, cellulose-acetate butyrate signs with 0.0396-inch galvanized-steel backing; and with colors, legend, and size required for application. 1/4-inch grommets in corners for mounting. Nominal size, 10x14 inches.
- E. Warning label and sign shall include, but are not limited to, the following legends:
 1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."
 2. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES."

2.5 INSTRUCTION SIGNS

- A. Engraved, laminated acrylic or melamine plastic, minimum 1/16-inch thick for signs up to 20 square inches and 1/8-inch thick for larger sizes.
 1. Engraved legend with Insert colors.
 2. Punched or drilled for mechanical fasteners.
 3. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

2.6 EQUIPMENT IDENTIFICATION LABELS

- A. Engraved, Laminated Acrylic or Melamine Label: Punched or drilled for screw mounting. White letters on a dark-gray background. Minimum letter height shall be 3/8 inch.
- B. Stenciled Legend: In non-fading, waterproof, black ink or paint. Minimum letter height shall be 1 inch.

2.7 MISCELLANEOUS IDENTIFICATION PRODUCTS

- A. Cable Ties: Fungus-inert, self-extinguishing, 1-piece, self-locking, Type 6/6 nylon cable ties.
 - 1. Minimum Width: 3/16 inch.
 - 2. Tensile Strength: 50 lb., minimum.
 - 3. Temperature Range: Minus 40 to plus 185°F.
 - 4. Color: Black, except where used for color-coding.
- B. Paint: Paint materials and application requirements are specified in Division 9 painting Sections.
- C. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

2.8 UNDERGROUND-LINE WARNING TAPE

- A. Tape:
 - 1. Acid- and alkali-resistant polyethylene film warning tape manufactured for marking and identifying underground utilities, a minimum of 6 inches wide and 4 mils thick, continuously inscribed with a description of the utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 30 inches deep. Tape shall be red in color for electrical, orange in color for communication. Printed legend shall indicate type of underground line
- B. Color and Printing:
 - 1. Comply with ANSI Z535.1 through ANSI Z535.5.
 - 2. Inscriptions for Red-Colored Tapes: "ELECTRIC LINES"

PART 3 - EXECUTION

3.1 APPLICATION

- A. Raceways and Duct Banks More Than 600 V Concealed within Buildings: 4-inch wide black stripes on 10-inch centers over orange background that extends full length of raceway or duct and is 12 inches wide. Stencil legend "DANGER CONCEALED HIGH VOLTAGE WIRING" with 3-inch high black letters on 20-inch centers. Stop stripes at legends. Apply to the following finished surfaces:
 - 1. Floor surface directly above conduits running beneath and within 12 inches of a floor that is in contact with earth or is framed above unexcavated space.
 - 2. Wall surfaces directly external to raceways concealed within wall.
 - 3. Accessible surfaces of concrete envelope around raceways in vertical shafts, exposed in the building, or concealed above suspended ceilings.
- B. Accessible Raceways and Metal-Clad Cables More Than 600 V: Identify with "DANGER-HIGH

- VOLTAGE" in black letters at least 2 inches high, with self-adhesive vinyl labels. Repeat legend at 10-foot maximum intervals.
- C. Accessible Raceways and Metal-Clad Cables, 600 V or Less, for Service, Feeder, and Branch Circuits: Identify with orange self-adhesive vinyl label.
 - D. Power-Circuit Conductor Identification: For primary and secondary conductors No. 1/0 AWG and larger in vaults, pull and junction boxes, manholes, and handholes use metal tags. Identify source and circuit number of each set of conductors. For single conductor cables, identify phase in addition to the above.
 - E. Branch-Circuit Conductor Identification: Where there are conductors for more than three branch circuits in same junction or pull box, use metal tags. Identify each ungrounded conductor according to source and circuit number.
 - F. Conductors to Be Extended in the Future: Attach write-on tags to conductors and list source and circuit number.
 - G. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, signal, sound, intercommunications, voice, and data connections.
 - 1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.
 - 2. Use system of marker tape designations that is uniform and consistent with system used by manufacturer for factory-installed connections.
 - 3. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and Operation and Maintenance Manual.
 - H. Locations of Underground Lines: Identify with underground-line warning tape for power, lighting, communication, and control wiring and optical fiber cable.
 - I. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Comply with 29 CFR 1910.145 and apply baked-enamel warning signs. Identify system voltage with black letters on an orange background. Apply to exterior of door, cover, or other access.
 - 1. Equipment with Multiple Power or Control Sources: Apply to door or cover of equipment including, but not limited to, the following:
 - a. Power transfer switches.
 - b. Controls with external control power connections.
 - 2. Equipment Requiring Workspace Clearance According to NFPA 70: Unless otherwise indicated, apply to door or cover of equipment but not on flush panelboards and similar equipment in finished spaces.
 - J. Instruction Signs:
 - 1. Operating Instructions: Install instruction signs to facilitate proper operation and maintenance of electrical systems and items to which they connect. Install instruction signs with approved legend where instructions are needed for system or equipment operation.
 - 2. Emergency Operating Instructions: Install instruction signs with white legend on a red background with minimum 3/8-inch high letters for emergency instructions at equipment used for power transfer.
 - K. Equipment Identification Labels: On each unit of equipment, install unique designation label

that is consistent with wiring diagrams, schedules, and Operation and Maintenance Manual. Apply labels to disconnect switches and protection equipment, central or master units, control panels, control stations, terminal cabinets, and racks of each system. Systems include power, lighting, control, communication, signal, monitoring, and alarm systems unless equipment is provided with its own identification.

L. Labeling Instructions:

1. Indoor Equipment: Engraved, laminated acrylic or melamine label. Unless otherwise indicated, provide a single line of text with 1/2-inch high letters on 1-1/2-inch high label; where 2 lines of text are required, use labels 2 inches high.
2. Outdoor Equipment: Stenciled legend 4 inches high.
3. Elevated Components: Increase sizes of labels and letters to those appropriate for viewing from the floor.
4. Equipment to Be Labeled:
 - a. Panelboards, electrical cabinets, and enclosures.
 - b. Access doors and panels for concealed electrical items.
 - c. Electrical switchgear and switchboards.
 - d. Transformers.
 - e. Electrical substations.
 - f. Emergency system boxes and enclosures.
 - g. Motor-control centers.
 - h. Disconnect switches.
 - i. Enclosed circuit breakers.
 - j. Motor starters.
 - k. Push-button stations.
 - l. Power transfer equipment.
 - m. Contactors.
 - n. Remote-controlled switches, dimmer modules, and control devices.
 - o. Battery inverter units.
 - p. Battery racks.
 - q. Power-generating units.
 - r. Voice and data cable terminal equipment.
 - s. Master clock and program equipment.
 - t. Intercommunication and call system master and staff stations.
 - u. Television/audio components, racks, and controls.
 - v. Fire-alarm control panel and annunciator.
 - w. Security and intrusion-detection control stations, control panels, terminal cabinets, and racks.
 - x. Monitoring and control equipment.
 - y. Uninterruptible power supply equipment.
 - z. Terminals, racks, and patch panels for voice and data communication and for signal and control functions.

3.2 INSTALLATION

- A. Verify identity of each item before installing identification products.
- B. Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.
- C. Apply identification devices to surfaces that require finish after completing finish work.
- D. Self-Adhesive Identification Products: Clean surfaces before application, using materials and methods recommended by manufacturer of identification device.
- E. Attach non-adhesive signs and plastic labels with screws and auxiliary hardware appropriate to the location and substrate.
- F. System Identification Color Banding for Raceways and Cables: Each color band shall completely encircle cable or conduit. Place adjacent bands of two-color markings in contact, side by side. Locate bands at changes in direction, at penetrations of walls and floors, at 50-foot maximum intervals in straight runs, and at 25-foot maximum intervals in congested areas.
- G. Color-Coding for Phase and Voltage Level Identification, 600 V and Less: Use the colors listed below for ungrounded service, feeder, and branch-circuit conductors.
 - 1. Color shall be factory applied or, for sizes larger than No. 10 AWG if authorities having jurisdiction permit, field applied.
 - a. Colors for 208/120 V Circuits:
 - 1) Phase A: Black.
 - 2) Phase B: Red.
 - 3) Phase C: Blue.
 - b. Colors for 480/277 V Circuits:
 - 1) Phase A: Brown.
 - 2) Phase B: Orange.
 - 3) Phase C: Yellow.
 - 2. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches from terminal points and in boxes where splices or taps are made. Apply last 2 turns of tape with no tension to prevent possible unwinding. Locate bands to avoid obscuring factory cable markings.
- H. Aluminum Wraparound Marker Labels and Metal Tags: Secure tight to surface of conductor or cable at a location with high visibility and accessibility.
- I. Painted Identification: Prepare surface and apply paint according to Division 9 painting Sections.

END OF SECTION

SECTION 26 05 73
POWER SYSTEM STUDIES

PART 1 - GENERAL

1.1 SUMMARY

A. General:

1. The Short Circuit Analysis, Protective Device Coordination Study, Emergency Power System Selective Coordination Study and Arc Flash and Electrical Hazard Studies specified in this section shall be completed and submitted prior to submitting submittals for [switchgear,] switchboards, [motor control centers,] distribution panels, panelboards, enclosed circuit breakers and other electrical gear with short circuit or interrupting ratings.
2. The Electrical Contractor shall provide the Engineer with a Power System Short Circuit Analysis, Protective Device Coordination Study, Emergency Power System Selective Coordination Study and Arc Flash and Electrical Hazard Study. These analysis's and studies shall include all power distribution systems, beginning at the electric service point from the Electric Utility Company and emergency power source(s) to the secondary buses of each panelboard as described hereafter.
3. Shall be prepared by and certified with a registration seal and signature of a Registered Professional Engineer. The Engineer shall be qualified by experience in preparation of studies having similar requirements and of similar magnitude to that specified in this section of the Specifications.
4. The Short Circuit Analysis shall terminate at each branch bus at the lowest utilization voltage secondary bus where the symmetrical short circuit RMS amperes, total source plus all motor contribution, is less than 10,000 amperes for 208/240 volts and 14,000 amperes for 480 volts. It is the intent of these Specifications to determine all locations in the entire electrical system where the symmetrical short circuit amperes meets or exceeds 10,000 amperes at 208 volts and 14,000 amperes at 480 volts. The short circuit analysis shall compare interrupting rating of all installed electrical protective devices connected to each bus included in the study with that of the available fault current at the load terminals of each protective device. Appropriate recommendations shall be made for corrective action in the conclusions of the report where the interrupting rating of electrical equipment is exceeded by the available fault current.
5. The Protective Device Coordination Study shall start at the electric service and include all electrical distribution equipment protective devices with adjustable trip units, relay settings or options for fuse types. The curves and settings for the Power Company protective devices shall be included in the scope of this study. The coordination plots shall terminate with the first non-adjustable overcurrent device or devices downstream of all protective devices with an adjustable trip unit, relay settings or options for fuse types. The protective device study shall include a separate analysis for phase and ground protection.
6. The Emergency Power System Selective Coordination Study shall comply with all applicable NEC requirements and shall start at the electric service and emergency power source(s) and include all electrical distribution equipment protective devices to

and including the final branch circuit protective devices serving applicable emergency loads. The curves and settings for the Power Company protective devices shall be included in the scope of this study. The coordination plots shall terminate with the final branch circuit protective devices serving applicable emergency loads. The protective device study shall include a separate analysis for phase and ground protection.

7. The Arc Flash and Electrical Hazard Study comply with applicable NEC and OSHA requirements and shall include calculating the Arc Flash and establishing the Electrical Hazard rating for each switchboard, distribution panel, panelboard, automatic transfer switch, enclosed circuit breaker and disconnect switch to be installed on the project.
 8. The Contractor shall obtain all lengths of cable from the electrical drawings and, where not shown the entire length of the run, from Contractor estimated lengths to longest possible lengths. All other equipment ratings shall be obtained by the Contractor from the equipment manufacturer's and/or suppliers.
- B. Short Circuit Analysis: The Analysis shall include the following:
1. A schematic one-line drawing of the entire electrical system included in the study, from the power company system including the point of delivery, to each primary transformer, and including all main secondary buses of each transformer included in the study. Secondary buses shall include multiple secondary transformations within the scope of the study. Each device shall be identified using project assigned identification labels. Each motor 10 hp and larger shall be shown and identified. Each bus shall be assigned an identification number.
 2. Source voltage and impedance data shall be given in the analysis, including reactance and resistance in OHMS to the source, and available symmetrical and asymmetrical short circuit amperes at the point of delivery of electrical power. Short circuit amperes shall be based on an assumed bolted 3 phase short circuit.
 3. At each bus, including buses of all primary protective and switching devices, primary and secondary of all transformers, all secondary main and feeder breakers, and all secondary devices and panelboards within the scope of the study, the following shall be calculated for assumed bolted 3 phase short circuits.
 - a. Symmetrical RMS short circuit amperes, calculated using total source and motor contribution reactance and resistance values.
 - b. Asymmetrical average 3 phase RMS amperes at 1/2 cycle, calculated using actual total source and motor contribution X/R ratio.
 - c. Reactance ("X") and Resistance ("R") in OHMS at the voltage of the device being examined, including both The Power Company source and all motor contributions.
 4. Calculation sheets for cable sections shall indicate voltage, wire size, cable length, reactance and resistance of the section in OHMS and total "X" and "R" to the source.
 5. Calculation sheets for transformer sections shall indicate transformer kVA, secondary voltage, percent impedance, percent reactance, percent resistance, and total "X" and "R" value in OHMS at the secondary voltage to source, including The Power Company source impedance plus any primary motor contribution.
 6. Calculation sheets for busway and miscellaneous devices shall provide all pertinent

parameters including operating voltage, section "X" and "R" values in OHMS, and total "X" and "R" values in OHMS to the source, based on source impedance plus any motor contribution.

7. Bus summary sheets shall be provided giving consecutive bus numbers, description, voltage, "X" and "R" values in OHMS including The Power Company plus all motor contributions, symmetrical and asymmetrical short circuit amperes, X/R ration, and asymmetrical factor.
8. Motor summary sheets shall provide motor description and all pertinent motor data including subtransient reactance for each motor 10 hp and larger. Symmetrical short circuit amperes shall be given for each motor at the motor terminals.
9. An evaluation of the adequacy of the short-circuit ratings of the electrical equipment supplied by that manufacturer. For this evaluation, circuit breakers shall all be fully rated.
10. All information shall be presented in a report form, signed and sealed by the engineer providing the analysis.

C. Protective Device Coordination Study: The Study shall include the following:

1. Time-current coordination plots shall be made on log-log sheets or equivalent software generated plots and shall graphically indicate the coordination proposed for all of the key systems. The plots shall include complete titles, one-line diagram and legend.
2. The Power Company's relay, fuse, or protective device shall be plotted with all load protective devices at the same voltage.
3. Transformer primary protective device, transformer magnetic inrush, transformer ANSI withstand points, secondary voltage fuse or circuit breaker and largest feeder fuse or circuit breaker shall be plotted at the secondary voltage. Circuit breaker curves shall include complete operating bands, terminating with the appropriate available short circuit current. Fuse curves shall be identified as either total clearing time or damage time as applicable.
4. Low voltage circuit breakers shall have instantaneous, short delay, long-time pick-up and ground fault trip settings and ground fault ampere and time delay settings identified as plotted. Sensor or monitor rating shall be stated for each circuit breaker. All regions of the circuit breaker curve shall be identified.
5. The coordination plots shall include significant motor starting characteristics and large motor protective devices.
6. Feeder circuit breakers shall have the time-damage curve of the feeder conductors plotted to indicate protection of the conductor insulation at the total clearing time of the circuit breaker or fuse. This time-damage point shall be calculated for the specific parameters of conductor insulation used, with average 3 phase RMS asymmetrical amperes as 1/2 cycle calculated using actual resistance and reactance values of the source plus all motor contributions which exist at the load end of the feeder conductors. Conductor initial temperature and conductor maximum transient temperature for short circuits as recommended by ICEA shall be indicated.
7. High voltage relays shall have coil taps, time-dial settings and pick-up settings identified as plotted. Current transformer ratios shall be stated. Relays shall be separated by a 0.45 second time margin to assure proper selectivity where feasible.

The relay operating curves shall be suitably terminated to reflect the actual maximum fault current sensed by the device.

8. A determination of settings or ratings for the overcurrent and ground fault protective devices supplied. Where necessary, an appropriate compromise shall be made between system protection and service continuity with [service continuity] [system protection] considered more important than system protection/service continuity. The time-current coordination analysis shall be performed with the aid appropriate software.
 9. A summary tabulation shall be provided listing manufacturer and type for all overcurrent protective devices and all recommended settings of each adjustable band included in each device.
 10. An evaluation of the degree of system protection and service continuity possible with the overcurrent devices supplied.
 11. When main breaker is provided with setback to reduce the arc fault level both settings shall be included in the study.
 12. All information shall be presented in a report form, signed and sealed by the Engineer providing the analysis.
- D. Emergency Power System Selective Coordination Study: The Study shall include the following:
1. Confirmation of selective coordination of all overcurrent devices associated with supplying utility and generator/UPS to emergency loads in accordance with all applicable requirements of NEC Article 100 and Paragraphs 700.27 and 701.18. Study shall be based on coordination to [0.1] [0.01] seconds. Study shall be based on the actual electrical equipment and overcurrent protective devices being submitted for the project.
 2. Time-current coordination plots shall be made on log-log sheets or equivalent software generated plots and shall graphically indicate the coordination proposed for all of the key systems. The plots shall include complete titles, one-line diagram and legend.
 3. Circuit breakers shall indicate manufacturer and type and have instantaneous, short delay, long-time pick-up and ground fault trip settings and ground fault ampere and time delay settings identified as plotted. Sensor or monitor rating shall be stated for each circuit breaker. All regions of the circuit breaker curve shall be identified. Circuit breaker curves shall include complete operating bands, terminating with the appropriate available short circuit current.
 4. Fuses shall have fuse manufacturer and type indicated. Fuse curves shall be identified as either total clearing time or damage time as applicable.
 5. High voltage relays shall indicate manufacturer and type and have coil taps, time-dial settings and pick-up settings identified as plotted. Current transformer ratios shall be stated. Relays shall be separated by a 0.45 second time margin to assure proper selectivity where feasible. The relay operating curves shall be suitably terminated to reflect the actual maximum fault current sensed by the device.
 6. A summary tabulation shall be provided listing manufacturer and type for all overcurrent protective devices and all recommended settings of each adjustable band included in each device.

7. Confirmation that the proposed overcurrent protection devices, set or selected as recommended, will provide the specified selective coordination. Should the overcurrent devices proposed for the project not be capable of providing the specified selective coordination, the report shall include recommendations for overcurrent protective device changes required to provide the specified coordination and calculations, plots, recommended settings as specified herein for the recommended overcurrent device changes to provide the specified selective coordination.
 8. All information shall be presented in a report form, signed and sealed by the Engineer providing the analysis.
- E. Arc Flash & Electrical Hazard Analysis: The Analysis shall include the following:
1. The Arc-Flash & Electrical Hazard Analysis (AFEHA) shall be performed in accordance with the requirements of NFPA 70 Section 110.16, NESC ANSI C2-2007 Section 410.A.3, IEEE Std. 1584 and OSHA 29 CFR 1910.132(d) and 1910.335.
 2. The AFEHA shall:
 - a. Calculate incident energy levels and flash protection boundaries at all relevant equipment busses based on available short-circuit current, protective device clearing time and other applicable one-line diagram information.
 - b. Calculate the Minimum Arc Fault Current, Arc Flash Boundary and Arc Fault Rating (cal/cm²) for each switchboard, distribution panel, panelboard, automatic transfer switch, enclosed circuit breaker and disconnect switch to be installed on the project.
 - c. Identify the Arc Flash Hazard Category and risk of personnel injury as a result of exposure to incident energy released during an arc flash event for each switchboard, distribution panel, panelboard, automatic transfer switch, enclosed circuit breaker and disconnect switch to be installed on the project.
 - d. Identify the current appropriate ratings of personal protective equipment (PPE) for each switchboard, distribution panel, panelboard, automatic transfer switch, enclosed circuit breaker and disconnect switch to be installed on the project.
 - e. Establish the Flash Protection Boundary (approach limit distance) as required by NFPA 70E for each switchboard, distribution panel, panelboard, automatic transfer switch, enclosed circuit breaker and disconnect switch to be installed on the project.
 - f. Provide equipment specific environment and chemical arc-flash hazard warning label requirements per NEC Section 110.16 for each switchboard, distribution panel, panelboard, automatic transfer switch, enclosed circuit breaker and disconnect switch to be installed on the project, including all information specified to be provided on individual equipment warning labels.
 - g. Provide recommendations and methods to mitigate the hazard risk, where applicable, in order to reduce PPE requirements
 - h. All information shall be presented in a report form, signed and sealed by the engineer providing the analysis.

1.2 REFERENCES - NOT USED

1.3 ADMINISTRATIVE REQUIREMENTS - NOT USED

1.4 SUBMITTALS:

- A. Shop Drawing submittals shall include, but not be limited to, the following:
1. Four copies of the Short-Circuit Analysis including, but not limited to:
 - a. A printout of input data, calculated results and an explanation of how to interpret the data.
 - b. A one-line diagram identifying all bus locations and the maximum available short-circuit current at each bus.
 - c. A bus-to-bus listing of the maximum available short-circuit current expressed in RMS symmetrical amperes and the X over R ratio of that fault current.
 - d. A table of specified equipment short-circuit ratings versus calculated short-circuit current values with notations of locations where specified equipment short-circuit ratings are less or greater than required at the point of application.
 - e. An analysis of the results in which any overrating or inadequacies shall be called to the attention of the Engineer and recommendations made for improvements.
 2. Four copies of the Protective Device Coordination Study including, but not limited to:
 - a. Time-current characteristic curve drawings on log-log printouts which illustrate:
 - 1) The recommended settings for all adjustable relays, overcurrent protective devices and ground fault protective devices provided for the project.
 - 2) The key or limiting overcurrent device characteristics, load characteristics, and protection requirements affecting the settings or ratings of the overcurrent protective devices supplied.
 - 3) The degree of service continuity and system protection achieved with the overcurrent protective devices supplied.
 - b. A tabulation of the recommended settings for all adjustable relays, overcurrent protective devices and ground fault protective devices and type selections for fuse protective devices supplied.
 - c. An analysis of the results in which any inadequacies related to selective coordination shall be called to the attention of the Engineer with recommendations for improved coordination.
 3. Four copies of the Emergency Power System Selective Coordination Study including, but not limited to:
 - a. Time-current characteristic curve drawings on log-log printouts which illustrate:
 - 1) Compliance of the provided overcurrent protective devices with the specified selective coordination requirements.
 - 2) The recommended settings for all adjustable relays, overcurrent protective devices and ground fault protective devices provided for the project.
 - b. A tabulation of the recommended settings for all adjustable relays, overcurrent protective devices and ground fault protective devices and type selections for fuse protective devices supplied.
 - c. An analysis of the results in which any inadequacies related to the specified selective coordination shall be called to the attention of the Engineer with

recommendations for improved coordination.

4. Four copies of the arc-flash & electrical hazard analysis including, but not limited to:
 - a. Minimum Arc Fault Current, Arc Flash Boundary and Arc Fault Rating (cal/cm²) for each switchboard, distribution panel, panelboard, automatic transfer switch, enclosed circuit breaker and disconnect switch to be installed on the project.
 - b. Arc Flash Hazard Category and risk of personnel injury as a result of exposure to incident energy released during an arc flash event for each switchboard, distribution panel, panelboard, automatic transfer switch, enclosed circuit breaker and disconnect switch to be installed on the project.
 - c. Current appropriate ratings of personal protective equipment (PPE) for each switchboard, distribution panel, panelboard, automatic transfer switch, enclosed circuit breaker and disconnect switch to be installed on the project.
 - d. The Flash Protection Boundary (approach limit distance) as required by NFPA 70 for each switchboard, distribution panel, panelboard, automatic transfer switch, enclosed circuit breaker and disconnect switch to be installed on the project.
 - e. Equipment specific environment and chemical arc-flash hazard warning label requirements per NEC Section 110.16 for each switchboard, distribution panel, panelboard, automatic transfer switch, enclosed circuit breaker and disconnect switch to be installed on the project, including all information specified to be provided on individual equipment warning labels.
 - f. Recommendations and methods to mitigate the hazard risk, where applicable, in order to reduce PPE requirements
5. Cut sheets and submittal information on the Arc Flash warning labels being provided.

1.5 QUALITY ASSURANCE

- A. The short circuit analysis/coordination study shall be performed by the Engineering Department of the electrical equipment supplied for the project or by a qualified engineering consultant approved in writing in advance by the Engineer.

1.6 DELIVERY, STORAGE, AND HANDLING - NOT USED

1.7 SITE CONDITIONS - NOT USED

1.8 WARRANTY - NOT USED

1.9 STUDY AND ANALYSIS SEQUENCE:

- A. All studies and analysis specified herein shall be completed and submitted with electrical distribution equipment submittals to allow the Engineer to review submitted electrical distribution equipment for interrupting rating, coordination and arc flash related coordination.

PART 2 - PRODUCTS

2.1 ARC FLASH WARNING LABELS:

- A. Labels: Seton Write-On Arc Flash Warning Labels or an approved equal label with NEC and OSHA required warning information and with Arc Flash Hazard Category, minimum Personal

Protection Equipment (PPE) required and Minimum Arc Rating (cal/cm2) clearly indicated.

PART 3 - EXECUTION

3.1 PROTECTIVE DEVICE SELECTION AND SETTING:

- A. Settings and Selection: Prior to project Substantial Completion, the Contractor shall set all relays, overcurrent devices and ground fault protection devices and confirm selection of fuse overcurrent devices as follows:
 - 1. Relays: Reset all adjustable relay settings from the factory default settings to the settings recommended in the studies specified in this section.
 - 2. Circuit Breakers: Reset all adjustable trip settings from the factory default settings to the settings recommended in the studies specified in this section.
 - 3. Ground Fault Protection Devices: Reset all adjustable device settings from the factory default settings to the settings recommended in the studies specified in this section.
 - 4. Fuses: Confirm that fuse types installed on the project are as recommended in the studies specified in this section.
- B. Certification: Prior to project Substantial Completion, the Contractor shall submit 4 signed copies of a document certifying that the Contractor has completed the settings and selection scope specified in Paragraph 3.1 A. to the Engineer.

3.2 ARC FLASH WARNING LABELS:

- A. Installation: Arc Flash warning labels shall be securely affixed to each switchboard, distribution panel, panelboard, automatic transfer switch, enclosed circuit breaker and disconnect switch in a readily visible location in accordance with NEC and OSHA requirements. The actual calculated Minimum Arc Rating (cal/cm2) for that individual piece of equipment along with the associated Arc Flash Hazard Category and minimum Personal Protection Equipment (PPE) required shall be clearly indicated on each warning label.

END OF SECTION

SECTION 26 29 16 PANELBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section panelboards and enclosure work, including cabinets, as scheduled, indicated and as specified.
- B. The types of panelboards and enclosures required for the project include, but are not limited to, the following:
 - 1. Power distribution panelboards identified as "DP" on the drawings.
 - 2. Power panel panelboards identified as "PP" on the drawings.
 - 3. Lighting and appliance panelboards identified as "LP" on the drawings.
 - 4. Circuit breakers for existing building panelboards.

1.3 REFERENCES

- A. General Publications: The publications listed below form a part of this Specification to the extent referenced. The publications are referred to in the text by the basic designation only. The edition/revision of the referenced publications shall be the latest date as of the date of the Contract Documents, unless otherwise specified.
 - 1. USA Federal Specifications (FS):
 - a. FS W-C-375, "Circuit Breakers, Molded Case, Branch Circuit and Service."
 - b. FS W-P-115, "Panel, Power Distribution."
 - 2. International Code Council (ICC):
 - a. ICC IBC, "International Building Code."
 - b. ICC IBC Section 1621, "Architectural, Mechanical, and Electrical Component Seismic Design Requirements."
 - 3. Canadian Standards Association (CSA):
 - a. CSA C22.2 No. 5, "Molded Case Circuit Breakers, Molded Case Switches and Circuit Breaker Enclosures."
 - b. CSA C22.2 No. 29, "Panelboards and Enclosed Panelboards."
 - 4. National Electrical Manufacturer Association (NEMA)
 - a. NEMA AB 1, "Molded Case Circuit Breakers and Molded Case Switches."
 - b. NEMA PB 1, "Panelboards."
 - c. NEMA PB 1.1, "General Instructions for Proper Installation, Operation and Maintenance of Panelboards Rated 600 Volts or Less."
 - 5. National Fire Protection Agency (NFPA)
 - a. NFPA 70, "National Electrical Code," hereinafter referred to as NEC.
 - b. NFPA 5000, "Building Construction and Safety Code."

6. Underwriters Laboratories, Inc. (UL)
 - a. UL 50, "Enclosures for Electrical Equipment, Non-Environmental Considerations."
 - b. UL50E, "Enclosures for Electrical Equipment, Environmental Considerations."
 - c. UL 67, "Standard for Panelboards."
 - d. UL 489, "Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures."
7. International Electrotechnical Commission (IEC)
 - a. IEC 60529: 1989+AMD1:1999+AMD2:2013 CSV Consolidated version. - Degrees of Protection Provided by Enclosures (IP Code).

1.4 DEFINITIONS

- A. Unless specifically defined within the Contract Documents, the words or acronyms contained within this specification shall be as defined within, or by the references listed within this specification, the Contract Documents, or, if not listed by either, by common industry practice.
 1. GFEP: Ground fault equipment protection
 2. LP: Lighting Panel
 3. PP: Power Panelboard
 4. MCB: Miniature circuit breaker
 5. MCCB: Molded-case circuit breaker
 6. NRTL: Nationally Recognized Testing Laboratory
 7. OCPD: Overcurrent protective device
 8. SPD: Surge Protective Device
 9. CT: Current Transformer
 10. MPM: Multipoint Metering System
 11. MCOV: Maximum Continuous Operating Voltage
 12. VPR: Voltage Protection Rating

1.5 SUBMITTALS

- A. General: Submittals shall be in accordance with the requirements of Section 01 33 00 Submittals and Section 26 00 00 Electrical, in addition to those specified herein.
 1. Submit sufficient information to determine compliance with the Contract Documents. Identify submittal data with the specific equipment tags and/or service descriptions to which they pertain. Submittal data shall be clearly marked to identify the specific model numbers, options, and features of equipment and work proposed.
 2. Deviations from the Contract Documents shall be indicated within the submittal. Each deviation shall reference the corresponding drawing or specification number, show the Contract Document requirement text and/or illustration, and shall be accompanied by a detailed written justification for the deviation.
- B. Product Data: For each type of panelboard. Include manufacturer's technical data on features, performance, electrical characteristics, ratings, and enclosure types and finishes.

1. Bus Materials, OCPDs, SPDs, and accessories indicated.
 2. Dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.
 3. Installation instructions complying with NEMA PB 1.1.
- C. Shop Drawings: Submit the following additional shop drawing information for each product and accessory required. Include information not fully detailed in manufacturer's standard product data.
1. Drawings shall include, but shall not be limited to: environmental protection; interior mounting dimensions; and wiring gutter dimensions.
 2. The location of the main shall be clearly shown.
 3. The location of the branches and solid neutral shall be clearly shown.
 4. Shop drawings shall illustrate one-line diagrams with applicable voltage systems.
 5. Evidence of NRTL listing for series rating on OCPDs.
- D. Field quality-control reports.
- E. Operation and Maintenance Data: In addition to items specified in Division 1 Section "Operation and Maintenance Data," include the following:
1. Installation instructions and NEMA Standards Publication PB 1.1 - Instructions for Safe Installation, Operation and Maintenance of Panelboards Rated 600 Volts or Less.
 2. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1.6 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Manufacturer shall be a firm engaged in the manufacture of specified products of types and sizes required, and whose products have been in satisfactory use in similar service for a minimum of 10 years.
1. The manufacturer shall have a valid ISO 9001 certification and an applicable quality assurance system that is regularly reviewed and audited by a third-party registrar. Manufacturing, inspection, and testing procedures shall be developed and controlled under the guidelines of the quality assurance system.
 2. The manufacturer or their representative shall have service, repair, and technical support services available 24 hours 7 days a week basis.
- B. All work performed and all materials used shall be in accordance with the National Electrical Code, and with applicable local regulations and ordinances. Process controllers, assemblies, materials, and equipment shall be listed and labeled by Underwriter's Laboratories or by a testing agency acceptable to authorities having jurisdiction and marked for intended use.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Prior to delivery to the Project site, ensure that suitable storage space is available to store materials in a well-ventilated area protected from weather, moisture, soiling, extreme temperatures, humidity, and corrosive atmospheres. Materials shall be protected during delivery and storage and shall not exceed the manufacturer stated storage requirements. As a minimum, store indoors in clean, dry space with uniform temperature to prevent condensation. In addition, protect electronics from all forms of electrical and magnetic

- energy that could reasonably cause damage.
- B. Deliver materials to the Project site in supplier's or manufacturer's original wrappings and containers, labeled with supplier's or manufacturer's name, material or product brand name, and equipment tag number or service name as identified within the Contract Documents.
- C. Inspect and report any concealed damage or violation of delivery storage, and handling requirements to the Engineer.

1.8 WARRANTY

- A. General: Refer to Section 01 77 00 - Closeout Procedures.
- B. The manufacturer shall warrant specified equipment free from defects in materials and workmanship for the lesser of 1 year from the date of installation or 18 months from the date of purchase.
- C. Additional Owner Rights: The warranty shall not deprive the Owner of other rights the Owner may have under other provisions of the Contract Documents and shall be in addition to and run concurrent with other warranties made by the Contractor under requirements of the Contract Documents.

1.9 SPECIAL TOOLS AND EXTRA MATERIALS/SPARE PARTS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Feeder Breakers: Furnish 2 spares for each size and type of breaker.
- B. The Contractor shall provide a recommended spare parts list with the following information provided as a minimum:
 - 1. Contact information for the closest parts stocking location to the Owner.
 - 2. Critical spare parts shall be identified as those parts being associated with long lead times and/or those being critical to the unit's operation.
 - 3. Maintenance spares shall be identified as being those parts required to regularly perform scheduled maintenance on the furnished equipment. These spares shall include, but shall not be limited to, consumable spares that are required to be exchanged during scheduled maintenance periods.
- C. Spare parts shall be provided for each type and size of unit furnished. At a minimum, the following shall be provided:
 - 1. Provide the minimum spare parts recommended by the manufacturer.
- D. Any manufacturer specific special tool, not normally found in an electrician's toolbox, required to remove and install recommended or furnished spare parts, shall be furnished. At a minimum the following shall be provided:
 - 1. If available from manufacture, provide PC-based configuration software tool and a minimum of [one] communication interface cable for each type of cable required to connect a PC-based computer to the devices specified herein for configuration and programming.
 - 2. Electronic configuration files, in a media format acceptable by the Owner (e.g. CD, USB stick, etc.). Configuration files must be updated to the installed and

commissioned state.

- E. Spare parts shall be properly marked and packaged for long term storage.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Subject to compliance with the requirements of this Section, provide products by one of the following:
 - 1. Eaton Corporation
 - 2. ABB/General Electric Company
 - 3. Siemens
 - 4. Square D
 - 5. Rockwell Automation

2.2 GENERAL REQUIREMENTS

- A. Panelboards shall be manufactured in accordance with standards listed within Article 1.3 REFERENCES.
- B. Panelboards specified herein shall be the product of a single manufacturer. Products and manufacturers specified are to establish a standard of quality for design, function, materials, and appearance. Products shall be modified as necessary by the manufacturer for compliance with requirements.
- C. Panelboard overcurrent protective devices shall be selectively coordinated with all supply side overcurrent protective devices as required for this project by NEC Articles 645.27, 700.27, 701.27 and 708.54

2.3 POWER DISTRIBUTION PANELBOARD - CIRCUIT BREAKER TYPE

- A. Ratings:
 - 1. Shall be rated 480/277VAC maximum. Continuous main AC current ratings as indicated on associated drawings not to exceed 1200 amperes maximum for main circuit breaker panelboards.
 - a. 480Y/277Vac maximum panelboards shall be suitable for use in lower potential AC voltage systems.
 - 2. Panelboard bus ratings shall be determined by heat-rise tests conducted in accordance with UL 67.
 - 3. Provide UL Listed short circuit current ratings (SCCR) as indicated on the associated drawings not to exceed the lowest interrupting capacity rating of any circuit breaker installed with a maximum of 200,000 RMS symmetrical amperes.
 - 4. The panelboard shall be rated for the minimum short circuit current rating:
 - a. Fully rated to 35,000 rms symmetrical amperes.
 - 5. Main breaker panelboards shall be suitable for use as Service Equipment when application requirements comply with UL 67 and NEC Articles 230-F and -G.
 - a. A solidly bonded copper equipment ground bar shall be provided.
 - b. Solid neutral shall be equipped with a full capacity bonding strap for service

entrance applications.

- c. UL Listed panelboards with 200% rated solid neutrals shall have plated copper neutral bus for non-linear load applications. Gutter-mounted neutral will not be acceptable.

B. Construction:

1. Interiors shall be completely factory assembled. They shall be designed such that switching and protective devices can be replaced without disturbing adjacent units and without removing the main bus connectors.
2. Neutral shall be plated, solid, and split for 20" nominal and wider panelboards. 14" wide and column width panelboards shall have a plated solid neutral.
3. Distribution panelboard trims shall cover all live parts. Switching device handles shall be accessible. Interior trim shall be of dead-front construction to shield user from energized parts. Dead-front trim shall have filler plates covering unused mounting spaces.
4. Nameplates shall contain system information and catalog number or factory order number. Interior wiring diagram, neutral wiring diagram, CSA and UL Listed label and short circuit current rating shall be displayed on the interior or in a booklet format.
5. Interiors in NEMA 1 or 2 enclosures shall be field convertible for top or bottom incoming feed. Interior leveling provisions shall be provided for flush mounted applications.
6. Main circuit breakers in power distribution panelboards shall be horizontally mounted up to 125A at 480Y/277Vac. All other main circuit breakers shall be vertically mounted. Sub-feed circuit breakers shall be vertically mounted.
7. The panelboard interior shall have three flat bus bars stacked and aligned vertically with glass reinforced polyester insulators laminated between phases. The molded polyester insulators shall support and provide phase isolation to the entire length of bus.
8. The entire interleaved bus assembly shall be contained between two (2) U-shaped steel channels, permanently secured to a galvanized steel-mounting pan by fasteners.
9. Leveling provisions shall be provided for flush mounted applications.

C. Bus:

1. Each bus bar shall have sequentially phased branch circuit connectors.
 - a. The bussing shall be fully rated, with one (1) continuous bus bar per phase, unless a Split Bus or Separated Distribution panel is specified:
 - 1) Up to 54 circuits for power distribution panelboards.
 - 2) For Split Bus and Separated distribution panelboards – provide one (1) continuous bus bar per phase for each branch distribution section.
 - a) Split Bus panelboard sections shall be connected from upstream lugs or branch breaker to one (1) back-fed main breaker in downstream section.
 - b) Separated Distribution panelboard sections shall be connected via removable, stranded copper cables, (to enable field installation of solid core CTs) secured via mechanical lugs on each section.

2. Bussing rated 100-400 amperes shall be plated copper. Bussing rated at or above 600 amperes shall be plated copper as standard construction. Bus bar plating shall run the entire length of the bus bar.
3. Interior phase bus shall be pre-drilled to accommodate field installable options i.e., Sub-Feed Lugs, Sub-Feed Breakers, Thru-Feed Lugs.
4. Full-size (100%-rated) insulated stand-off neutral bars shall be included for panelboards shown with neutral. Bus bar taps for panels with single-pole branches shall be arranged for sequence phasing of the branch circuit devices. Neutral busing shall have a suitable lug for each outgoing feeder requiring a neutral connection.
5. 200%-rated neutrals shall be supplied for panels designated on drawings with oversized neutral conductors.

2.4 POWER PANELBOARD

A. Ratings:

1. Shall be rated 480/277VAC maximum. Continuous main AC current ratings as indicated on associated drawings not to exceed 800 amperes maximum for main circuit breaker panelboards.
 - a. 480Y/277Vac maximum panelboards shall be suitable for use in lower potential AC voltage systems.
2. Panelboard bus ratings shall be determined by heat-rise tests conducted in accordance with UL 67.
3. Provide UL Listed short circuit current ratings (SCCR) as indicated on the associated drawings not to exceed the lowest interrupting capacity rating of any circuit breaker installed with a maximum of 200,000 RMS symmetrical amperes.
4. The panelboard shall be rated for the minimum short circuit current rating:
 - a. Fully rated to 35,000 rms symmetrical amperes.
5. Main breaker panelboards shall be suitable for use as Service Equipment when application requirements comply with UL 67 and NEC Articles 230-F and -G.
 - a. A solidly bonded copper equipment ground bar shall be provided.
 - b. Solid neutral shall be equipped with a full capacity bonding strap for service entrance applications.
 - c. UL Listed panelboards with 200% rated solid neutrals shall have plated copper neutral bus for non-linear load applications. Gutter-mounted neutral will not be acceptable.

B. Construction:

1. Interiors shall be completely factory assembled. They shall be designed such that switching and protective devices can be replaced without disturbing adjacent units and without removing the main bus connectors.
2. Neutral shall be plated, solid, and split for 20" nominal and wider panelboards. 14" wide and column width panelboards shall have a plated solid neutral.
3. Distribution panelboard trims shall cover all live parts. Switching device handles shall be accessible. Interior trim shall be of dead-front construction to shield user from energized parts. Dead-front trim shall have filler plates covering unused mounting spaces.

4. Nameplates shall contain system information and catalog number or factory order number. Interior wiring diagram, neutral wiring diagram, CSA and UL Listed label and short circuit current rating shall be displayed on the interior or in a booklet format.
 5. Interiors in NEMA 1 or 2 enclosures shall be field convertible for top or bottom incoming feed. Interior leveling provisions shall be provided for flush mounted applications.
 6. Main circuit breakers in power distribution panelboards shall be horizontally mounted up to 125A at 480Y/277Vac. All other main circuit breakers shall be vertically mounted. Sub-feed circuit breakers shall be vertically mounted.
 7. The panelboard interior shall have three flat bus bars stacked and aligned vertically with glass reinforced polyester insulators laminated between phases. The molded polyester insulators shall support and provide phase isolation to the entire length of bus.
 8. The entire interleaved bus assembly shall be contained between two (2) U-shaped steel channels, permanently secured to a galvanized steel-mounting pan by fasteners.
 9. Leveling provisions shall be provided for flush mounted applications.
- C. Bus:
1. Each bus bar shall have sequentially phased branch circuit connectors.
 - a. The bussing shall be fully rated, with one (1) continuous bus bar per phase, unless a Split Bus or Separated Distribution panel is specified:
 - 1) Up to 54 circuits for power distribution panelboards.
 - 2) For Split Bus and Separated distribution panelboards – provide one (1) continuous bus bar per phase for each branch distribution section.
 - a) Split Bus panelboard sections shall be connected from upstream lugs or branch breaker to one (1) back-fed main breaker in downstream section.
 - b) Separated Distribution panelboard sections shall be connected via removable, stranded copper cables, (to enable field installation of solid core CTs) secured via mechanical lugs on each section.
 2. Bussing rated 100-400 amperes shall be plated copper. Bussing rated at or above 600 amperes shall be plated copper as standard construction. Bus bar plating shall run the entire length of the bus bar.
 3. Interior phase bus shall be pre-drilled to accommodate field installable options i.e., Sub-Feed Lugs, Sub-Feed Breakers, Thru-Feed Lugs.
 4. Full-size (100%-rated) insulated stand-off neutral bars shall be included for panelboards shown with neutral. Bus bar taps for panels with single-pole branches shall be arranged for sequence phasing of the branch circuit devices. Neutral bussing shall have a suitable lug for each outgoing feeder requiring a neutral connection.
 5. 200%-rated neutrals shall be supplied for panels designated on drawings with oversized neutral conductors.
- D. Provide shunt trips, bell alarms, and auxiliary switches as shown on the contract drawings.

2.5 LIGHTING AND APPLIANCE PANELBOARD

A. Ratings:

1. Shall be rated 240Vac maximum. Continuous main AC current ratings as indicated on associated drawings not to exceed 600 amperes maximum for main circuit breaker panelboards.
2. Panelboard bus ratings shall be determined by heat-rise tests conducted in accordance with UL 67.
3. Provide UL Listed short circuit current ratings (SCCR) as indicated on the associated drawings not to exceed the lowest interrupting capacity rating of any circuit breaker installed with a maximum of 200,000 RMS symmetrical amperes.
4. The panelboard shall be rated for the minimum short circuit current rating:
 - a. Fully rated to 10,000 rms symmetrical amperes at 240Vac.
5. Main lug interiors up to 600 amperes shall be field convertible to main breaker.

B. Construction:

1. Interiors shall be completely factory assembled. They shall be designed such that switching and protective devices can be replaced without disturbing adjacent units and without removing the main bus connectors.
2. Neutral shall be plated, solid, and split for 20" nominal and wider panelboards. 14" wide and column width panelboards shall have a plated solid neutral.
3. A solidly bonded copper equipment ground bar shall be provided.
4. Distribution panelboard trims shall cover all live parts. Switching device handles shall be accessible. Interior trim shall be of dead-front construction to shield user from energized parts. Dead-front trim shall have filler plates covering unused mounting spaces.
5. Nameplates shall contain system information and catalog number or factory order number. Interior wiring diagram, neutral wiring diagram, CSA and UL Listed label and short circuit current rating shall be displayed on the interior or in a booklet format.
6. Interiors in NEMA 1 or 2 enclosures shall be field convertible for top or bottom incoming feed. Interior leveling provisions shall be provided for flush mounted applications.
7. Main circuit breakers in 240 Vac max panelboards shall be horizontally mounted up to 150A. All other main circuit breakers shall be vertically mounted. Sub-feed circuit breakers shall be vertically mounted.

C. Bus:

1. Each bus bar shall have sequentially phased branch circuit connectors.
 - a. The bussing shall be fully rated, with one (1) continuous bus bar per phase, unless a Split Bus or Separated Distribution panel is specified:
 - b. Up to 84 circuits for 240 Vac maximum panelboards,
 - 1) For Split Bus and Separated distribution panelboards – provide one (1) continuous bus bar per phase for each branch distribution section.
 - a) Split Bus panelboard sections shall be connected from upstream lugs or branch breaker to one (1) back-fed main breaker in downstream section.
 - b) Separated Distribution panelboard sections shall be connected via

removable, stranded copper cables, (to enable field installation of solid core CTs) secured via mechanical lugs on each section.

2. Bussing rated 100-400 amperes shall be plated copper. Bussing rated at 600 amperes shall be plated copper as standard construction. Bus bar plating shall run the entire length of the bus bar.
3. Interior phase bus shall be pre-drilled to accommodate field installable options i.e., Sub-Feed Lugs, Sub-Feed Breakers, Thru-Feed Lugs.
4. Full-size (100%-rated) insulated stand-off neutral bars shall be included for panelboards shown with neutral. Bus bar taps for panels with single-pole branches shall be arranged for sequence phasing of the branch circuit devices. Neutral busing shall have a suitable lug for each outgoing feeder requiring a neutral connection.
5. 240 Vac maximum panelboards shall have branch circuit connectors suitable for both plug-on and bolt-on branch circuit breakers.
6. 200%-rated neutrals shall be supplied for panels designated on drawings with oversized neutral conductors.

2.6 SURGE PROTECTION DEVICES

- A. SPD shall comply with ANSI/UL 1449 4th Edition or later listing by Underwriters Laboratories (UL).
- B. SPD shall be factory installed integral to the panelboard by the original equipment manufacturer and shall be a product of the same manufacturer as the panelboard and breakers.
- C. The SPD must protect all modes of the electrical system being utilized.
- D. SPD shall be electrically connected to each phase bus of the panelboard and should be installed close to the main incoming lugs or main circuit breaker.
- E. The SPD shall be maintenance free and shall not require any user intervention throughout its life. SPDs containing items such as replaceable single-mode modules, replaceable fuses, or replaceable batteries shall not be accepted. SPDs requiring any maintenance of any sort such as periodic tightening of connections shall not be accepted. SPDs requiring user intervention to test the unit via a diagnostic test kit or similar device shall not be accepted.
- F. Unit shall operate without the need for an external overcurrent protection device (OCPD) and be listed by UL as such. Unit must not require external OCPD or replaceable internal OCPD for the UL Listing.
- G. Electrical Requirements:
 1. Unit Operating Voltage – Refer to drawings for operating voltage and unit configuration.
 2. Maximum Continuous Operating Voltage (MCOV) – The MCOV shall not be less than 115% of the nominal system operating voltage.
 3. Nominal Discharge Current (In) – All SPDs applied to the distribution system shall have a 20kA SCCR rating regardless of their SPD Type (includes Types 1 and 2) or operating voltage. SPDs having an SCCR less than 20kA shall be rejected.
 4. Voltage Protection Rating - The maximum ANSI/UL 1449 4th Edition VPR for the

device shall not exceed the following:

- a. L-N, L-G, N-G:
 - 1) 480Y-277: 1200
 - 2) 208Y/120: 700
- b. L-L:
 - 1) 480Y-277: 2000
 - 2) 208Y/120: 1200

2.7 PANELBOARD SUBMETERING

- A. Where shown on the drawings, supply a UL listed microprocessor-based Multi-Point Metering System (MPM), Eaton type PX Multipoint Meter or approved equal having the specified features.
- B. MPM shall have 60 channels for current sensor input. Meter shall auto-detect sensor rating and have standard tamper detection.
- C. MPM shall calculate power and energy consumption in accordance with ANSI C12.20 (0.5%) metering specification and store metered data in nonvolatile memory.
- D. MPM shall store the following per phase and system total for each metering point
 - 1. Voltage, Current, and Frequency (system total only)
 - 2. Watts, VAR, VA, and power factor
 - 3. Watt hours including forward and reverse
- E. MPM shall store energy profile information for each metering point in non-volatile memory. The demand profile time period shall be adjustable from 1, 5, 15, 30 and 60 minutes for fixed method and 1, 5, and 15 minutes for sliding method. The MPM shall have the ability to sync with external input to the on board demand input. The MPM shall be able to save a minimum of 1 year of load profile data for all 60 meter points on a 15 minutes basis.
- F. MPM shall be provided with multiple communications ports and protocols, including the following capability:
 - 1. RS-485 remote display port
 - 2. RS-485 Modbus RTU
 - 3. USB Local Configuration Port
 - 4. HTML web pages
 - 5. File transfer protocol (ftp)
 - 6. RJ-45 10/100Base-T Ethernet network port
 - 7. Modbus TCP
 - 8. BACnet/IP
 - 9. SMTP(Simple Mail Transfer Protocol) for email support
 - 10. SNMP(Simple Network Management Protocol) MIB support
 - 11. Ethernet TCP/IP
 - 12. NTP(Network Time Protocol) support

2.8 PANELBOARD ENCLOSURES

- A. The surfaces of the trim assembly shall be properly cleaned, primed, and a finish coat of gray ANSI 61 paint applied.
- B. Leveling provisions shall be provided for flush mounted applications.
- C. Type 1 Boxes
 - 1. Boxes shall be hot zinc dipped galvanized steel constructed in accordance with UL 50 and UL50E requirements. Unpainted galvanized steel is not acceptable.
- D. Type 1 Fronts
 - 1. Front shall meet strength and rigidity requirements per UL 50 standards. Front shall have ANSI 49 gray enamel baked onto cleaned phosphatized steel.
 - 2. Fronts shall be hinged 1-piece with door. Mounting shall be as indicated on associated schedules or drawings.
 - 3. Doors on front shall have rounded corners and edges shall be free of burrs.
 - 4. Front shall have cylindrical tumbler type lock with catch and spring-loaded steel door pull, quarter-turn fasteners, or three-point latch. All lock assemblies shall be keyed alike. Two keys shall be provided with each lock. A clear plastic directory cardholder, or welded metal frame directory cardholder, shall be mounted on the inside of door.
- E. Type 3R, 5, and 12
 - 1. Enclosures shall be constructed in accordance with UL 50 and UL50E requirements. Enclosures shall be painted with ANSI 49 gray enamel baked onto cleaned phosphatized steel.
 - 2. All doors shall be equipped with at least one L-Handle lock mechanisms. Enclosures 59 inches or more in height shall have additional L-Handle mechanisms or two (2) additional quarter turn fasteners. All lock assemblies shall be keyed alike. Two keys shall be provided with each lock. A clear plastic directory cardholder, or welded metal frame directory cardholder, shall be mounted on the inside of door. Doors in enclosures which may configured for NEMA 5 or 12 service shall be gasketed.
 - 3. Nominal enclosure dimensions shall be:
 - a. 21" wide and 6.75" deep, not counting the handle, for standard Type 3R, 5, 12.
 - b. 21" wide and 8.75" deep, not counting the handle, for Door-in-door Type 12.
 - c. 27" wide and 8.75" deep, not counting the handle, for vented NEMA Type 3R.
- F. Type 4, 4X
 - 1. Enclosures shall be constructed in accordance with UL 50 and UL 50E requirements.
 - 2. All doors shall be gasketed and equipped with a L-Handle mechanism with additional clamps or fasteners on the top, bottom, and/or side to ensure tight closure. All lock assemblies shall be keyed alike. Two keys shall be provided with each lock. A clear plastic directory cardholder, or welded metal frame directory cardholder, shall be mounted on the inside of door.
 - 3. Nominal enclosure dimensions shall be 20.13" wide and 7.25" deep, not counting the handle.

2.9 MAIN CIRCUIT BREAKER

- A. Main circuit breakers shall have an over center, trip-free, toggle mechanism which will

provide quick-make, quick-break contact action. Main circuit breakers shall have Thermal Magnetic trip units.

1. Thermal Magnetic circuit breakers shall have a permanent trip unit with thermal and magnetic trip elements in each pole. Each thermal element shall be true rms sensing and be factory calibrated to operate in a 40° C ambient environment. Thermal elements shall be ambient compensating above 40° C.
- B. Two- and three-pole circuit breakers shall have common tripping of all poles. Vertically mounted molded case circuit breaker frame sizes above 125 amperes shall have a single magnetic trip adjustment located on the front of the circuit breaker that allows the user to simultaneously select the desired trip level of all poles. Molded case circuit breakers shall have a push-to-trip button for maintenance and testing purposes.
- C. Breaker handle and faceplate shall indicate rated ampacity. Standard construction circuit breakers shall be UL Listed for reverse connection without restrictive line or load markings.
- D. Vertically mounted main circuit breaker escutcheon shall have international I/O markings, in addition to standard ON/OFF markings. Circuit breaker handle accessories shall provide provisions for locking handle in the ON or OFF position.
- E. Lugs shall be CSA and UL Listed to accept solid or stranded copper and aluminum conductors. Lugs shall be suitable for 75° C rated wire. Lug body shall be bolted in place; snap-in designs are not acceptable.
- F. The circuit breakers shall be CSA and UL Listed for use with the following accessories: Shunt Trip, Under Voltage Trip, Ground Fault Shunt Trip, Auxiliary Switch, Alarm Switch, Mechanical Lug Kits, and Compression Lug Kits.
- G. Main breakers, if furnished, shall be equipped with microprocessor based trip units that have integral Arc Flash Reduction trip feature. The use of zone selective interlocking to emulate this function does not meet the intent of this specification and will not be allowed.

2.10 BRANCH CIRCUIT BREAKERS

- A. Circuit breakers shall be CSA and UL Listed with amperage ratings, interrupting ratings, and number of poles as indicated on the associated schedules or drawings.
- B. Where indicated, provide circuit breakers UL listed for application at 100% of their continuous ampere rating in their intended enclosure.
- C. Molded case branch circuit breakers in Power Distribution and Power panelboards shall bolt-on to the bus and shall not require additional external mounting hardware.
 1. Branch circuit breakers shall be available with the following nominal interrupting ratings:
 - a. 1 pole: 10A - 70A
 - b. 2 poles: 15 - 125A
 - c. 3 poles: 15 – 125A
- D. Molded case branch circuit breakers in lighting panelboards shall bolt-on or plug-on to the bus, and shall not require additional external mounting hardware, except when installed into IP2X enhanced fingersafe interiors.
 1. Branch circuit breakers shall be available with the following nominal interrupting

ratings:

- a. 1 pole: 10A - 70A
 - b. 2 poles: 15 - 125A (up to 200A in a single phase. panelboard)
 - c. 3 poles: 15 - 125A
- E. Circuit breakers shall have an over center toggle mechanism which will provide quick-make, quick-break contact action. Circuit breakers shall have a permanent trip unit with thermal and magnetic trip elements in each pole. Each thermal element shall be true RMS sensing and shall be factory-calibrated to operate in a 40 degrees C ambient environment. Circuit breakers shall have an operating range from - 10 degrees C to + 60 degrees. Thermal elements shall be ambient compensating above 40 degrees C.
- F. Two- and three-pole circuit breakers shall have common tripping of all poles.
- G. There shall be two forms of visible trip indication. The breaker handle shall reside in a position between ON and OFF. In addition, there shall be a red, Visi-Trip indicator appearing in the clear window of the circuit breaker housing.
- H. Lugs shall be UL Listed to accept solid or stranded copper conductors only. Lugs shall be suitable for 75° C rated wire. Branch circuit breakers rated 30 amperes and below shall be CSA and UL Listed to accept 60° C rated wire.
- I. Circuit Breakers shall be CSA and UL Listed for use with the following factory installed accessories: Shunt Trip, Auxiliary Switch, and Alarm Switch
- J. Line-side circuit breaker connections are to be jaw type.
- K. All circuit breakers with permanent trip units shall be UL Listed for reverse connection without restrictive line and load markings and be suitable for mounting in any position.
- L. Circuit breakers equipped with line terminal jaws shall not require additional external mounting hardware. Circuit breakers shall be held in mounted position by a self-contained bracket secured to the mounting pan by fasteners. Circuit breakers of different frame sizes shall be capable of being mounted across from each other.

PART 3 - EXECUTION

3.1 GENERAL

- A. In addition to the requirements specified herein, execution shall be in accordance with the requirements of Specification Section 26 00 00 and Drawings.
- B. Examine equipment exterior and interior prior to installation. Report any damage and do not install any equipment that is structurally, moisture, or mildew damaged.
- C. Verification of Conditions: Examine areas and conditions under which the work is to be installed, and notify the Contractor in writing, with a copy to the Owner and the Engineer, of any conditions detrimental to the proper and timely completion of the work. Do not proceed with the work until unsatisfactory conditions have been corrected.
- D. Beginning the work shall indicate acceptance of the areas and conditions as satisfactory by the Installer.
- E. Install equipment in accordance with reviewed product data, final shop drawings, manufacturer's written instructions and recommendations, and as indicated on the

Drawings.

- F. Functional testing, commissioning, and first parameter adjusting shall be carried out by a factory trained manufacturer's representative field service engineer. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment. Report to the Engineer any discrepancies or issues with the installation.
- G. Provide final protection and maintain conditions in a manner acceptable to the manufacturer that shall help ensure that the equipment is without damage at time of Substantial Completion.
- H. Directory Card: Type the enclosure's circuit directory card upon completion of work. Refer to Section 26 05 53 "Identification for Electrical Systems" for additional requirements.

3.2 INSTALLATION

- A. Install panelboards in accordance with manufacture's written instructions, NEMA PB 1.1 and NEC Standards.
- B. Coordinate installation of panelboards and enclosure with cable and raceways installation work.
- C. Anchoring: Anchor the enclosures firmly to walls and structural surfaces ensuring that they are permanently and mechanically secured. All panels shall mount to 1-5/8" unistrut. Minimum Hardware: 15/16".
- D. Concrete Pads: Install each floor-mounted power distribution panelboard on a reinforced concrete housekeeping pad. The housekeeping pad shall extend 3" beyond the housing of the distribution panel, unless otherwise shown. Furnish the exact position of any block outs, dimensions, and location of the housekeeping pads in time to prevent delay of the concrete work. Refer to Section 26 00 00 "Electrical General Provisions" for additional requirements.
- E. Inspect complete installation for physical damage, proper alignment, anchorage, and grounding.
- F. Measure steady state load currents at each panelboard feeder; rearrange circuits in the panelboard to balance the phase loads within 20% of each other. Maintain proper phasing for multi-wire branch circuits.
- G. Check tightness of bolted connections and circuit breaker connections using calibrated torque wrench or torque screwdriver per manufacturer's written specifications.

END OF SECTION

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SECTION 26 27 26 WIRING DEVICES

PART 1 - GENERAL

1.1 SCOPE OF WORK

- A. Furnish all labor, materials, equipment and install wiring devices as shown on the Drawings and as specified herein.
- B. Provide all interconnecting conduit and branch circuit wiring for receptacle circuits in accordance with the NEC.

1.2 RELATED WORK

- A. Section 26 05 33 Raceways and Boxes for Electrical Systems.

1.3 SUBMITTALS

- A. Submittals shall be in accordance with Section 26 00 00.

1.4 REFERENCE STANDARDS

- A. Wiring devices shall comply with the requirements of the National Electric Code (NEC) and shall be Underwriters Laboratories (UL) labeled.

PART 2 - PRODUCTS

2.1 MATERIALS

2.2 WALL SWITCHES

- A. Wall switches shall be heavy duty, specification grade, toggle action, flush mounting quiet type. All switches shall conform to the latest revision of Federal Specification WS 896. Wall switches shall be suitable for the area classification indicated and shall be of the following types and manufacturer:
 - 1. Single pole, 20 Amp, 120/277 Volt - Cooper Wiring Devices; Hubbell Wiring Devices-Kellems; Pass & Seymour, Inc. or equal.
 - 2. Double pole, 20 Amp, 120/277 Volt - Cooper Wiring Devices; Hubbell Wiring Devices-Kellems; Pass & Seymour, Inc. or equal.
 - 3. Three way, 20 Amp, 120/277 Volt - Cooper Wiring Devices, Hubbell Wiring Devices-Kellems; Pass & Seymour, Inc. or equal.
 - 4. Four way, 20 Amp, 120/277 Volt - Cooper Wiring Devices; Hubbell Wiring Devices-Kellems; Pass & Seymour, Inc. or equal.
 - 5. Single pole, 20 Amp, 120/277 Volt - key operated, Cooper Wiring Devices; Hubbell Wiring Devices-Kellems; Pass & Seymour, Inc. or equal.
 - 6. Single pole, 20 Amp, 120 Volt - red pilot-lighted handle, Cooper Wiring Devices; Hubbell Wiring Devices-Kellems; Pass & Seymour, Inc. or equal.
 - 7. Single pole, 20 Amp, 120 Volt, clear lighted handle, Cooper Wiring Devices; Hubbell Wiring Devices-Kellems; Pass & Seymour, Inc. or equal.
 - 8. Momentary contact, three position, 2 circuit, center off - Cooper Wiring Devices;

Hubbell Wiring Devices-Kellems; Pass & Seymour, Inc. or equal.

- B. Fluorescent wall box dimmer switch for 120/277 Volt control of rapid start fluorescent lamps with a dimming range of 100 percent to 0.5 percent light for 120 Volt and 100 to 1 percent light for 277 Volt shall be compatible with dimming ballast. Dimmer switch controls shall be as manufactured by Lutron Electronics Inc.; Lithonia Lighting; Pass & Seymour, Inc. or equal.
- C. Explosion-proof single pole factory sealed switches shall be for 20 Amps, 120/277 volts, mounted in copper free aluminum or malleable iron cast boxes and be similar and equal to Crouse-Hinds EDS Series, Appleton Electric Co. EDS; Hubbell HBL or equal.

2.3 RECEPTACLES

- A. Receptacles shall be heavy duty, specification grade of the following types and manufacturer or equal. Receptacles shall conform to Fed Spec WC596-F.
 - 1. Duplex, 20 Amp, 125 Volt, 2 Pole, 3 Wire; Cooper Wiring Devices; Hubbell Wiring Devices-Kellems; Pass & Seymour, Inc. or equal.
 - 2. Weatherproof/corrosion resistant single, 20 Amp, 125 Volt, 2 Pole, 3 Wire, with cover; Crouse-Hinds Co., Catalog No. WLRS-5-20; Appleton Electric FSKJ520; Pass & Seymour or equal.
 - 3. Corrosion resistant duplex, 20 Amp, 125 Volt, 2-pole, 3-wire, high visibility yellow nylon face, nickel plated brass or copper alloy power contacts, Cooper-Arrow/Hart Catalog No. 5362CRY; Hubbell Catalog No. HBL53CM62; Bryant-Electric Catalog No. BRY5362CR; or equal.
 - 4. Weather & tamper resistant ground fault interrupter, duplex, 20 Amp, 125 Volt, 2-pole, 3-wire, gray nylon face, Cooper Wiring Devices Catalog No. TWRVG20GY; Hubbell Catalog No. GFTR20GY; Bryant-Electric Catalog No. GFTR20GY; or equal.
 - 5. Ground fault interrupter, duplex, 20 Amp, 125 Volt, 2 Pole, 3 Wire, GFCI feed thru type with "test" and "reset" buttons. Cooper Wiring Devices; Hubbell Wiring Devices-Kellems; Pass & Seymour, Inc. or equal.
 - 6. Duplex, 20 Amp, 125 Volt, 2 Pole, 3 Wire, transient voltage surge suppressor and audio alarm or indicating light to indicate bad ground or failed MOV. Cooper Wiring Devices; Hubbell Wiring Devices-Kellems; Pass & Seymour, Inc. or equal.
 - 7. Clock hanger single, 15 Amp, 125 Volt, 2 Pole, 3 Wire, with hanging hook on device plate. Cooper Wiring Devices; Hubbell Wiring Devices-Kellems; Pass & Seymour, Inc. or equal.
 - 8. Single, "power lock", 20 Amp, 125 Volt, 2 Pole, 3 Wire; Cooper Wiring Devices; Hubbell Wiring Devices-Kellems; Pass & Seymour, Inc. or equal.
 - 9. Single, 20 Amp, 250 Volt, 2 Pole, 3 Wire; Cooper Wiring Devices; Hubbell Wiring Devices-Kellems; Pass & Seymour, Inc. or equal.
 - 10. Single twist-lock, 30 Amp, 125 Volt, 2 Pole, 3 Wire; Cooper Wiring Devices; Hubbell Wiring Devices; Arrow Hart, Pass & Seymour, Inc. or equal.
 - 11. Single twist-lock with matching plug, 20 Amp, 250 Volt, 2 Pole, 3 Wire; Cooper Wiring Devices; Hubbell Wiring Devices; Arrow Hart, Pass & Seymour, Inc. or equal.
 - 12. Single twist-lock with matching plug, 30 Amp, 250 Volt, 2 Pole, 3 Wire; Arrow-Hart, or similar by Harvey Hubbell, Inc.; Pass & Seymour, Inc. or equal.

13. Explosion-proof and factory sealed Class 1, Divisions 1&2, Groups C&D; wet location rated; delayed action; minimum 115 – 230Vac; 2-wire; 3-pole; angle receptacle with spring cover and cast or malleable iron back box; matching plug:
 - a. Single gang (singlex): Cooper Crouse-Hinds CPS152-xx1 (receptacle); CPP516 (plug); Appleton Electric; Hubbell-Killark; or equal.
 - b. Two gang (duplex): Cooper Crouse-Hinds CPS152-xx2 (receptacle); two (2) CPP516 (plugs); Appleton Electric; Hubbell-Killark; or equal.
14. Explosion-proof and factory sealed Class 1, Divisions 1&2, Groups C&D; wet location rated; interlocked circuit breaking; minimum 125 – 250Vac; 2-wire; 3-pole; angle receptacle with spring cover and cast or malleable iron back box (receptacle shall NOT accept non-explosion proof standard NEMA configuration plugs); matching plug (plug shall fit any non-explosion proof receptacle (NEMA 5-20R, 6-20R)).
 - a. Single gang (singlex): Cooper Crouse-Hinds ENRxx1201 (receptacle); ENP5201 (plug); Appleton Electric; Hubbell-Killark; or equal.
 - b. Two gang (duplex): Cooper Crouse-Hinds ENRxx2201 (receptacle); two (2) ENP5201 (plugs); Appleton Electric; Hubbell-Killark; or equal.

2.4 DEVICE PLATES

- A. Plates for indoor flush mounted devices shall be of the required number of gangs for the application involved and shall be as follows:
- B. Administration type buildings: Smooth, high impact nylon of the same manufacturer and color as the device. Final color shall be as selected by the Architect.
 1. Where permitted in other areas of the plant, flush mounted devices in cement block construction shall be Type 302 high nickel (18-8) stainless steel of the same manufacturer as the devices.
 2. Plates for indoor surface mounted device boxes shall be cast metal of the same material as the box, Crouse-Hinds No. DS23G and DS32G; Appleton FSK1DRC, FSK1TSEC; Pass & Seymour or equal.
- C. Oversized plates shall be installed where standard plates do not fully cover the wall opening.
- D. Device plates for switches mounted outdoors or indicated as weatherproof shall be gasketed, cast aluminum with provisions for padlocking switches "On" and "Off", Crouse Hinds No. DS185; Appleton FSK1VS; Pass & Seymour or equal.
- E. Multiple surface mounted devices shall be ganged in a single, common box and provided with an adapter, if necessary, to allow mounting of single gang device plates on multigang cast boxes.
- F. Engraved device plates shall be provided where required.
- G. Weatherproof, gasketed cover for GFI receptacle mounted in a FS/FD box shall be Cooper Crouse-Hinds; RACO (Hubbell); Pass & Seymour, Inc. or equal.
- H. Weatherproof metallic 'Not Attended/While-In-Use' cover, UV & powder die-cast metal construction, minimum 3-1/2 in deep cover, gasketed, horizontal or vertical mounting as required, single or double gang as required, lockable hasp, as manufactured by Thomas & Betts (Red Dot); TayMac; Orbit Electric; or equal.

- I. Weatherproof (with plug NOT inserted) cover, lift-lid, single or double gang as required, corrosion resistant die-cast construction, self closing stainless steel spring doors, screw attach to FS, FD or other device boxes, EPDM gasket on base of cover (not in lid) surrounding receptacle providing protection while plug is installed, as manufactured by Cooper Crouse-Hinds WLRS (or WLRD), Appleton FSK-WR1 (or -WRD); Arrow-Hart; or equal.

2.5 THREE PHASE POWER RECEPTACLES

- A. Three phase power receptacles and plugs shall be rated for the voltage and current ratings of the connected load unless otherwise shown on the Drawings.
- B. Receptacles and plug housings shall be constructed of copper free aluminum listed to UL Standard 498 for watertight construction. Hardware shall be stainless steel.
- C. Performance
 - 1. Maximum working voltage: 600 Volts RMS.
 - 2. Dielectric withstand voltage: 3000 Volts.
 - 3. Full load break capability at rated current.
 - 4. 5000 connect/disconnect cycles at rated voltage and current.
- D. Furnish and install one mating plug with each receptacle.
- E. Provide the following features:
 - 1. Color coded by voltage.
 - 2. One piece housing/angled backbox
 - 3. Shrouded pins
 - 4. Self closing gasketed cover.
 - 5. Watertight cable entrances/stress relief grips.
 - 6. Mating keys.
- F. Acceptable manufacturers:
 - 1. Hubbell
 - 2. Appleton
 - 3. Cooper Crouse-Hinds

2.6 INTERLOCKED THREE PHASE POWER RECEPTACLES

- A. Interlocked three phase power receptacles shall include a combination receptacle and a mechanically interlocked disconnect switch. The two units shall be interlocked to prevent removal or insertion of the plug unless the switch is in the OFF position.
- B. Provide a matching plug for every unit furnished.
- C. Switch, power receptacle and mating plug shall be constructed of copper free aluminum.
- D. Assemble shall be listed to UL Standard 498 for watertight- construction.
- E. Hardware shall be stainless steel.
- F. Performance:
 - 1. Maximum working voltage: 600 Volts RMS.
 - 2. Dielectric withstand voltage: 3000 Volts.

3. Full load break capability at rated current.
 4. 5000 connect/disconnect cycles at rated voltage and current.
- G. Provide the following features:
1. Color coded by voltage.
 2. One piece housing/angled backbox
 3. Shrouded pins
 4. Self closing gasketed cover.
 5. Watertight cable entrances/stress relief grips.
 6. Mating keys.
- H. The disconnect switch shall be [unfused] [fused] with ratings as hereinbefore specified. Provide lockout provisions on the disconnect switch handle.
- I. Acceptable manufacturers:
1. Crouse-Hinds
 2. Appleton
 3. Killark (Hubbell)
 4. Hubbell

2.7 POKE-THRU SERVICE FITTINGS

- A. Poke-thru service fittings shall be installed in a 2-in core drilled hole, fit floor thicknesses of 2-1/2-in to 7-in and be fire rated.
- B. Poke-thru service fittings shall be barriered to handle both high and low tension services and be designed for both new construction and building retrofit.
- C. Service fitting heads shall each contain a 20 Amp, 125 Volt, 2 Pole, 3 Wire duplex receptacle on one side and provisions for up to 2-25 pair telephone cables on the remaining side.
- D. Complete poke-thru services fitting shall be as manufactured by Wiremold; Hubbell Wiring Devices; Steel City (Thomas & Betts); Walker or equal.

2.8 WALL SWITCH OCCUPANCY SENSORS – SMALL AREAS

- A. Sensor shall recess into single gang switch box and fit a standard GFCI opening.
- B. Sensor must meet NEC grounding requirements by providing a dedicated ground connection and grounding to mounting strap. Line and load wire connections shall be interchangeable. Sensor shall not allow current to pass to the load when sensor is in the unoccupied (OFF) condition.
- C. Sensor shall use Passive Infrared (PIR) sensing incorporating a nominal one half inch focal length lens viewing 9 inches above and below horizontal view pattern measured at 10 feet.
- D. Sensor shall optional features for photocell/daylight override, vandal resistant lens, and no switch as specified.
- E. In areas with inboard/outboard switching, sensor shall provide two dedicated relays and override switches. Each relay shall have independent programmable time delays.
- F. In areas with obstructions to the occupant's workspace, sensor shall utilize programmable

- dual technology PIR/Microphonic Passive Dual Technology (PDT) sensing.
- G. Ultrasonic or Microwave based sensing technologies will not be acceptable.
 - H. All models shall "Reduced Turn On". This is a field programmable function for problematic areas with unforeseen reflective surfaces. False turn on shall be eliminated with this feature.
 - I. Sensor shall be UL Listed and warranted for 5 years.
 - J. Sensor shall be the following model as manufactured by Sensor Switch, Inc., or equal. Device color and optional features as specified.
 - 1. WSD (PIR)
 - 2. WSD-2P (PIR inboard/outboard)
 - 3. WSD-PDT (PIR/Microphonic)
 - 4. WSD-PDT-2P (PIR/Microphonic inboard/outboard)
 - 5. WSD-SA (PIR Semi-Automatic)
 - 6. WSD-PDT-SA (PIR/Microphonic Semi-Automatic)

2.9 WALL SWITCH OCCUPANCY SENSORS – LARGE AREAS

- A. Sensor shall recess into single gang switch box and fit a standard GFCI opening.
- B. Sensor must meet NEC grounding requirements by providing a dedicated ground connection and grounding to mounting strap. Line and load wire connections shall be interchangeable. Sensor shall not allow current to pass to the load when sensor is in the unoccupied (OFF) condition.
- C. Sensor shall use Passive Infrared (PIR) sensing incorporating a nominal one-inch focal length lens viewing 9 inches above and below horizontal view pattern measured at 20 feet.
- D. Sensor shall optional features for photocell/daylight override, vandal resistant lens, and no switch as specified.
- E. In areas with inboard/outboard switching, sensor shall provide two dedicated relays and override switches. Each relay shall have independent programmable time delays.
- F. In areas with obstructions to the occupant's workspace, sensor shall utilize programmable dual technology PIR/Microphonic Passive Dual Technology (PDT) sensing.
- G. Ultrasonic or Microwave based sensing technologies will not be acceptable.
- H. All models shall "Reduced Turn On". This is a field programmable function for problematic areas with unforeseen reflective surfaces. False turn on shall be eliminated with this feature.
- I. Sensor shall be UL Listed and warranted for 5 years.
- J. Sensor shall be the following model as manufactured by Sensor Switch, Inc., or equal. Device color and optional features as specified.
 - 1. LWS (PIR)
 - 2. LWS-2P (PIR inboard/outboard or two circuits)
 - 3. LWS-PDT (PIR/Microphonic)
 - 4. LWS-PDT-2P (PIR/Microphonic inboard/outboard or two circuits)
 - 5. WSD-SA (PIR Semi-Automatic)

6. WSD-PDT-SA (PIR/Microphonic Semi-Automatic)

2.10 CEILING MOUNTED OCCUPANCY SENSORS

- A. Occupancy sensors shall be provided in areas as shown on the Drawings. Sensor shall be line voltage, microprocessor based ultrasonic and infrared unit with adjustable sensitivity and time delay functions, LED indicator lamp and self-contained relay for switching the lighting load. Sensors shall be CMR-PDT-9 as manufactured by Sensorswitch, Inc., or similar by Watt Stopper, Leviton Manufacturing Co., or approved equal.
- B. Occupancy sensors shall be ceiling mounted and wired into the 120 Volt lighting circuits ahead of the area switch controls so that the occupancy sensor shall activate lights in their "as-left" switched state.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Switch and receptacles outlets shall be installed flush with the finished wall surfaces in areas with stud frame and gypsum board construction, in dry areas with cement block construction or when raceways are shown as concealed on the Drawings.
- B. Do not install flush mounted devices in areas designated DAMP, WET or WET/CORROSIVE on the Drawings. Provide surface mounted devices in these areas.
- C. Where individual ground fault interrupter type receptacles are shown on the Drawings connected to the same circuit, the Contractor shall provide all ground fault interrupter type receptacles. Use of one ground fault interrupter type receptacle to protect downstream conventional receptacles is unacceptable.
- D. Provide corrosion resistant receptacles and 'While-In-Use' weatherproof covers in areas designated CORROSIVE on the Drawings.
- E. Convenience outlets shall be 18-in above the floor unless otherwise required or shown on the Drawings.
- F. Convenience outlets installed in rooms designated as WET or where equipment may be hosed down shall be mounted minimum 48-in above deck or grade (or as shown on the Drawings) and shall be weather & tamper resistant, ground fault circuit interrupter type, installed within a 'While-In-Use' weatherproof cover.
- G. Convenience outlets mounted outdoors shall be mounted minimum 48-in above deck or grade (or as shown on the Drawings) and shall be weather & tamper resistant, ground fault circuit interrupter type, installed within a 'While-In-Use' weatherproof cover.
- H. Switches and dimmer controls for lighting shall be mounted 48-in above the finished floor unless otherwise noted or required.
- I. The location of all devices is shown, in general, on the Drawings and may be varied within reasonable limits so as to avoid any piping or other obstruction without extra cost, subject to the approval of the Engineer. Coordinate the installation of the devices for piping and equipment clearance.

3.2 IDENTIFICATION

- A. Comply with Division 26 Section "Electrical Identification."
 - 1. Receptacles: Identify panelboard and circuit number from which served. Use hot, stamped or engraved machine printing with white-filled lettering on face of plate, and durable wire markers or tags inside outlet boxes.

END OF SECTION

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SECTION 26 28 16
ENCLOSED SWITCHES AND CIRCUITS BREAKERS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Fusible (blade) switches.
 - 2. Nonfusible (blade) switches.
 - 3. Nonfusible (rotary) switches.
 - 4. Molded-case circuit breakers (MCCBs).
 - 5. Flange-mounted (blade) switches.
 - 6. Compact, Class I, Division I/II Non-fused disconnect switch

1.2 SUBMITTALS

- A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include dimensioned elevations, sections, weights, and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.
 - 1. Enclosure types and details.
 - 2. Current and voltage ratings.
 - 3. Short-circuit current ratings (interrupting and withstand, as appropriate).
- B. Shop Drawings: For enclosed switches and circuit breakers. Include plans, elevations, sections, details, and attachments to other work.
 - 1. Wiring Diagrams: For power, signal, and control wiring.
- C. Field quality-control reports.
 - 1. Test procedures used.
 - 2. Test results that comply with requirements.
 - 3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.
- D. Manufacturer's field service report.
- E. Operation and Maintenance Data: For enclosed switches and circuit breakers to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 1 Section "Operation and Maintenance Data," include the following:
 - 1. manufacturer's written instructions for testing and adjusting enclosed switches and circuit breakers.

1.3 QUALITY ASSURANCE

- A. Source Limitations: Obtain enclosed switches and circuit breakers, overcurrent protective devices, components, and accessories, within same product category, from single source from single manufacturer.
- B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for enclosed switches and circuit breakers, including clearances between enclosures, and

- adjacent surfaces and other items.
- C. Comply with indicated maximum dimensions.
- D. 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.
- E. Comply with NFPA 70.

1.4 PROJECT CONDITIONS

- A. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:
 - 1. Ambient Temperature: Not less than minus 22° F and not exceeding 120° F.
 - 2. Altitude: Not exceeding 6,600 feet.

1.5 COORDINATION

- A. Coordinate layout and installation of switches, circuit breakers, and components with equipment served and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

1.6 EXTRA MATERIALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Fuses: Equal to 10% of quantity installed for each size and type, but no fewer than three of each size and type.
 - 2. Fuse Pullers: Two for each size and type.

PART 2 - PRODUCTS

2.1 FUSIBLE (BLADE) SWITCHES

- A. Manufacturers: Subject to compliance with the requirements of this Section, provide products by one of the following:
 - 1. Eaton Corporation; Cutler-Hammer Products.
 - 2. General Electric Company; GE Industrial Systems.
 - 3. Rockwell Automation; Allen Bradley
 - 4. Square D; Schneider Electric.
- B. Type HD, Heavy Duty, Single Throw, 600 Vac, 1,200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate specified fuses, lockable handle with capability to accept 3 padlocks, and interlocked with cover in closed position.
- C. Accessories:
 - 1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
 - 2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
 - 3. Lugs: Mechanical type, suitable for number, size, and conductor material.

4. Service-Rated Switches: Labeled for use as service equipment.
5. Provide a flange mounted disconnect switch handle on enclosure front as indicated on the contract drawings.
 - a. Flange mounted switch depth can be variable or fixed as required by disconnect switch size and fusible or non-fusible type following manufacturer recommendations.
 - b. Enclosures and switches shall have defeatable door interlocks that prevent the door from opening when the handle is in the ON position. Defeater mechanism shall be front accessible.

2.2 NONFUSIBLE (BLADE) SWITCHES

- A. Manufacturers: Subject to compliance with the requirements of this Section, provide products by one of the following:
 1. Eaton Corporation; Cutler-Hammer Products.
 2. General Electric Company; GE Industrial Systems.
 3. Rockwell Automation; Allen Bradley
 4. Square D; Schneider Electric.
- B. Type HD, Heavy Duty, Single Throw, 600 Vac, 1,200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept 3 padlocks, and interlocked with cover in closed position.
- C. Accessories:
 1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
 2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
 3. Lugs: Mechanical type, suitable for number, size, and conductor material.

2.3 NONFUSIBLE (ROTARY) SWITCHES

- A. Manufacturers: Subject to compliance with the requirements of this Section, provide products by one of the following:
 1. Eaton Corporation; Cutler-Hammer Products.
 2. General Electric Company; GE Industrial Systems.
 3. Rockwell Automation; Allen Bradley
 4. Square D; Schneider Electric.
- B. Ratings
 1. The non-fusible rotary disconnect switches shall have UL ratings in 100, 200, 400, 600, 800, and 1200A sizes (at 600 VAC), with power/voltage as indicated on the drawings.
- C. Construction
 1. Switch
 - a. The non-fusible rotary disconnect switches shall have a compact design and high resistance to humidity.
 - b. Each non-fusible rotary disconnect switch shall be a 3- or 4-pole version, as

indicated on the drawings.

2. Operating Shafts and Handles

- a. The non-fusible rotary disconnect switches shall have 12 inch or 22 inch operating shafts.
- b. Rotary operating handles shall be matte black with defeater, ingress rated NEMA 4X.
- c. Three-point slotted latch system shall be provided with quarter turn rotary handle.

D. Accessories

1. The non-fusible rotary disconnect switches shall accommodate up to 2 N.O./N.C. Form C contacts.
2. Terminal shields shall offer line and load protection against contact with terminals.
3. Line and load lugs shall be suitable for single- or dual-conductor applications.
4. Bolt kits shall be supplied for adapting lugs or ring/crimp conductors.

2.4 MOLDED-CASE CIRCUIT BREAKERS

A. Manufacturers: Subject to compliance with the requirements of this Section, provide products by one of the following:

1. Eaton Corporation; Cutler-Hammer Products.
2. General Electric Company; GE Industrial Systems.
3. Square D; Schneider Electric.

B. General Requirements: Comply with UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents.

C. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.

D. Features and Accessories:

1. Standard frame sizes, trip ratings, and number of poles.
2. Lugs: Mechanical type, suitable for number, size, trip ratings, and conductor material.

2.5 FLANGE-MOUNTED (BLADE) SWITCHES

A. Manufacturers: Subject to compliance with the requirements of this Section, provide products by one of the following:

1. Eaton Corporation; Cutler-Hammer Products.
2. General Electric Company; GE Industrial Systems.
3. Rockwell Automation; Allen Bradley
4. Square D; Schneider Electric.

B. Type HD, Heavy Duty, Single Throw, 600 Vac, 200 A and Smaller: UL 98, UL 9422 and NEMA KS 1, horsepower rated, lockable handle with capability to accept padlock, and interlocked with cover in closed position.

C. Accessories:

1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
3. Lugs: Mechanical type, suitable for number, size, and conductor material.
4. Provide a flange mounted disconnect switch handle on enclosure front as indicated on the contract drawings.
 - a. Flange mounted switch depth can be variable or fixed as required by disconnect switch size and fusible or non-fusible type following manufacturer recommendations.
 - b. Enclosures and switches shall have defeatable door interlocks that prevent the door from opening when the handle is in the ON position. Defeater mechanism shall be front accessible.

2.6 COMPACT, CLASS I, DIVISION I/II NON-FUSED DISCONNECT SWITCH

- A. Manufacturers: Subject to compliance with the requirements of this Section, provide products by one of the following:
 1. Hubbell, Killark, B7NFD Series
 2. Larson Electronics
- B. Features
 1. The mechanism shall be load-break switching and isolation, IL508 and UL98 rated.
 2. Rotary handle style operating mechanism with lock out provisions.
- C. Materials
 1. Enclosure Copper-free aluminum
 2. Cover Bolts: 316 Stainless Steel
 3. O-ring: Silicone
 4. Finish: Grey Powder Polyester painted, exterior, electrostatically applied
 5. Electrical rated: 600-VAC 30-100 Amp.
- D. Accessories:
 1. Removable ductile mounting lugs adjusting to irregular mounting services.

2.7 ENCLOSURES

- A. Enclosed Switches and Circuit Breakers: NEMA AB 1, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.
 1. Indoor, Air Conditioned Locations: NEMA 250, NEMA 12.
 2. Indoor, Ventilated, Dry and Clean Locations: NEMA 250, NEMA 4X Type 316 Stainless Steel.
 3. Outdoor Locations: NEMA 250, NEMA 4X Type 316 Stainless Steel.
 4. Other Wet or Damp, Indoor Locations: NEMA 250, NEMA 4X Type 316 Stainless Steel.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.
- B. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.
- C. Install fuses in fusible devices.
- D. Comply with NECA 1.

3.3 IDENTIFICATION

- A. Comply with requirements in Division 26 Section 26 05 53 "Identification for Electrical Systems."
 - 1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
 - 2. Label each enclosure with engraved metal or laminated-plastic nameplate.

3.4 FIELD QUALITY CONTROL

- A. Acceptance Testing Preparation:
 - 1. Test insulation resistance for each enclosed switch and circuit breaker, component, connecting supply, feeder, and control circuit.
 - 2. Test continuity of each circuit.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to perform the following:
 - 1. Inspect switchgear, wiring, components, connections, and equipment installation. Test and adjust components and equipment.
 - 2. Assist in field testing of equipment, including pretesting and adjusting of automatic power factor correction units as applicable.
 - 3. Report results in writing.
- C. Tests and Inspections:
 - 1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 - 2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
 - 3. Perform the following infrared scan tests and inspections and prepare reports:
 - a. Initial Infrared Scanning: After Substantial Completion, but not more than 60

- days after Final Acceptance, perform an infrared scan of each enclosed switch and circuit breaker. Remove front panels so joints and connections are accessible to portable scanner.
- b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each enclosed switch and circuit breaker 11 months after date of Substantial Completion.
 - c. Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
4. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.
- D. Enclosed switches and circuit breakers will be considered defective if they do not pass tests and inspections.
 - E. Prepare test and inspection report, including a certified report that identifies enclosed switches and circuit breakers and that describes scanning results. Include notation of deficiencies detected, remedial action taken and observations after remedial action.
- 3.5 ADJUSTING
- A. Adjust moving parts and operable components to function smoothly and lubricate as recommended by manufacturer.
 - B. Set field-adjustable circuit-breaker trip ranges.

END OF SECTION

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SECTION 26 29 03
LOW-VOLTAGE PILOT CONTROL DEVICES

PART 1 - GENERAL

1.1 SUMMARY

- A. Furnish and install all equipment, accessories and materials in accordance with these specifications and drawings
- B. Electrical control devices for panels, motor controllers, control stations, etc. This Section includes the following:
 - 1. Pilot Devices
 - 2. Relays and Timers
 - 3. Miniature Circuit Breakers
 - 4. Terminal Blocks and Fuse Blocks
 - 5. Alarms and Signals
 - 6. Power Supplies
 - 7. Signal Conditioners/Isolators

1.2 REFERENCES

- A. Electrical control devices shall be designed, fabricated, and tested in accordance with the latest revision of the following standards.
 - 1. National Electrical Manufacturers Association (NEMA):
 - a. 250, Enclosures for Electrical Equipment (1,000 V Maximum).
 - b. ICS-2 Industrial Control and Systems: Controllers, Contactors, and Overload Relays Rated 600 V
 - 2. NFPA (National Fire Protection Association):
 - a. 70 National Electrical Code (NEC)
 - 3. Underwriters Laboratories (UL):
 - a. 508, Standard for Safety Industrial Control Equipment.
 - b. 508A, Standard for Safety Industrial Control Panels.

1.3 ENVIRONMENTAL REQUIREMENTS

- A. The supplier shall confirm specified service conditions during and after installation of products.
- B. The supplier shall maintain the area free of dirt and dust during and after installation of products.

1.4 SUBMITTALS

- A. Submittals shall be made in accordance with Submittal Procedures.
- B. Shop drawings (to NEMA ICS 1) shall be submitted to indicate control panel layouts, wiring connections and diagrams, dimensions and support points.
- C. Product data for each electrical control device specified shall be submitted and included as

part of the system in which the device is specified.

D. The manufacturer's installation and user instructions shall be submitted, providing:

1. Receiving, handling and storage instructions.
2. Instructions for adjusting and resetting devices.
3. Recommended preventive maintenance procedures.

1.5 QUALITY ASSURANCE

A. Supplier of Industrial Control Panels shall build control panel under the provisions of UL 508A.

1. Entire assembly shall be affixed with a UL 508A label "Listed Enclosed Instruction Control Panel" prior to shipment to the jobsite.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Unless listed within the product description, product shall be subject to compliance with requirements and provided by one of the following:

1. Eaton Corporation; Cutler-Hammer Products.
2. General Electric Company; GE Industrial Systems.
3. Rockwell Automation; Allen-Bradley Co.; Industrial Control Group.
4. Square D; a brand of Schneider Electric.

2.2 PILOT DEVICES

A. Push Buttons, Selector Switches and Pilot Lights

1. Push buttons, Type 4/4X/13 corrosion-resistant/watertight/oiltight plastic, selector switches and pilot lights shall be 30.5 mm type.
2. Push buttons, selector switches and pilot lights shall have electrical ratings of:
 - a. Dielectric strength: 2,200 V for 1 min.
 - b. Electrical design life cycles: 10,000,000 at maximum rated load
3. Push buttons, selector switches and pilot lights shall have an operating range of minus 40-131°F (minus 40-55°C).
4. Illuminated devices shall offer universal LED, push-to-test, that accepts 12-130 Vac/Vdc voltage input. Lens color shall be as follows:
 - 1) Running, on, open: Red.
 - 2) Stopped, off, closed: Green.
 - 3) Alarm: Amber.
 - 4) White: Power on
 - 5) Blue: All other status indications not covered by the above
 - 6) Lens caps shall be approximately 0.46-inch diameter. Provide legend faceplates engraved to indicate the required function of each device; NEMA 4X rating.
5. Push buttons shall have a diaphragm seal for protection from liquids, particles and

corrosive agents. Button colors shall be as follows:

- 1) Start, open: Red.
 - 2) Stop, close: Green.
 - 3) Black: All other status indications not covered by the above
6. Selector switches shall incorporate a positive detent to prevent the switch from hanging up between positions.
- a. Selector switches shall incorporate a positive detent to prevent the switch from hanging up between positions.

B. Potentiometer Devices

1. Potentiometer devices shall be Type 4/4X/13 corrosion-resistant/watertight/oiltight plastic, 30.5 mm type.
2. Potentiometer devices shall be rated for 300 Vac/Vdc, 2 W maximum (6 Vdc minimum):
 - a. Mechanical design life: Minimum 25,000 cycles
 - b. Rotational torque: 3-12 in/oz
 - c. Stopping torque: Minimum 12 in/lb.
3. Potentiometer devices shall have single-turn operation, 312 degree rotation.
4. Potentiometer devices shall be finger-safe.

C. Elapsed Time Meters

1. Meter shall be heavy duty, electro-mechanical, non-resettable, 6 digit 99999.9h Unit shall be NEMA 4X rated.
2. Mounting of unit with gasket shall maintain rating of enclosure.

2.3 OPERATOR CONTROL STATIONS

A. Devices

1. Control stations shall be provided with heavy industrial 30.5 mm push button(s) or selector switch with appropriate contact action, button/lever type and color/legend marking. Devices shall be Type 4/4X/13 corrosion-resistant/watertight/oiltight plastic. Field mounted stop push buttons shall be supplied with pad lockable attachment to hold the button in position.

B. NEMA 4/13 rated:

1. Die cast aluminum body with manufacturer's standard finish.
2. Gasketed die cast aluminum cover with manufacturer's standard finish.
3. Number of service mounting holes as required.

C. NEMA 4X rated:

1. Type 316 stainless steel body.
2. Gasketed Type 316 stainless steel cover.
3. Number of service mounting holes as required.

2.4 RELAYS AND TIMERS

A. Relays – Time Delay

1. Time delay relays shall mount on tube-type bases with pin-style socket mounting.
 2. Time delay relays shall have 10 amp, B300, DPDT contact ratings and coil voltages as shown on drawings.
 3. Time delay relays shall have adjustable timing ranges. Timing ranges shall be as shown on drawings.
- B. Relays – General Purpose
1. General purpose relays shall have tube-base/Octal 8-pin or 11-pin terminals and "ON" and "OFF" flag indicators.
 2. General purpose relay contacts shall be silver nickel and have 10 amp, B300, DPDT or 3PDT ratings. Coil voltages shall be as shown on drawings.
 3. General purpose relays shall have an electrical schematic on the faceplate, a clear cover for visual inspection and snap-in marker ability.
 4. General purpose relays shall have LED status indicators, push-to-test and manual override.
- C. Relays – Miniature
1. Miniature relays shall be square-base, 4-pole, plug-in type with blade-style terminals and "ON" and "OFF" flag indicators.
 2. Miniature relay contacts shall be silver nickel and have 7 A or 10 A, DPDT or 4PDT ratings. Coil voltages shall be as shown on drawings.
 3. Miniature relays shall have an electrical schematic on the faceplate and a clear cover for visual inspection.
 4. Miniature relays shall have LED status indicators and push-to-test button with incorporated manual override lever.
- D. Relays – Industrial Type
1. Industrial-type relays shall be ruggedly constructed (10 million operation mechanical life), 2-pole or 4-pole, 8-pole, 12-pole, configured NO or NC as shown on drawings, and panel, strip, or DIN rail mounted.
 2. Industrial-type relays shall be finger-safe.
 3. Industrial-type relay contacts shall be silver nickel with a double-break and bifurcated design and 10A, A600 rating for ac.
 4. Accessories shall include adder decks, time delay, latching, surge suppressors and/or mounting strip.
- E. Relays – Voltage Monitoring
1. Relays shall be ruggedly constructed (10 million operation mechanical life) and shall be DIN rail mounted.
 2. Protective functions shall include undervoltage, overvoltage, phase imbalance, phase loss, and phase reversal. Unit shall be capable of automatic and manual reset and shall have LED indication.
 3. Phase imbalance, undervoltage and time dial shall be adjustable.
 4. Relay shall be self-powered, connected to load side with input fuses.
 5. Output contacts shall DPDT, 10 amp at 120 Vac, B300 pilot duty.

F. Relays - Duplex Alternator Relay

1. Relays shall be ruggedly constructed (10 million operation mechanical life) and shall be tube-base/Octal 8-pin relay socket.
2. Detects input of float switch inputs and determines outputs to turn on with line voltage. As the lead and lead switches open, the loads remain energized. When all switches open both loads de-energize simultaneously and the lead load alternates.
3. Output contacts shall be SPDT 5 A at 120 Vac.
4. LED indication shown output position.

G. Timers – Solid-State

1. Solid-state timers shall be DIN rail-mounted.
2. The solid-state timer contacts shall be available as SPDT or DPDT, 8 amp.
3. Solid-state timers shall be available with On-Delay, Off-Delay, On-Delay and Off-Delay, One-Shot, and Flasher operating modes as required on the drawings.
4. Solid-state timers shall have coil surge protection and adjustable timing ranges of 0.05 sec to 60 hours as shown on drawings.

H. Timers – Programmable

1. Programmable timers shall be digital timing relays with LCD display and shall be socket or panel mounted.
2. Programmable timer contacts shall be SPDT, rated 5 A, B300.
3. Programmable timer panel surface shall offer Type 4X/IP66 protection.
4. Programmable timers shall be configurable for "SIGNAL ON-DELAY", "POWER ON-DELAY", "OFF-DELAY", "REPEAT CYCLE", "ONE-SHOT", and "CUMMULATIVE" operating modes as required on the drawings.
5. Programmable timers shall have timing ranges of 0.000 sec. to 9999 hours depending on selected mode and as shown on drawings.

2.5 MINIATURE CIRCUIT BREAKERS

A. Miniature circuit breakers shall be thermal-magnetic, current-limiting type, sized as specified on the drawings:

1. 0.5-63 A current rating
2. 1-pole, 2-pole, or 3-pole
3. Type C or Type D tripping characteristic

B. Miniature circuit breakers shall be UL Listed.

C. Miniature circuit breakers shall be rated for:

1. Voltage: Maximum 480Y/277 Vac (UL/CSA)
2. Interrupting capacity: 10 A (UL/CSA)

D. Housing shall satisfy Insulation Group II/RAL 7035, shall have IP20 finger-safe design, shall be suitable for DIN rail mounting and shall include status indicator window and scratch- and solvent-resistant printing.

E. Miniature circuit breakers shall support reversible line and load connections and shall have dual terminals that:

1. Connect up to 4 wires, or 2 wires and a bus bar.
 2. Clamp from both sides.
 3. Have a unique design that directs wires into openings to prevent wiring misses.
- F. Miniature circuit breakers shall be compatible with UL 508 Listed bus bars, auxiliary contacts, signal contacts, shunt trips and toggle-mount lockout attachments.

2.6 TERMINAL BLOCKS AND FUSE BLOCKS

- A. Terminal Blocks: Control, No. 22 to No. 8 AWG
1. Control terminal blocks shall be screw-type, feed-through.
 2. Nickel-Plated terminals and stainless steel screws.
 3. Control terminal blocks shall be certified:
 - a. UR/CSA: No. 22 to No. 8 AWG wire range, 50 A maximum current, 600 Vac/Vdc rating
 4. Control terminal blocks shall have a snap-in card marking system.
- B. Terminal Blocks – Power
1. Power terminal blocks shall be one of the following styles:
 - a. Mini-block: 3-pole, rated at 600 Vac/Vdc, 115 A
 - b. Open-style power distribution block with copper connectors: 3-pole or 1-pole, rated at 600 Vac/Vdc, 175-760A
 - c. Open-style feed-through/splicer terminal block with copper connectors: 3-pole or 1-pole, rated at 600 Vac/Vdc, 175-760 A
 2. Power terminal blocks shall be certified by UR, CSA, and CE.
 3. Wire ranges and tightening torques shall be labeled on the block.
 4. Power terminal blocks shall have a write-on marking surface or marker retention feature.
- C. Fuse Blocks
1. Fuse block kits shall be used for protection of transformers and control circuits capable of delivering no more than 200,000 RMS symmetrical Amps, 600 V maximum.
 2. Fuse block kits shall be 1-pole, 2-pole or 3-pole.
 3. Each pole shall have a fuse cover.

2.7 PANEL MOUNT SIGNALING ALARM

- A. Combined Sounder and LED Beacon
1. The combined sounder and flashing LED beacon shall have polycarbonate housing and lens, 45 mm size, 22 mm mounting hole, and Type 4/4X/13, IP65/IP66 ingress rating as required on the drawings.
 2. Control logic shall be provided so that the unit can be silenced until the alarm is cleared and reset.
 3. The sounder shall have an average of 103 dBA at 1 m and shall be configured as pulsing.

2.8 CURRENT LOOP SIGNAL SURGE PROTECTOR

- A. Signal conditioner/isolator shall be provided for each analog input/output signal leaving panel.
 - 1. High-density device: 6 mm wide, current/voltage isolator
- B. The signal conditioner/isolator shall mount on DIN rail and provide local status indications

2.9 ENCLOSURE BREATHER/DRAIN

- A. Provide enclosure breather/drain on all wall or switchrack mounted enclosures mounted outdoors or indoors in non-air-conditioned rooms. Breather/Drain shall be Type 316 Stainless, 3/4-inch size and shall not violate NEMA rating of enclosure. Breather/Drain shall be similar Crouse-Hinds, ACD Series.

2.10 TEMPERATURE CONTROL

- A. Provide thermostatic controlled heaters on all panels mounted outdoors or as indicated on the drawings. Heating element shall be Positive Temperature Coefficient (PTC). Heaters shall be sized to protect equipment for low temperatures, condensation, and corrosion.

2.11 POWER SUPPLIES

- A. Control Power Transformer
 - 1. The control power transformer shall be epoxy encapsulated 120 V secondary and shall offer finger-safe protection. Control transformer shall be UL 5085 listed.
 - 2. The control transformer shall have dual primary and secondary fuses.
 - 3. The control transformer shall have sufficient capacity to operator integral device, remotely located pilot, indicating, control devices, motor winding heater and panel heater.
 - 4. The control transformer shall be sized with a 200 VA spare capacity.
- B. 24 Vdc Power Supplies
 - 1. 24 Vdc power supplies shall be switched, DIN rail mounted, screw terminals, temperature range of minus 0 to plus 60 degrees C.
 - 2. 24 Vdc power supplies shall have low inrush current and shall incorporate a minimum 120% Power Burst design.

PART 3 - EXECUTION

3.1 DELIVERY, STORAGE AND HANDLING

- A. The supplier shall coordinate the shipping of equipment.
- B. The supplier shall store the equipment in a clean and dry space.
- C. The supplier shall protect the devices from dirt, water, construction debris, and traffic.

3.2 INSTALLATION

- A. The supplier shall verify all settings have been properly adjusted prior to energizing.
- B. The supplier shall ensure accessibility to electrical control devices.

3.3 OPERATOR CONTROL STATIONS

- A. Permitted uses of NEMA 4/13 Enclosure:
 - 1. Indoor spaces that are dry, ventilated, or air-conditioned spaces.
- B. Permitted uses of NEMA 4X 316 SS Enclosure:
 - 1. All outdoor spaces.
 - 2. Indoor spaces that are damp, wet, or in chemical areas.

END OF SECTION

SECTION 26 41 00
FACILITY LIGHTNING PROTECTION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. The Section specifies the lightning protection system to be installed for the following buildings and structures:
 - 1. Treatment building
- B. Perimeter Fencing
- C. The work includes lightning protection for the structures, internal & external operational equipment, all contents, and occupants by preventing damage to the structure caused by lightning.

1.3 STANDARDS:

- A. The following specifications and standards of the latest issue form a part of this specification:
 - 1. Underwriters Laboratories, Inc. Installation requirements UL 96A
 - 2. National Fire Protection Association, Installation NFPA 780 2014 edition

1.4 SUBMITTALS

- A. Product Data: For air terminals and mounting accessories.
- B. Shop Drawings: Detail lightning protection system, including air-terminal locations, conductor routing and connections, and bonding and grounding provisions. Include indications for use of raceway, data on how concealment requirements will be met, and calculations required by NFPA 780 for bonding of grounded and isolated metal bodies.
- C. Qualification data for firms and persons specified in "Quality Assurance" Article to demonstrate their capabilities and experience. Include data on listing or certification by an NRTL or LPI.
- D. Certification, signed by CONTRACTOR, that roof adhesive for air terminals is approved by manufacturer s of both the terminal assembly and the single-ply membrane roofing material.
- E. Field inspection reports indicating compliance with specified requirements.

1.5 QUALITY ASSURANCE

- A. Installer Qualifications: Engage an experienced installer who is an NRTL or who is certified by LPI as a Master Installer/Designer.
- B. The lightning protection system shall conform to the requirements and standards for

lightning protection systems of UL and NFPA. Upon completion, application shall be made to the Underwriters Laboratories, Inc. for inspection and issuance of the UL Master Label and LPI-177 certification and inspection.

- C. The system to be furnished under this specification shall be the standard product of a manufacturer regularly engaged in the production of lightning protection equipment and shall be the manufacturer's latest approved design. The equipment shall be UL listed and properly UL labeled. All equipment shall be new and of a design and construction to suit the application where it is used in accordance with accepted industry standards as well as UL and NFPA requirements.

1.6 COORDINATION

- A. Coordinate installation of lightning protection with installation of other building systems and components, including electrical wiring, supporting structures, and building materials; metal bodies requiring bonding to lightning protection components; and building finishes.
- B. Coordinate installation of air terminals attached to roof systems with roofing manufacturer and Installer.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. Automatic Lightning Protection.
 - 2. ERICO International Corporation.
 - 3. Harger Lightning Protection, Inc.
 - 4. Heary Bros. Lightning Protection Co. Inc.
 - 5. Independent Protection Co.
 - 6. Robbins Lightning Inc.
 - 7. Thompson Lightning Protection, Inc.

2.2 LIGHTNING PROTECTION SYSTEM COMPONENTS

- A. Provide and install a complete lightning protection system in compliance with the specifications and standards of the most current editions of the National Fire Protection Association's Lightning Protection Standard NFPA 780, and Underwriters Laboratories Lightning Protection Standard UL 96 A. A lightning protection CONTRACTOR who is listed by Underwriters Laboratories, Inc. and a certified Master Installer by the Lightning Protection Institute shall install the system.
- B. Material Requirements:
 - 1. All lightning protection materials and components shall comply in weight, size and composition with class II UL 96 and NFPA 780 lightning protection material requirements. All materials shall be UL listed for lightning protection.
 - 2. Copper materials shall not be mounted on aluminum, Galvalume, galvanized steel or zinc surfaces. This includes those materials that have been painted.

3. Aluminum materials shall not come into contact with earth or where rapid deterioration is possible. Aluminum materials shall not come into contact with copper surfaces or where exposed to runoff from copper surfaces. Aluminum materials shall not be attached to surfaces covered with alkaline-based paint, embedded in concrete or masonry, or installed in a location subject to excessive moisture.
 4. Copper shall be used on all non-aluminum areas
 - a. Air terminals shall be a minimum of 1/2x12 inch solid copper
 - b. Cable shall be 28 strands of .066 inch diameter cable. 133,500 circular mils.
 - c. Connectors and splicers: Cast bronze mechanical with stainless steel bolt and nut.
 - d. Counterpoise shall utilize exothermic type connections to steel cable splicing and cable to ground rods.
 - e. Fasteners shall be copper with stainless steel anchors on masonry locations and stainless steel screws on wood and metal locations
 5. Aluminum materials shall be used on all HVAC units, roof perimeters, and other roof surfaces that are aluminum. If the parapets utilize aluminum coping the roof system shall be completely aluminum except for down conductors & grounding equipment.
 - a. Air terminals shall be a minimum of 5/8x12 inch solid aluminum
 - b. Cable shall be 37 strands of .0756 diameter cable. 211,600 circular mils.
 - c. Connectors and splicers: Cast aluminum mechanical with stainless steel bolt and nut. Exothermic type for grounding connections and splicing below grade
 - d. Fasteners shall be aluminum with stainless steel anchors on masonry locations and stainless steel screws on wood and metal locations
- C. Air Terminals
1. Air terminals shall extend a minimum of 10 inches above the object or area they are to protect. Air terminals shall be located at intervals not exceeding 20 feet along ridges of pitched roofs and along the perimeter of flat or gently sloping roofs (flat or gently sloping roofs include roofs that have a pitch less than 3:12). Flat or gently sloping roofs exceeding 50 feet in width shall be provided with additional air terminals located at intervals not exceeding 50 feet. Air terminals shall be located within 2 feet of the ends of ridges, roof edges and outside corners of protected areas.
 2. Air terminals shall be installed on stacks, flues, mechanical units and other objects not located within a zone of protection. Permanent metal objects on the structure having an exposed metal thickness of 3/16 inches or greater may be substituted for air terminals and shall connected to the lightning protection system as required by the specified standards using main size conductor and bonding plates having a minimum of 3 square inches of surface contact area.
 3. Air terminal bases shall be securely fastened to the structure in accordance with the specified standards. Fasteners may include stainless steel screws, bolts, nails, anchors or adhesive. Adhesive shall be compatible with the surface on which it is used. Any protective sheets or pads that may be required by the roofing manufacturer shall be furnished and installed by the roofing CONTRACTOR.
 4. Main conductors shall be sized as Class I or Class II materials in accordance with the specified standards. Conductors shall provide a 2 way, horizontal or downward path

from each strike or air terminal to connections to the lightning protection ground electrode system. Conductors shall be free of excessive splices and no bend of a conductor shall form an included angle of less than 90 degrees nor have a radius of bend less than 8 inches.

5. Conductors shall be securely fastened to the structure on which they are placed at intervals not exceeding 3 feet. Fasteners shall be of the same material or of a material equally resistant to corrosion as that of the conductor. Any protective sheets or pads that may be required by the roofing manufacturer shall be furnished and installed by the roofing CONTRACTOR.
6. Connector fittings shall be listed for the purpose and of the same material as the conductor or of electrolytically compatible materials.
7. Down conductors shall be sized as Class II materials in accordance with the specified standards. Class II conductors from a higher portion of a structure shall continue to connections to the lightning protection ground electrode system. Down conductors shall be spaced at intervals averaging not more than 100 feet around the perimeter of the structure. In no case shall a structure have fewer than 2 down conductors. Where down conductors are installed exposed on the exterior of a structure and are subject to physical damage or displacement, guards shall be used to protect the conductor a minimum of 6 feet above grade. Metallic guards shall be bonded at each end.
8. In case of structural steel frame construction, down conductors may be omitted and roof conductors shall be connected to the structural steel frame at intervals not exceeding 100 feet along the perimeter of the structure.

D. Roof Penetrations

1. Roof penetrations required for down conductors or for connection to structural steel framework shall be made using thru-roof assemblies with solid riser bars or conduits and appropriate roof flashing. Conductors shall not pass directly through the roof. The roofing CONTRACTOR shall furnish and install the materials required to properly seal all roof penetrations of the lightning protection components and any additional roofing materials or preparations required by the roofing MANUFACTURER for lightning conductor runs to assure compatibility with the warranty for the roof including roof pads that may be required to protect the roof under each of the lightning protection components.

E. Ground Electrodes:

1. Each down conductor shall terminate at a ground electrode dedicated to the lightning protection system, or to a building or facility ground electrode system that consists of multiple ground electrodes that are interconnected with a ground ring conductor.
2. Ground rod electrodes shall be copper-clad steel, a minimum 3/8 inch diameter and 10 feet long. The down conductor shall be connected to the ground electrode using a bronze ground rod clamp having a minimum of 1-1/2 inch contact between the ground rod electrode and the conductor measured parallel to the axis of the ground rod electrode, or by an exothermically welded connection. Ground rod electrodes shall be located a minimum of 2 feet below grade and shall be installed below the frost line where possible (excluding shallow topsoil conditions).
3. Where it is not possible to drive ground rod electrodes because of bedrock or shallow topsoil conditions, ground plate electrodes, radial electrodes, ground ring electrodes,

concrete-encased electrodes, or combinations of these may be used in accordance with NFPA 780.

4. Where the structural steel framework is utilized as down conductors for the system, ground electrodes shall be connected to columns around the perimeter of the structure at intervals averaging not more than 60 feet apart. Columns shall be grounded using either bonding plates having 8 square inches of surface contact area or by exothermically welded connections.

F. Common Bonding of Grounded Systems

1. Common bonding of all grounded systems within the building shall be ensured by interconnecting them to the lightning protection system using main size conductor and fittings.
2. For structures the interconnection of the lightning protection system ground electrodes and other grounded systems shall be in the form of a ground loop conductor.
3. These grounded systems shall include but are not limited to the electrical service, communication, and antenna system grounds as well as all underground metallic piping systems including water, gas, sewer, underground metallic conduits, etc. Interconnection to a gas line shall be made on the customer's side of the meter.

G. Potential Equalization

1. Grounded metal bodies located within the required bonding distance as determined by the bonding distance formula in NFPA 780 shall be bonded to the lightning protection system using the required bonding conductors and connections.

PART 3 - EXECUTION

3.1 INSTALLATION OF CONDUCTORS

- A. General: Conductors shall be installed to interconnect all air terminals to the system of grounding electrodes, and in general provide a minimum of at least 2 paths to ground from any air terminal on the system. Conductors shall provide a horizontal or downward path between the system air terminals and grounding electrode system.
- B. Routing: Conductors shall be routed in such a manner that maximum concealment from public view is achieved. Down conductors may be installed in 1-inch PVC conduit from roof to grade.
- C. Counterpoise Conductors: Counterpoise conductors shall be installed after finished grades are established to insure specified depth and to minimize the possibility of damage. Any counterpoise conductor which is cut or damaged shall be repaired or replaced with no additional cost to the contract.
- D. Connections: All connections between conductors below grade shall be exothermically welded. Improper application of weld shall be replaced at no additional cost to the contract.

3.2 INSTALLATION OF GROUND RODS

- A. General: Ground rods shall be installed vertically at each down conductor position at a minimum of 2 feet from the building foundation wall. Inspection and documentation at each grounded location, weld, depth of counterpoise, etc., shall be made prior to backfill.

CONTRACTOR shall notify ENGINEER in writing to request inspection of underground work and for LPI inspection before backfill. Allow a minimum of 1 week for ENGINEER to make the inspection after notification from CONTRACTOR.

- B. Test Wells and Inspection Wells: Provide prefabricated test and inspection wells for all ground rods installed in paved or concrete areas.

3.3 BONDING OF SECONDARY METALLIC BODIES

- A. Structure Grounding: Provision shall be made at the roof level on reinforced concrete structures for bonding between the roof or down conductors, metallic elements of the roof system and metallic exterior wall systems.
- B. Bonding: All down conductors run in concrete columns shall be bonded to the reinforcing steel at the top and the bottom of the column.

3.4 GENERAL WORKMANSHIP

- A. General: All elements of the Lightning Protection System shall be installed in a professional and workmanlike manner consistent with the best industry practices.
- B. Concealed Installation: All system components shall be concealed to the maximum extent possible to preserve the aesthetic appearance of the project building on which the system is installed.

3.5 COORDINATION WITH OTHER TRADES

- A. Coordination: The CONTRACTOR shall coordinate his work with all trades, to ensure the use of proper materials and procedures in and around the roof in order not to jeopardize the roofing warranty.
- B. Fasteners: Where fasteners are to be embedded in masonry or the structural system, they shall be coordinated to insure installation at the proper time of construction.

3.6 CORROSION PROTECTION

- A. Do not combine materials that can form an electrolytic couple that will accelerate corrosion in the presence of moisture unless moisture is permanently excluded from junction of such materials.
- B. Use conductors with protective coatings where conditions would cause deterioration or corrosion of conductors.

3.7 INSPECTION, CERTIFICATION AND MAINTENANCE

- A. At completion of the installation of the lightning protection system, the CONTRACTOR shall apply for inspection of the system by UL field representatives. The system is to be inspected for compliance with NFPA 780.
- B. If the lightning protection system covers an entire independent structure and the system passes inspection, UL will issue a Master Label® Certificate of Inspection for Lightning Protection System. The CONTRACTOR will submit the certificate for distribution to the premises' OWNER. For the certificate to be valid, the CONTRACTOR must publish the certificate to the UL website, <https://lps.ul.com> where it may be viewed by consumers,

- building OWNERS, insurance agencies and other interested parties. The Master Label Certificate of Inspection is valid for a period of 5 years. If the building changes structurally or if modifications are made to the system during that period, the certificate is no longer valid.
- C. If the scope of the lightning protection system is limited by contractual or other reasons, the installer may limit the scope of the UL inspection. In those cases where the entire system is not inspected, a Master Label Certificate of Inspection will not be issued by UL. They will issue a Letter of Findings of their inspection indicating compliance with the limited scope of the inspection.
 - D. At project closeout, the CONTRACTOR shall provide the OWNER with accurate as-built drawings as well as recommended guidelines for maintenance of the system.

END OF SECTION

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SECTION 31 05 16
AGGREGATES FOR EARTHWORK

PART 1 - GENERAL

1.1 WORK INCLUDED

- A. This Section of the specifications describes the various classes of Aggregate Fill. All of the classes of Aggregate Fill contained in this specification may not be used on this project. The classes of Aggregate Fill used on this project are shown on the drawings or specified in other sections of the specifications. This Section does not include installation. Installation of Aggregate Fill is included in other sections of the specifications and/or on the drawings.

1.2 QUALITY ASSURANCE AND SUBMITTALS

- A. Classification Testing:
 - 1. Contractor Testing:
 - a. Arrange and pay for the services of an independent testing laboratory to sample and test proposed Aggregate Fill materials.
 - b. Submit the test results to the Engineer, and obtain approval prior to providing Aggregate Fill.
 - 2. Owner Testing: When additional testing is required by the Owner, CONTRACTOR shall arrange and pay for additional testing on the Aggregate Fill after delivery to the project site as determined necessary by the Engineer. Contractor to submit for approval the independent testing laboratory.
- B. Contamination Certification:
 - 1. Obtain a written, notarized certification from the Supplier of each proposed Aggregate Fill source stating that to the best of the Supplier's knowledge and belief there has never been contamination of the source with hazardous or toxic materials.
 - 2. Submit these certifications to the Engineer prior to proceeding to furnish Aggregate Fill to the site. The lack of such certification on a potential Aggregate Fill source shall be cause for rejection of that source.

1.3 STANDARDS

- A. Aggregate Fill shall be classified into the appropriate class listed below according to ASTM testing procedures as specified for the various classes.
 - 1. American Society for Testing and Materials (ASTM) Standards:
 - a. ASTM C33 - Specification for Concrete Aggregates
 - b. ASTM C40-Standard Test for Method for Organic Impurities in Fine Aggregates for Concrete
 - c. ASTM C88 - Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium sulfate
 - d. ASTM C94- Standard Specification for Ready-Mixed Concrete
 - e. ASTM C125 - Terminology Relating to Concrete and Concrete Aggregates
 - f. ASTM C131 - Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine

- g. ASTM C535 - Test Method for Resistance to Degradation of Large-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
- h. ASTM D448 - Classification for Sizes of Aggregate for Road and Bridge Construction

PART 2 - PRODUCTS

2.1 MATERIALS; CLASSIFICATIONS

- A. Class 1 Aggregate Fill: Consist of durable particles of crushed stone free of silt, clay, or other unsuitable materials and have a percentage of wear of not more than 40 percent when tested in accordance with ASTM C131 or C535. When material is subjected to five cycles of the sodium sulfate soundness test in accordance with ASTM C88, Sodium Sulfate Solution, the weighted percentage of loss shall not exceed 12 percent. The source of the material shall be approved by the Engineer and meet the following gradation in accordance with ASTM D448, size number 57:

Sieve Size Square Opening	Percent Passing
1-1/2"	100
1"	95-100
1/2"	25-60
No. 4	0-10
No. 8	0-5

- B. Class 2 Aggregate Fill: Consist of durable particles of crushed stone free of silt, clay, or other unsuitable materials and have a percentage of wear of not more than 40 percent when tested in accordance with ASTM C131 or C535. When material is subjected to five cycles of the sodium sulfate soundness test in accordance with ASTM C88, Sodium Sulfate Solution, the weighted percentage of loss shall not exceed 12 percent. The source of the material shall be approved by the Engineer and meet the following gradation in accordance with ASTM D448, size number 67:

Sieve Size Square Opening	Percent Passing
1"	100
3/4"	90-100
3/8"	20-55
No. 4	0-10
No. 8	0-5

- C. Class 3 Aggregate Fill: Consist of durable particles of crushed stone free of silt, clay, or other unsuitable materials and have a percentage of wear of not more than 40 percent when tested in accordance with ASTM C131 or C535. When material is subjected to five cycles of the sodium sulfate soundness test in accordance with ASTM C88, Sodium Sulfate Solution, the weighted percentage of loss shall not exceed 12 percent. The source of the material shall be approved by the Engineer and meet the following gradation in accordance with ASTM D448, size number 7:

Sieve Size Square Opening	Percent Passing
3/4"	100
1/2"	90-100
3/8"	40-70
No. 4	0-15
No. 8	0-5

- D. Class 4 Aggregate Fill: Consist of durable particles of crushed stone free of silt, clay, or other unsuitable materials and have a percentage of wear of not more than 40 percent when tested in accordance with ASTM C131 or C535. When material is subjected to five cycles of the sodium sulfate soundness test in accordance with ASTM C88, Sodium Sulfate Solution, the weighted percentage of loss shall not exceed 12 percent. The source of the material shall be approved by the Engineer and meet the following gradation in accordance with ASTM D448, size number 467:

Sieve Size Square Opening	Percent Passing
2"	100
1-1/2"	95-100
3/4"	35-70
3/8"	10-30
No. 4	0-5

- E. Class 5 Aggregate Fill: Consist of durable particles of crushed stone free of silt, clay, or other unsuitable materials and have a percentage of wear of not more than 40 percent when tested in accordance with ASTM C131 or C535. When material is subjected to five cycles of the sodium sulfate soundness test in accordance with ASTM C88, Sodium Sulfate Solution, the weighted percentage of loss shall not exceed 12 percent. The source of the material shall be approved by the Engineer and meet the following gradation in accordance with ASTM D448, size number 357:

Sieve Size Square Opening	Percent Passing
2-1/2"	100
2"	95-100
1"	35-70
1/2"	10-30
No. 4	0-5

- F. Class 6 Aggregate Fill: Consist of durable particles of crushed stone free of silt, clay, or other unsuitable materials and have a percentage of wear of not more than 40 percent when tested in accordance with ASTM C131 or C535. When material is subjected to five cycles of the sodium sulfate soundness test in accordance with ASTM C88, Sodium Sulfate Solution, the weighted percentage of loss shall not exceed 12 percent. The source of the material shall be approved by the Engineer and meet the following gradation in accordance with ASTM D448, size number 1:

Sieve Size Square Opening	Percent Passing
4"	100
3-1/2"	90-100
2-1/2"	25-60
1-1/2"	0-15
3/4"	0-5

- G. Class 7 Aggregate Fill: Consist of durable particles of crushed stone free of silt, clay, or other unsuitable materials and shall have a percentage of wear of not more than 40 percent when tested in accordance with ASTM C131 or C535. When material is subjected to five cycles of the sodium sulfate soundness test in accordance with ASTM C88, Sodium Sulfate Solution, the weighted percentage of loss shall not exceed 12 percent. The source of the material shall be approved by the Engineer and meet the following gradation in accordance with ASTM D448, size number 6:

Sieve Size Square Opening	Percent Passing
1"	100
3/4"	90-100
1/2"	20-55
3/8"	0-15
No. 4	0-5

- H. Class 8 Aggregate Fill: Consist of durable particles of crushed stone free of silt, clay, or other unsuitable materials and shall have a percentage of wear of not more than 40 percent when tested in accordance with ASTM C131 or C535. When material is subjected to five cycles of the sodium sulfate soundness test in accordance with ASTM C88, Sodium Sulfate Solution, the weighted percentage of loss shall not exceed 12 percent. The source of the material shall be approved by the Engineer and meet the following gradation in accordance with ASTM D448, size number 56:

Sieve Size Square Opening	Percent Passing
1-1/2"	100
1"	90-100
3/4"	40-85
1/2"	10-40
3/8"	0-15
No. 4	0-5

- I. Class 9 Aggregate Fill:
1. Consist of washed and screened gravel and natural sands or sands manufactured by crushing stones complying with the requirements of ASTM C33, except that the gradation shall be as follows:

Sieve Size Square Opening	Percent Passing
1/2"	100
3/8"	95-100
No. 4	80-95
No. 8	65-85
No. 16	50-75
No. 30	25-60
No. 50	10-30
No. 100	0-10

2. Class 9 Aggregate Fill shall have not more than 45 percent passing any sieve and retained on the next consecutive sieve of those shown above, and its fineness modulus, as defined in ASTM C125, shall be not less than 2.3 nor more than 3.1.

J. Class 10 Aggregate Fill:

1. Consist of washed and screened natural sands or sands manufactured by crushing stones complying with the requirements and tests of ASTM C33. The gradation as included in ASTM C33 is as follows:

Sieve Size Square Opening	Percent Passing
3/8"	100
No. 4	95-100
No. 8	80-100
No. 16	50-85
No. 30	25-60
No. 50	10-30
No. 100	0-10

2. Class 10 Aggregate Fill shall have not more than 45 percent passing any sieve and retained on the next consecutive sieve of those shown above, and its fineness modulus, as defined in ASTM C125, shall be not less than 2.3 nor more than 3.1.

- K. Class 11 Aggregate Fill: Consist of durable particles of crushed stone free of silt, clay, or other unsuitable material and have a percentage of wear of not more than 40 percent when tested in accordance with ASTM C131 or C535. When material is subjected to five cycles of the sodium sulfate soundness test in accordance with ASTM C88, Sodium Sulfate Solution, the weighted percentage of loss shall not exceed 12 percent. The source of the material shall be approved by the Engineer and meet the following gradation:

Sieve Size Square Opening	Percent Passing
1-3/4"	100
7/8"	65-90
3/8"	50-70
No. 4	35-55
No. 40	15-30
No. 100	0-12 (Wet Sieve Method)

- L. Class 12 Aggregate Fill: Consist of durable particles of crushed stone free of silt, clay, or other unsuitable material and have a percentage of wear of not more than 40 percent when tested in accordance with ASTM C131 or C535. When material is subjected to five cycles of the sodium sulfate soundness test in accordance with ASTM C88, Sodium Sulfate Solution, the weighted percentage of loss shall not exceed 12 percent. The source of the material shall be approved by the Engineer and meet the following gradation:

Sieve Size Square Opening	Percent Passing
1-1/2"	100
1"	85-100
3/4"	60-95
3/8"	50-80
No. 4	40-65
No. 16	20-40
No. 100	0-12 (Wet Sieve Method)

- M. Class 13 Aggregate Fill: Consist of durable particles of crushed stone free of silt, clay, or other unsuitable material and have a percentage of wear of not more than 40 percent when tested in accordance with ASTM C131 or C535. When material is subjected to five cycles of the sodium sulfate soundness test in accordance with ASTM C88, Sodium Sulfate Solution, the weighted percentage of loss shall not exceed 12 percent. The source of the material shall be approved by the Engineer and shall meet the following gradation:

Sieve Size Square Opening	Percent Passing
1-3/4"	100
7/8"	65-90
3/8"	50-70
No. 4	35-55
No. 40	15-30
No. 100	0-3 (Wet Sieve Method)

- N. Class 14 Aggregate Fill: Consist of durable particles of crushed stone free of silt, clay, or other unsuitable material and have a percentage of wear of not more than 40 percent when tested in accordance with ASTM C131 or C535. When material is subjected to five cycles of the sodium sulfate soundness test in accordance with ASTM C88, Sodium Sulfate Solution, the weighted percentage of loss shall not exceed 12 percent. The source of the material shall be approved by the Engineer and meet the following gradation:

Sieve Size Square Opening	Percent Passing
1-1/2"	100
1"	85-100
3/4"	60-95
3/8"	50-80
No. 4	40-65

Sieve Size Square Opening	Percent Passing
No. 16	20-40
No. 100	0-3 (Wet Sieve Method)

- O. Class 15 Aggregate Fill: Consist of durable particles of silica sand, washed clean, chemically inert, and packaged by the Supplier. The material shall meet applicable regulatory requirements for monitor well filter pack. The source of the material shall be approved by the Engineer and shall meet the following gradation requirements:

Sieve Size Square Opening	Percent Passing
No. 20	98-100
No. 40	0-2

PART 3 - EXECUTION (NOT APPLICABLE)

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SECTION 31 12 00
SELECTIVE CLEARING, GRUBBING, TREE, AND SHRUB REMOVAL

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Provide selective clearing, grubbing, tree and shrub removal around construction site.
 - 2. Coordinate all selective clearing, grubbing, tree and shrub removal with the Owner and will minimize disturbance to existing site as much as possible.
- B. Related Sections:
 - 1. Section 31 23 00 - Excavation Trenching and Backfilling for Utilities.

1.2 REFERENCES

- A. Code of Federal Regulations:
 - 1. 29 CFR 1926 - Safety and Health Regulations for Construction.

1.3 SUBMITTAL

- A. General: Stationing and dimensional details of construction area requiring selective clearing, grubbing, and tree and shrub removal.
- B. Shop Drawings:
 - 1. Indicate typical layout including dimensions.
 - 2. Submit plan(s) as required for selective clearing, grubbing, tree and shrub removal.
 - 3. Submit detail drawings of special accessory components not included in the manufacturer's product data.

1.4 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in work specified in this Section with minimum 5 years documented experience.

1.5 DELIVERY, STORAGE AND HANDLING

- A. Packing, Shipping, Handling and Unloading:
 - 1. As specified herein.
 - 2. Deliver materials to store at the site and handle in a manner which will maintain the materials in their original manufactured or fabricated condition until ready for use.

PART 2 - PRODUCTS – NOT APPLICABLE

PART 3 - EXECUTION

3.1 PREPARATION

- A. Protection:
 - 1. Roads and Walks:
 - a. Keep roads and pedestrian walks that are open to the public free of dirt and

debris at all times.

2. Trees, Shrubs, and Existing Facilities:
 - a. Trees and vegetation to be left standing shall be protected from damage incident to clearing, grubbing, and construction operations by the erection of high visibility fencing or by such other means as the circumstances require.
3. Utility Lines:
 - a. Protect existing utility lines that are indicated to remain from damage.
 - b. Notify the Engineer, Owner, and governing utility, immediately of damage to or an encounter with an unknown existing utility line.
 - c. Repair all damage to existing utility lines prior to start of clearing and grubbing operations.
 - d. When utility lines which are to be removed are encountered within the area of operations, notify the Owner and governing utility within a reasonable time to minimize interruption of the service.

3.2 APPLICATION

A. Clearing:

1. Clear all trees, shrubs, brush and vegetation necessary for construction of the project. All clearing shall be coordinated with the Owner. All trees, shrubs, vegetation not directly impacted by the construction shall be preserved and protected.
2. Clearing shall consist of the felling, trimming, and cutting of trees into sections and the satisfactory disposal of the trees and other vegetation designated for removal, including downed timber, snags, brush, and rubbish occurring within the areas to be cleared.
3. Clearing shall also include the removal and disposal of structures that obtrude, encroach upon, or otherwise obstruct the work.
4. Trees, stumps, roots, brush, and other vegetation in areas to be cleared shall be cut off flush with or slightly above the original ground surface, except such trees and vegetation as may be indicated or directed to be left standing.
5. Trees designated to be left standing within the cleared areas shall be trimmed where needed of dead branches 1-1/2 inches or more in diameter to the heights indicated or directed.
6. Limbs and branches to be trimmed shall be neatly cut close to the bole of the tree or main branches.

B. Tree and Shrub Removal:

1. Where necessary to perform construction operations, remove trees and shrubs within the construction areas. Keep tree and shrub removal to a minimum.
2. This work shall include the removal of trees and their above-ground stumps.
 - a. Below-ground stumps / roots shall not be removed.
 - b. Place geotextile and aggregate above root area of cut trees and shrubs removed in order to minimize risk of tree kill and encourage re-growth.
 - 1) Geotextile: Mirafi N140 or equivalent.
 - 2) Aggregate: Crushed rock provided by Contractor.

3. Removed tree and shrub material shall be disposed of as specified in the Disposal of Materials paragraph.
 4. Depressions made by grubbing shall be filled with suitable material and compacted to make the surface conform with the original adjacent surface of the ground.
- C. Tree and Shrub Pruning:
1. As much as practicable, preference shall be given to tree and shrub pruning over tree and shrub removal.
 2. Prune trees and shrubs within the cleared areas of dead branches 1-1/2 inches or more in diameter; trim branches to heights and in a manner as indicated.
 3. Neatly cut limbs and branches to be trimmed close to the bole of the tree / shrub or main branches.
 4. Limbing of trees should be done so that branches do not rip off strips of tissue. This can be done with an undercut first. Cut far enough from the trunk to avoid damage to the branch collar.
- D. Grubbing:
1. Perform limited grubbing within the project area as required by construction operations.
 2. Grubbing shall consist of the removal and disposal of stumps, and matted roots from the designated grubbing areas.
 3. Material to be grubbed, together with logs and other organic or metallic debris not suitable for foundation purposes, shall be removed to the original ground surface or as indicated.
 4. Depressions made by grubbing shall be filled with suitable material and compacted to make the surface conform with the original adjacent surface of the ground.
- E. Mulching / Reuse or Disposal of Materials:
1. Mulch or otherwise reuse organic materials from selective clearing, grubbing, tree and shrub removal. If materials cannot be mulched / reused, materials shall be disposed.
 2. Logs, stumps, roots, brush, rotten wood, and other organics from the clearing and grubbing operations shall be either mulched on site and spread over cleared and grubbed area or disposed of, except when otherwise directed in writing.
 - a. Such directive will state the conditions covering the disposal of such products and will also state the areas in which they may be placed.
 - b. Burning of refuse and debris shall not be permitted.
 3. Maintain compliance with all Federal and State laws and regulations.
 4. Trash and debris shall be disposed of off-site per Federal, State and local regulations.
- F. Revegetation
1. Disturbed areas shall be revegetated as shown on the Contract Drawings and per the Town of Frisco Unified Development Code, Chapter 180.

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**SECTION 31 20 00
EARTHWORK**

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Site grading.
 - 2. Excavation cut and fill for areas outside of roadways, structures, and trenches.
 - 3. Preparing subgrades for roadways, structures, slabs-on-grade, and related facility work not specified elsewhere.
- B. Related Sections:
 - 1. Section 01 50 00 "Temporary Facilities and Controls" for plant shutdowns.
 - 2. Section 31 12 00 "Site Clearing, Grubbing, Tree, and Shrub Removal"
 - 3. Section 31 23 00 "Excavation, Trenching, and Backfilling for Utilities" for excavation, trenching, and backfilling for utilities.
 - 4. Section 31 23 10 "Structural Excavation and Backfill" for excavation, subgrade preparation, structural backfill, and wall backfill.

1.3 REFERENCES

- A. Definitions.
 - 1. Backfill: Soil material or controlled low-strength material used to fill an excavation.
 - 2. Borrow Soil: Satisfactory soil imported from off-site for use as fill or backfill.
 - 3. Completed Course: A course or layer that is ready for next layer or next phase of Work.
 - 4. Drainage Course: Course supporting the slab-on-grade that also minimizes upward capillary flow of pore water.
 - 5. Earthwork: Includes excavation, fill and compaction, grading, and disposal of waste and surplus material.
 - 6. Excavation: Removal of material encountered above subgrade elevations and to lines and dimensions indicated.
 - a. Authorized Additional Excavation: Excavation below subgrade elevations or beyond indicated lines and dimensions as directed by ENGINEER. Authorized additional excavation and replacement material will be paid for according to Contract provisions for unit prices.
 - b. Bulk Excavation: Excavation more than 10 feet in width and more than 30 feet in length.

- c. Unauthorized Excavation: Excavation below subgrade elevations or beyond indicated lines and dimensions without direction by ENGINEER. Unauthorized excavation, as well as remedial work directed by ENGINEER, shall be without additional compensation.
 - 7. Prepared Ground Surface: Ground surface after completion of required demolition, clearing and grubbing, stripping of topsoil, excavation or fill to grade, and subgrade preparation.
 - 8. Fill: Soil materials used to raise existing grades.
 - 9. Lift: Loose (uncompacted) layer of material.
 - 10. Optimum Moisture Content: Determined in accordance with ASTM Standard specified to determine maximum dry density for relative compaction. Determine field moisture content on basis of fraction passing 3/4-inch sieve.
 - 11. Relative Compaction: Ratio, in percent, of as-compacted field dry density to laboratory maximum dry density as determined in accordance with ASTM D698. Apply corrections for oversize material to either as-compacted field dry density or maximum dry density, as determined by ENGINEER.
 - 12. Rock: Rock material in beds, ledges, unstratified masses, conglomerate deposits, and boulders of rock material that exceed 1 cu. yd. for bulk excavation or 3/4 cu. yd. for footing, trench, and pit excavation that cannot be removed by rock excavating equipment equivalent to the following in size and performance ratings, without systematic drilling, ram hammering, ripping, or blasting, when permitted:
 - a. Excavation of Footings, Trenches, and Pits: Late-model, track-mounted hydraulic excavator; equipped with a 42-inch- wide, maximum, short-tip-radius rock bucket; rated at not less than 138-hp flywheel power with bucket-curling force of not less than 28,090 lbf and stick-crowd force of not less than 18,650 lbf; measured according to SAE J-1179.
 - b. Bulk Excavation: Late-model, track-mounted loader; rated at not less than 210-hp flywheel power and developing a minimum of 48,510-lbf breakout force with a general-purpose bare bucket; measured according to SAE J-732.
 - 13. Structures: Buildings, footings, foundations, retaining walls, slabs, tanks, curbs, mechanical and electrical appurtenances, or other man-made stationary features constructed above or below the ground surface.
 - 14. Subgrade: Surface or elevation remaining after completing excavation, or top surface of a fill or backfill immediately below subbase, drainage fill, or topsoil materials.
 - 15. Utilities: On-site underground pipes, conduits, ducts, and cables, as well as underground services within buildings.
 - 16. Well-Graded: A mixture of particle sizes that has no specific concentrations or lack thereof of one or more sizes producing a material type which, when compacted, produces a strong and relatively incompressible soil mass free from detrimental voids.
- B. Reference Standards.
- 1. ASTM International:
 - a. D448 – Standard Method Classification for sizes of Aggregate for Road and Bridge construction.

- b. D698 – Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,499 ft-lb.ft3 (600 kN-m/m3))
 - c. D2487 – Standard Method Classification of Soils for Engineering Purposes (Unified Soil Classification system)
 - d. D6938 – Standard Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)
- 2. American Association of State Highways and Transportation Officials (AASHTO):
 - a. M288 – Geotextile Specification for Highway Application

1.4 MATERIAL QUALITY CONTROL

- A. Sampling of material stockpiles and material sources shall be in accordance with ASTM D75.
- B. Perform gradation analysis in accordance with ASTM C136 for:
 - 1. Coarse and fine aggregate, natural gravel, crushed stone for foundation, sand, select fill, impervious clay fill, earth fill, and topsoil.
- C. Perform abrasion testing in accordance with ASTM C131 or ASTM C535.
 - 1. Coarse and fine aggregate and when requested by ENGINEER for natural gravel and crushed stone for foundation.
- D. Soundness testing in accordance with ASTM C88.
 - 1. Coarse and fine aggregate and when requested by ENGINEER for natural gravel and crushed stone for foundation.
- E. Deleterious materials determination in accordance with ASTM C40, C117, and C142.
 - 1. Coarse and fine aggregate and when requested by ENGINEER for natural gravel and crushed stone for foundation
- F. Determine liquid limit and plasticity index in accordance with ASTM D4318.
 - 1. Sand for particles passing No. 8 sieve, select fill, impervious clay fill, and earth fill.
- G. Determine pH of topsoil in accordance with ASTM D2974.
- H. Determine permeability (hydraulic gradient) in accordance with ASTM D5084 and percent dispersion in accordance with ASTM D4221 of impervious clay fill materials.
- I. Provide tests results showing flowable fill mix design achieves desired compressive strength.

1.5 SUBMITTALS

- A. Product Data: For the following:
 - 1. Geotextile, if specified on Drawings.
 - 2. Controlled low-strength material, including design mixture.
- B. Samples: 12-by-12-inch Sample of subdrainage and/or separation geotextile.
- C. Material Quality Controls: From a qualified testing agency indicating and interpreting test results for compliance with the Material Quality Control requirements of this specification.
- D. Material Test Reports: From a qualified testing agency indicating and interpreting test results for compliance of the following with requirements indicated:

1. Classification according to ASTM D 2487 "Standard Classification of Soils for Engineering Purposes (Unified Soil Classification System)" or other appropriate methods as designated by the Engineer of each on-site and borrow soil material proposed for fill..
 2. Laboratory compaction curve according to ASTM D 698 for each on-site and borrow soil material proposed for fill..
 3. Designated submittals for materials per Section 31 05 13 "Soils for Earthwork" and Section 31 05 16 "Aggregates for Earthwork."
- E. For imported fill, provide a written and notarized certification from the landowner for each proposed off-site borrow source stating that to the best of the landowner's knowledge and belief there has never been contamination of the borrow source site with hazardous or toxic materials. Soil materials derived from the excavation of underground petroleum storage tanks shall not be used as fill on Project.
- F.
- G. Pre-excavation Photographs or Videotape: Show existing conditions of adjoining construction and site improvements, including finish surfaces, which might be misconstrued as damage caused by earthwork operations. Submit before earthwork begins.

1.6 PROJECT CONDITIONS

- A. Existing Utilities: If applicable, do not interrupt utilities serving facilities occupied by OWNER or others unless permitted in writing by ENGINEER and then only after arranging to provide temporary utility services according to requirements indicated.
1. Notify ENGINEER not less than two days in advance of proposed utility interruptions. Comply with Section 01 50 00 "Temporary Facilities and Controls" for plant shutdowns.
 2. Do not proceed with utility interruptions without ENGINEER'S written permission.
 3. Contact utility-locator service for area where Project is located before excavating.
- Demolish and completely remove from site existing underground utilities as indicated to be removed. Coordinate with utility companies to shut off services if lines are active.
- B. Weather Limitations:
1. Material excavated when frozen or when air temperature is less than 32° F shall not be used as fill or backfill until material completely thaws.
 2. Material excavated during inclement weather shall not be used as fill or backfill until after material drains and dries sufficiently for proper compaction.

PART 2 - PRODUCTS

2.1 SOIL MATERIALS

- A. General: Provide borrow soil materials when sufficient satisfactory soil materials are not available from excavations.
- B. Satisfactory Soils: ASTM D 2487 Soil Classification Groups GW, GP, GM, SW, SP, and SM or a combination of these groups; free of rock or gravel larger than 4 inches in any dimension, debris, waste, frozen materials, vegetation, and other deleterious matter; and, a liquid limit

of less than 60. Satisfactory soils shall comply with the requirements of Section 31 05 13 "Soils for Earthwork" and Section 31 05 16 "Aggregates for Earthwork." Fill material should be uniform with respect to material type and moisture content

- C. Unsatisfactory Soils: Soil Classification Groups GC, SC, CL, ML, OL, CH, MH, OH, and PT according to ASTM D 2487 or a combination of these groups.
 - 1. Unsatisfactory soils also include satisfactory soils not maintained within 2 percent of optimum moisture content at time of compaction.
 - 2. Depending on the plasticity index (PI) and liquid limits (LL), Soil Classification Groups GC and SC may be used.
- D. Excavated soils may be used for general site fill but may not be used for select or structural backfill. On-site soils are also suitable for use in general site grading. The fill material shall be free of vegetation and debris.

2.2 DRAINAGE COURSE AND FILTER MATERIAL

- A. Drainage Course: Narrowly graded mixture of washed crushed stone, or crushed or uncrushed gravel; ASTM D 448; coarse-aggregate grading Size 57; with 100 percent passing a 1-1/2-inch sieve and 0 to 5 percent passing a No. 8 sieve.
- B. Filter Material: Narrowly graded mixture of natural or crushed gravel, or crushed stone and natural sand; ASTM D 448; coarse-aggregate grading Size 67; with 100 percent passing a 1-inch sieve and 0 to 5 percent passing a No. 4 sieve.

2.3 GEOTEXTILES

- A. Subsurface Drainage Geotextile: When shown on Drawings, provide non-woven needle-punched geotextile, manufactured for subsurface drainage applications, made from polyolefin or polyesters; with elongation greater than 50 percent; complying with AASHTO M 288 and the following, measured per test methods referenced:
 - 1. Survivability: Class 2; AASHTO M 288.
 - 2. Grab Tensile Strength: 157 lbf; ASTM D 4632.
 - 3. Sewn Seam Strength: 142 lbf; ASTM D 4632.
 - 4. Tear Strength: 56 lbf; ASTM D 4533.
 - 5. Puncture Strength: 56 lbf; ASTM D 4833.
 - 6. Apparent Opening Size: No. 60 sieve, maximum; ASTM D 4751.
 - 7. Permittivity: 0.2 per second, minimum; ASTM D 4491.
 - 8. UV Stability: 50 percent after 500 hours' exposure; ASTM D 4355.
- B. Separation Geotextile: If shown on the Drawings, provide woven geotextile fabric, manufactured for separation applications, made from polyolefin or polyesters; with elongation less than 50 percent; complying with AASHTO M 288 and the following, measured per test methods referenced:
 - 1. Survivability: Class 2; AASHTO M 288.
 - 2. Grab Tensile Strength: 247 lbf; ASTM D 4632.
 - 3. Sewn Seam Strength: 222 lbf; ASTM D 4632.
 - 4. Tear Strength: 90 lbf; ASTM D 4533.

5. Puncture Strength: 90 lbf; ASTM D 4833.
6. Apparent Opening Size: No. 60 sieve, maximum; ASTM D 4751.
7. Permittivity: 0.02 per second, minimum; ASTM D 4491.
8. UV Stability: 50 percent after 500 hours' exposure; ASTM D 4355.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by earthwork operations.
- B. Preparation of subgrade for earthwork operations including removal of vegetation, topsoil, debris, obstructions, and deleterious materials from ground surface is specified in Section 31 12 00 "Site Clearing, Grubbing, Tree, and Shrub Removal."
- C. Protect and maintain erosion and sedimentation controls, which are specified in Section 31 12 00 "Site Clearing, Grubbing, Tree, and Shrub Removal," during earthwork operations.
- D. Excavation, trenching, and backfilling work for utilities shall be accomplished in accordance with Section 31 23 00 "Excavation, Trenching, and Backfilling for Utilities."
- E. Excavation and backfill work for structures shall be accomplished in accordance with Section 31 23 10 "Structural Excavation and Backfill."

3.2 DEWATERING

- A. Prevent surface water and ground water from entering excavations, from ponding on prepared subgrades, and from flooding Project site and surrounding area.
- B. Protect subgrades from softening, undermining, washout, and damage by rain or water accumulation.
 1. Reroute surface water runoff away from excavated areas. Do not allow water to accumulate in excavations. Do not use excavated trenches as temporary drainage ditches.
 2. Install a dewatering system, specified in Section 31 23 19 "Dewatering," to keep subgrades dry and convey ground water away from excavations. Maintain until dewatering is no longer required.

3.3 EXPLOSIVES

- A. No explosives of any kind will be allowed on site at any time.

3.4 EXCAVATION, GENERAL

- A. Excavations shall be observed by the Geotechnical Engineer to make sure that the proper bearing material has been reached. The excavations shall be checked for size and observed by the Geotechnical Engineer to make sure that loose material has been removed prior to concrete placement.
- B. The side slopes of excavations through the overburden soils should be made in such a manner to provide for their stability during construction. Existing structures, utilities, or

other facilities, which are constructed prior to or during the proposed construction and which require excavation, should be protected from loss of end bearing or lateral support.

- C. Unclassified Excavation: Excavate to subgrade elevations regardless of the character of surface and subsurface conditions encountered. Unclassified excavated materials may include rock, soil materials, and obstructions. No changes in the Contract Sum or the Contract Time will be authorized for rock excavation or removal of obstructions.
 - 1. If excavated materials intended for fill and backfill include unsatisfactory soil materials and rock, replace with satisfactory soil materials.

3.5 SUBGRADE INSPECTION

- A. Notify ENGINEER when excavations have reached required subgrade.
- B. If ENGINEER and/or Geotechnical Engineer determines that unsatisfactory soil is present, continue excavation and replace with compacted backfill or fill material as directed.
- C. Proofroll subgrade to identify soft pockets and areas of excess yielding using rollers that when loaded weigh at least 25 tons and no more than 50 tons. Proofrolling should be performed using a heavy pneumatic tired roller, loaded dump truck, or similar piece of equipment.
 - 1. Do not proof-roll wet or saturated subgrades.
 - 2. Make at least two passes, offsetting each pass one tire width. Operate at speed between 2 and 6 miles per hour.
 - 3. Excavate soft pockets, unsatisfactory soils, and areas of excessive pumping or rutting, as determined by ENGINEER, and replace with select fill as directed.
 - 4. Following proofrolling and replacement of unsatisfactory soil with satisfactory soil, the following preparations shall be made to the subgrade in the following order.
 - a. Scarify the site
 - b. Moisture condition to above optimum moisture content
 - 5. Recompect to a minimum 95% dry density Standard Proctor (ASTM D 698)
 - 6. Work in areas under CDOT jurisdiction, proofroll in accordance with CDOT standards.
 - 7. Proofrolling operations shall be performed under the observation of the Geotechnical Engineer.
- D. Authorized additional excavation and replacement material will be paid for according to Contract provisions for unit prices.
- E. Reconstruct subgrades damaged by freezing temperatures, frost, rain, accumulated water, or construction activities, as directed by ENGINEER, without additional compensation.

3.6 UNAUTHORIZED EXCAVATION

- A. Fill unauthorized excavation using suitable onsite material or suitable imported material. Place in accordance with Fill below.
- B. For unauthorized excavation under foundations or wall footings or utility trenches, refer to 31 23 00 "Excavation, Trenching and Backfilling for Utilities" and 31 23 10 "Structural Excavation and Backfill".

3.7 MATERIALS

- A. Stockpile borrows soil materials and excavated satisfactory soil materials without intermixing. Place, grade, and shape stockpiles to drain surface water. Cover to prevent windblown dust.
 - 1. Stockpile soil materials away from edge of excavations. Do not store within drip line of remaining trees.
 - 2. Confine stockpiles to within easements, right-of-way, and approved areas. Do not obstruct roads or streets.

3.8 FILL

- A. Place and compact fill in excavations promptly, but not before completing the following work as applicable:
 - 1. Construction below finish grade including, where applicable, subdrainage, damp proofing, waterproofing, and perimeter insulation.
 - 2. Surveying locations of underground utilities for Record Documents.
 - 3. Testing and inspecting underground utilities.
 - 4. Removing concrete formwork.
 - 5. Removing trash and debris.
 - 6. Removing temporary shoring and bracing, and sheeting.
 - 7. Installing permanent or temporary horizontal bracing on horizontally supported walls.
 - 8. Leakage tests for structures.
- B. Place fill on subgrades free of mud, frost, snow, or ice.
- C. Plow, scarify, bench, or break up sloped surfaces steeper than 1 vertical to 4 horizontal so fill material will bond with existing material.

3.9 SOIL MOISTURE CONTROL

- A. Uniformly moisten or aerate subgrade and each subsequent fill soil layer before compaction.
 - 1. Do not place backfill or fill soil material on surfaces that are muddy, frozen, or contain frost or ice.
 - 2. Remove and replace, or scarify and air dry otherwise satisfactory soil material that exceeds optimum moisture content by 2 percent and is too wet to compact to specified dry unit weight.
 - 3. Do not allow the moisture content in the subgrade to fall below the optimum moisture content.
 - 4. Water required for sprinkling to bring the fill material to the proper moisture content should be applied evenly through each layer.
 - 5. The moisture content for general earth fill shall range from 2 percent below optimum moisture content to 5 percent above optimum moisture content (-2 to +5 percent).

3.10 COMPACTION OF SOIL BACKFILLS AND FILLS

- A. Place backfill and fill soil materials in layers not more than 8 inches in loose depth for material compacted by heavy compaction equipment, and not more than 4 inches in loose depth for material compacted by hand-operated tampers.

- B. Compact soil materials to not less than the following percentages of maximum dry unit weight according to ASTM D 698, if not specified on the Drawings:
 - 1. Fill material shall be compacted to a minimum density of 95 percent of maximum dry density.
 - 2. Fills placed in excess of 10 feet below final grades shall be compacted to a minimum density of 98 percent of maximum dry density.
- C. Field density tests shall be taken as each lift of fill material is place and in the presence of the Geotechnical Engineer.
- D. Avoid over compaction of the subgrade and any other layers of backfill or fill soil.
- E. Fill material should be uniform with respect to material type and moisture content. Clods and chunks of material should be broken down and the fill material mixed by disking, blading, or plowing, as necessary, so that a material of uniform moisture and density is obtained for each lift.
- F. Crushed stone shall be compacted via three passes of a vibratory roller over a 6-inch lift.

3.11 GRADING

- A. General: Uniformly grade areas to a smooth surface, free of irregular surface changes. Comply with compaction requirements and grade to cross sections, lines, and elevations indicated.
 - 1. Provide a smooth transition between adjacent existing grades and new grades.
 - 2. Cut out soft spots, fill low spots, and trim high spots to comply with required surface tolerances.
- B. Site Grading: Slope grades to direct water away from buildings and structures and to prevent ponding during or after construction. A slope of 1.5 to 3 percent should be provided, such that the soil slopes away from the proposed structure, foundations, and excavations. Finish subgrades to required elevations within the following tolerances:
 - 1. Lawn or Unpaved Areas: Plus or minus 1-inch.
 - 2. Walks: Plus or minus 1 inch.
 - 3. Pavements: Plus or minus 1/2 inch.
- C. Grading inside Building Lines: Finish subgrade to a tolerance of 1/2 inch when tested with a 10-foot straightedge.

3.12 SUBSURFACE DRAINAGE

- A. When shown on the Drawings, provide subsurface drainage in accordance with the following paragraphs.
- B. Subdrainage Pipe, as required. Rainwater collected by any gutter system should be transported by pipe to a storm drain or to a paved area. If downspout discharges next to a structure onto flatwork or paved areas, the are should be watertight to eliminate infiltration next to the building.
- C. Subsurface Drain: Place subsurface drainage geotextile around perimeter of subdrainage trench. Place a 6 inch course of filter material on subsurface drainage geotextile to support subdrainage pipe. Encase subdrainage pipe in a minimum of 12 inches of filter material,

placed in compacted layers 6 inches thick, and wrap in subsurface drainage geotextile, overlapping sides and ends at least 6 inches. Compact each filter material layer with a minimum of two passes of a plate-type vibratory compactor.

- D. Drainage Backfill: Place and compact filter material over subsurface drain, in width indicated, to within 12 inches of final subgrade, in compacted layers 6 inches thick. Overlay drainage backfill with one layer of subsurface drainage geotextile, overlapping sides and ends at least 6 inches.
 - 1. Compact each filter material layer with a minimum of two passes of a plate-type vibratory compactor.
 - 2. As shown on the Drawings, place and compact impervious fill over drainage backfill in 6 inch thick compacted layers to final subgrade.

3.13 DRAINAGE COURSE

- A. Place drainage course on subgrades free of mud, frost, snow, or ice.
- B. On prepared subgrade, place and compact drainage course under cast-in-place concrete slabs-on-grade as follows:
 - 1. Install subdrainage geotextile on prepared subgrade according to manufacturer's written instructions, overlapping sides and ends.
 - 2. Place drainage course 6-inches or less in compacted thickness in a single layer.
 - 3. Place drainage course that exceeds 6-inches in compacted thickness in layers of equal thickness, with no compacted layer more than 6-inches thick or less than 3 inches thick.
 - 4. Compact each layer of drainage course to required cross sections and thicknesses to not less than 95 percent of maximum dry unit weight according to ASTM D 698.

3.14 FIELD QUALITY CONTROL

- A. Allow testing agency to inspect and test subgrades and each fill or backfill layer. Proceed with subsequent earthwork only after test results for previously completed work comply with requirements.
- B. Testing agency will test compaction in accordance with ASTM D 2922 and moisture content in accordance with ASTM of soils. Tests for both compaction and moisture content will be performed at the following locations and frequencies:
 - 1. General site grading: at least one field density test per lift for each 5,000 sq. ft. of compacted area.
 - 2. For small areas or critical areas: one test per 2,500 sq. ft of compacted area.
 - 3. A minimum of 2 tests per lift are required.
- C. When testing agency reports that subgrades, fills, or backfills have not achieved degree of compaction specified, scarify and moisten or aerate, or remove and replace soil to depth required; recompact and retest until specified compaction is obtained.

3.15 PROTECTION

- A. All disturbed areas should be protected from erosion and sedimentation during construction, and all permanent slopes and other areas subject to erosion or sedimentation

should be provided with permanent erosion and sediment control facilities. All applicable ordinances and codes regarding erosion and sediment control should be followed.

- B. Protecting Graded Areas: Protect newly graded areas from traffic, freezing, and erosion. Keep free of trash and debris.
- C. Repair and reestablish grades to specify tolerances where completed or partially completed surfaces become eroded, rutted, settled, or where they lose compaction due to subsequent construction operations or weather conditions.
 - 1. Scarify or remove and replace soil material to depth as directed by ENGINEER; reshape and recompact.
- D. Where settling occurs before Project correction period elapses, remove finished surfacing, backfill with additional soil material, compact, and reconstruct surfacing.
 - 1. Restore appearance, quality, and condition of finished surfacing to match adjacent work, and eliminate evidence of restoration to greatest extent possible.

3.16 DISPOSAL OF SURPLUS AND WASTE MATERIALS

- A. Disposal: Remove surplus satisfactory soil and waste material, including unsatisfactory soil, trash, and debris, and legally dispose of it off OWNER'S property.

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SECTION 31 23 00
EXCAVATION, TRENCHING, AND BACKFILLING FOR UTILITIES

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes:
 - 1. Excavation, excavation support and protection, trenching, embedment, concrete encasement, and backfilling for utilities within utility trenches.
- B. Products Installed by Not Supplied Under This Section:
 - 1. Pipe, conduit, duct banks, cable, and other utilities installation, along with embedment, fill within the pipe zone, thrust blocks, backfill, and related items are shown on the Drawings and described in this Section and related Sections. Pipeline testing is covered in other Sections.
- C. The design and installation of trench excavation support and protection systems shall be the responsibility of the CONTRACTOR and shall comply with the requirements of Section 31 50 00 - Excavation Support and Protection.

1.2 REFERENCES

- A. Abbreviations and Acronyms:
 - 1. American Public Works Association (APWA)
 - 2. American Society for Testing and Materials (ASTM)
 - 3. National Electrical Manufacturers Association (NEMA)
- B. Definitions.
 - 1. Backfill: Soil material or controlled low-strength material used to fill an excavation.
 - 2. Bedding Course: Material placed over the excavated subgrade in a trench before laying pipe, conduits, cables, or duct bank, around the utility, and directly above the utility.
 - 3. Imported Material: Material obtained by CONTRACTOR from source(s) offsite.
 - 4. Lift: Loose (uncompacted) layer of material.
 - 5. Pipe Zone: Bedding course and initial backfill, which includes full trench width, extending from trench bottom to an upper limit above top of pipe, conduct, duct bank, or other utility.
 - 6. Prepared Trench Bottom: Graded, compacted trench bottom after excavation and installation of stabilized material, if required, but before placement of bedding course.
 - 7. Select Backfill Material. Materials available onsite or offsite complying with the specified values.
 - 8. Well-Graded: A mixture of particle sizes that has no specific concentrations or lack thereof of one or more sizes producing a material type, which when compacted, produces a strong and relatively incompressible soil mass free from detrimental voids. Well-graded does not define any numerical value that must be placed on the coefficient of uniformity, coefficient of curvature, or other specific grain size

distribution parameters.

C. Standards

1. APWA Color Code for Temporary Marking of Underground Utility Locations.
2. ASTM International:
 - a. C33 – Standard Specification for Concrete Aggregates
 - b. D75 – Standard Practice for Sampling Aggregates
 - c. D448 - Standard Classification for Sizes of Aggregate for Road and Bridge Construction
 - d. D698 – Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,499 ft-lb.ft3 (600 kN-m/m3))
 - e. D1557 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3 (2,700 kN-m/m3))
 - f. D2049 – Standard Safety Performance Specification for Fences/Barriers for Public, Commercial, and Multi-Family Residential Use Outdoor Play Areas
 - g. D2922 - Standard Test Methods for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth)
 - h. D3017 - Standard Test Method for Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth)
 - i. D4253 - Standard Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table
 - j. D4254 - Standard Test Methods for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density
3. NEMA: Z535.1, Safety Color Code.

D. Related Sections:

1. Section 02 41 19 – Selective Demolition
2. Section 26 05 43 – Underground Ducts and Raceways for Electrical Systems
3. Section 31 12 00 – Site Clearing, Grubbing, Tree, and Shrub Removal
4. Section 31 23 19 – Dewatering
5. Section 31 50 00 – Excavation Support and Protection
6. Section 33 05 05 – Buried Piping Installation

1.3 ADMINISTRATIVE REQUIREMENTS

A. Sequencing and Scheduling

1. Complete applicable clearing as described in Section 31 12 00 “Selective Clearing, Grubbing, Tree, and Shrub Removal”.
2. Complete applicable demolition as required in accordance with Division 02.
3. Provide an approved excavation support and protection plan prior to start of trenching operations in accordance with Section 31 50 00 “Excavation Support and Protection.”

1.4 SUBMITTALS

A. Action Submittals

1. Samples:
 - a. Provide two 1-gallon samples of imported materials to be used for inspection and testing by ENGINEER, when requested.
- B. Test and Evaluation Reports:
 1. Certified Gradation Analysis: Submit not less than 30 days prior to delivery for imported materials or anticipated to be used for trench stabilization, bedding, backfill within the pipe zone, and backfill above the pipe zone.
 2. Certified Testing Analysis: Liquid limits, plasticity index, and other parameters for materials showing compliance with specified limits.
 3. Flowable Fill: Certified mix design and test results. Include material types and weight per cubic yard for each component of mix.

PART 2 - PRODUCTS

2.1 MARKING TAPE

- A. Detectable Warning Tape: Acid- and alkali-resistant polyethylene film warning tape manufactured for marking and identifying underground utilities, a minimum of six inches wide and four mils thick, continuously inscribed with a description of the utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 30 inches deep.
- B. Color: Comply with the requirements of APWA Uniform Color Code for Temporary Marking of Underground Utilities as well as CDPHE guidelines for color coding pipes.

Color*	Facility
Red	Electric power lines, cables, conduit, and lightning cables
Orange	Communication alarm or signal lines, cables, or conduit
Yellow	Gas, oil, steam, petroleum, or gaseous materials
Green	Sewers and drain lines
Blue	Potable water
Purple	Reclaimed water, irrigation, and slurry lines
*As specified in NEMA Z535.1, Safety Color Code	

2.2 MATERIAL REQUIREMENTS

- A. Bedding:
 1. Bedding material supporting the pipe bottom should consist of an uncompacted layer of imported granular material meeting the pipe manufacturer's specifications for bedding, and in compliance with the Drawings. Material shall be free draining, coarse-grained sand and/or fine gravel. Material must be reviewed and approved by the ENGINEER.
- B. Encasement:
 1. Encase utilities using granular material meeting the pipe manufacturer's specifications for bedding, and in compliance with the Drawings and section 31 05 16 "Aggregate for Earthwork". Material must be reviewed and approved by the ENGINEER.

- C. Backfill:
 - 1. Backfill utility trenches using suitable on-site soil obtained from the utility excavation. Suitable soils shall have maximum size of four (4) inches and should be free of organics, wood, or other deleterious materials that could decay over time.
 - a. It is anticipated that on-site soils will be suitable for reuse but may require screening of larger particle sizes.
 - b. If grading is performed during times of freezing weather, fill shall not contain frozen materials.

PART 3 - EXECUTION

3.1 PROTECTION OF EXISTING UTILITIES

- A. Existing utilities or obstructions indicated on Drawings show approximate location only and the CONTRACTOR must field verify. This does not relieve CONTRACTOR from responsibility in anticipating the presence of all underground utilities whether or not shown on the Drawings.
- B. CONTRACTOR shall, at his own expense, maintain in working order and without interruption of service all existing utilities and services which may be encountered in the Work. Except when notified by ENGINEER, the service may be temporarily interrupted to permit removal or to make temporary changes for the completion of Work. All costs associated with these changes shall be at the CONTRACTOR'S expense.
- C. Before starting construction, the CONTRACTOR shall notify all utility companies involved to locate and mark their utilities in the field. All underground utilities shall then be uncovered for verification of location and elevation prior to start of construction.
- D. The CONTRACTOR must obtain the required permits from the utility companies.
- E. The Geotechnical ENGINEER will determine if soil at existing utilities is suitable. If the soil is found to be unsuitable, then the Contractor shall remove, replace, and compact the unsuitable soil in accordance with Specification Section 31 20 00 "Earthwork".

3.2 PREPARATION

- A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by excavation for trenches.
- B. Trench Excavation:
 - 1. Excavate to lines, grades, depths, and dimensions shown on Contract Drawings and as necessary to accomplish Work. Allow for excavation support and protection materials, working space, bedding course, topsoil, and related materials.
 - 2. Excavation is unclassified. Complete all excavation regardless of the type, nature, or condition of materials encountered. Remove all loose soil, mud, rock, or other deleterious matter from beneath roadways, utility lines, and related work. No changes in the Contract Sum or the Contract Time will be authorized for rock excavation or removal of obstructions.
 - 3. Excavate trenches to uniform widths to provide required clearance of each side of pipe or conduit. Trench walls shall be vertical to elevation equal to 12 inches above

top of pipe, conduits, cables, or duct banks.

4. Minimum Width of Trenches:
 - a. Single pipes, conduits, cables, and duct banks:
 - 1) Outside Diameter, less than 4 inches: 12 inches plus OD of pipe.
 - 2) Outside Diameter, equal to or greater than 4 inches: 12 inches greater than outside diameter or width of pipe, conduit, cables, or duct banks.
 - b. Multiple pipes, conduits, cables, or duct banks in single trench: 12 inches greater than aggregate width of pipes, conduits, cables, duct banks, plus space between.
 - c. Trench width to be increased for excavation support and protection systems.
 5. Maximum trench width: No more than 24 inches nor less than 12 inches from outside diameter of pipes plus excavation support materials. When maximum trench is exceeded, the CONTRACTOR shall use the next higher class of embedment, at no additional cost.
 6. Proceed with caution in areas of existing utilities exposing them by hand excavation or other means acceptable to utility OWNER. Protect, support, and maintain existing utilities.
 7. Avoid disturbing soil within branch spread of trees designated for protection. If it is necessary to excavate through roots, perform work by hand and cut roots with a sharp axe.
 8. Trench excavation shall not advance more than 100 feet ahead of the completed pipe work except where specifically authorized by ENGINEER.
 9. Trench excavation should not be steeper than 2H:1V. Excavations may need to be braced or sheeted. CONTRACTOR is responsible for excavation support and protection per Section 31 50 00 "Excavation Support and Protection".
- C. Surface Preparation
1. Drainage and Groundwater:
 - a. Grade adjacent site work to prevent surface water runoff into trench and excavation areas.
 - b. Maintain excavations and trenches free from water during construction.
 - c. Remove water encountered in trenches to a minimum of 6 inches below the pipe embedment zone, to permit joints to be made in the dry, and to prevent the entrance of water into the pipeline.
 - 1) If dewatering is required, Contractor must obtain a groundwater discharge permit from the Colorado Department of Health and Environment prior to proceeding with groundwater discharge Work. Reference Section 31 23 19 "Dewatering".
 - d. Ponding of water should not be allowed in backfill material or in a zone within 10 feet of structures, whichever is greater.
 - e. Maintain the excavation or trench free from water until the structure, or pipe to be installed therein, is completed to the extent that no damage from hydrostatic pressure, flotation, or other cause will result.
 - f. The ground surface surrounding the exterior of structures and paved areas

g. To promote runoff, the upper 1 to 2 feet of backfill shall be relatively impervious on-site soil or be covered by flatwork or pavement structure.

- a. Grade trench bottoms uniformly to provide clearance for each section of pipe.
- b. Remove loose materials, water and foreign objects.
- c. Provide firm subgrade suitable for application of bedding material.
- d. Wherever unstable material that in the opinion of the ENGINEER or OWNER is incapable of supporting the pipe is encountered in the bottom of the trench, over-excavate such material to a depth suitable for construction of a stable subgrade. Backfill over-depth with Stabilization Material and compact.

- a. Pile suitable material for backfilling in an orderly manner a sufficient distance from banks of the trench to avoid overloading and to prevent slides or cave-ins.
- b. Remove and dispose of excess excavated materials not suitable or not required for backfilling.
- c. Do not stockpile excavated material against existing structures, or appurtenances, trees or cultivated shrubs.

A. Equipment and Methods:

- B. Bedding Course Material:

1. Unless otherwise specified on the Contract Drawings, bedding and encasement shall be as described herein. Furnish imported bedding material, where excavated material is unsuitable for bedding or insufficient quantity.
2. Place minimum geotextile fabric on top of trench bottom or trench stabilizing material prior to laying bedding course.
3. Place over full width of prepared trench bottom in two equal lifts when the required depth exceeds eight inches. Hand grade and compact each lift to provide a firm,

unyielding surface.

4. Minimum thickness below and above outside of utility: As follows, except increase depths by 2 inches in areas of rock excavation.
 - a. Pipe: O.D./8 or 6-inches minimum.
 - b. Conduit: three inches.
 - c. Cable: three inches.
 - d. Duct Banks: three inches.
 5. Check grade, correcting irregularities in bedding material. Loosen top 1 inch to 2 inches of compacted bedding material with a rake or other means to provide a cushion before laying each section of pipe, conduits, cables, or duct banks.
 6. Install to form continuous and uniform support except at bell holes, if applicable. Excavate bedding at each joint to permit proper assembly and inspection of joint and to provide uniform bearing along barrel of pipe or conduit.
 7. Utility and pipelines shall not use bedding course beneath or adjacent to structures to minimize the percolation of water through the bedding course towards the structure. Utility and pipe trenches shall include a plug formed from low permeable clays at the structure. The plug shall extend 2 feet beyond the footing, each way, and from the bottom of the trench to the surface.
 8. Restrain pipe, conduit, cables, or duct banks as necessary to prevent their movement during backfill operations, particularly during placement of controlled low strength fill.
 9. Place material simultaneously in lifts on both sides of pipe and, if applicable, between pipes, conduits, cables, and duct banks installed in same trench.
 - a. Pipe ten inch and smaller diameter: First lift less than or equal to one-half pipe diameter.
 - b. Pipe over ten-inch diameter: Maximum six-inch lifts.
 10. Thoroughly tamp each lift, including area under haunches, to ensure voids are filled before placing next lift. After the full depth of pipe zone material has been placed, compact the material with vibratory plate compactor. Do not use power-driven impact type compactors to compact pipe zone material.
 11. The pipe bedding shall be compacted to a relative density of at least 75% as determined by ASTM D4253 and ASTM D4254.
 12. Install geotextile fabric on top of bedding prior to final backfill.
 13. Care should be taken in placement of utility trench backfill so that the compaction operations do not damage underlying utilities.
- C. Marking Tape Installation:
1. Install detectable warning tape directly above utilities, approximately 12 inches above top of pipe.
- D. Encasement:
1. Compact utility encasement to at least 75 percent relative density (ASTM D4353 and ASTM D4254).
 2. Provide adequate compaction below pipe with concrete vibrator, vibratory plates, or other compaction equipment. In confined spaces here compaction is difficult,

flowable fill encasement is acceptable. Refer to the Drawings for flowable fill encasement requirements.

E. Final Backfill:

1. General:

- a. Process excavated material to meet specified soil fill requirements. Moisture condition fill to optimum moisture content (from -2 below to +2 percent above optimum) as necessary to obtain specified compaction,. Place and compact backfill in 8-inch loose lifts.
- b. Compaction requirements as percentage of maximum modified proctor density (ASTM D1557) are as follows:
 - 1) Utility Trenches:
 - a) Exterior less than 8 feet below final ground surface: 93 percent
 - b) Exterior more than 8 feet below final ground surface: 97 percent
 - 2) Landscape and other areas: 93 percent
- c. Contractor shall account soil processing to add water or allowing time for material to dry will likely be required.
- d. Do not allow backfill to free-fall into the trench or allow heavy, sharps pieces of material to be placed as backfill until after 2 feet of backfill has been placed.
- e. Deposit backfill material in uniform layers not exceeding eight inches in uncompacted thickness. Increased layer thickness may be acceptable provided it is demonstrated that the specified compacted density will be obtained.
- f. Do not use power-driven impact type compactors until at least four feet of backfill is place over top of pipe.
- g. Backfill to grade with allowances for topsoil, crushed rock surfacing, pavements, or other work.
- h. Backfill as soon as practicable after installation of piping, valves, encasement, restraint, and blocking.
- i. Touch up damaged protective coatings prior to backfilling. Exercise care to avoid damaging piping or protective coatings with tamping equipment.
- j. Use methods and equipment appropriate for the backfill material. Do not use equipment or methods that will transmit damaging shocks to the pipe. Do not perform compaction by jetting.

2. Concrete Backfill:

- a. Place above bedding with minimum concrete thickness 6-inches on top and sides of pipe. Use concrete having a minimum compressive strength of 2,000 psi at 28 days.
- b. Allow sufficient time for concrete to reach initial set before additional backfill material is place. Prevent floatation of pipe.
- c. Begin and end concrete placement within four inches of a pipe joint. Do not encase pipe joints.

3. Flowable Fill: Discharge from truck mounted drum type mixer into trench. Place in lifts as necessary to prevent floatation of pipe, conduits, and related items.

4. Topsoiling: Replace topsoil to the depth of stripping over all areas disturbed by

construction operations and which will not receive other surface treatment.

F. Special Techniques:

1. Trench Excavation:

- a. Saw cut all existing concrete and asphalt surfacing vertically plumb and perpendicular to road centerlines and curbs. Dispose of material.

2. Clearance:

- a. Excavate trench so a minimum clearance of six (6) inches is maintained on each side of the pipe for proper placement and densification of the bedding or backfill material.
- b. Provide clearances as noted on the Contract Drawings.

G. Material excavated when frozen or when air temperature is less than 32 degrees F shall not be used until material completely thaws. Material excavated during inclement weather shall not be used as fill or backfill until after material drains and dries sufficiently for proper compaction.

H. Moisture Content: Compact soils within -2 below to +2 percent of optimum moisture. Add water, harrow, disc, blade or otherwise work material as required.

I. Surfaced Areas:

1. Restore all surfaces to a condition equal to that prior to construction.

3.4 MAINTENANCE OF TRENCH BACKFILL

A. After each section of the trench is backfilled, maintain the surface even with the adjacent ground until final surface restoration is complete.

B. Add topsoil as required to maintain surface of the backfilled trench with adjacent ground.

C. Asphalt Pavement: Replace settled areas or fill with asphalt surface.

D. Other areas: Add excavated material where applicable and keep backfilled surface level with adjacent ground surface.

3.5 CEMENT-SOIL BACKFILL

A. When shown on the Drawings, provide cement-soil backfill as subgrade under structures.

B. Mix not less than 1-1/2 sacks of Portland cement per cubic yard of sand with water using a pug mill type mixer. Stamp batch ticket with time of loading. Material will be rejected if not place within 1-1/2 hours after loading or if the mixture has dried out.

C. Application:

1. Pipes and Conduits. Use cement-sand material as bedding and backfill for pipes, conduits and other utilities as indicated on the Drawings or because of site conditions.
2. Foundations. Use cement-sand material for stabilizing foundation for manholes, inlets or other utility or drainage structures.
3. Manholes. Use cement-sand material as backfill around manholes if the manhole adjoins pavement.
4. Density Control:
 - a. Place in lifts not exceeding 8-inches measured loose. Compact with mechanical

- hand tamps in accordance with Density Control requirements.
- b. Areas Subjected to or Influenced by Vehicular Traffic. Unless otherwise indicated on the Drawings, compact backfill to a minimum 100 percent of maximum density as determined in accordance with ASTM D698, with required moisture content within minus 2 to plus 4 of optimum.
 - c. Areas Not Subjected to or Influenced by Vehicular Traffic. Unless otherwise indicated on the Drawings, compact backfill to a minimum 95 percent of maximum density as determined in accordance with ASTM D698, with required moisture content within minus 2 to plus 4 of optimum.
5. Field Quality Control
- a. Test Method:
 - 1) Determine the maximum density and the optimum moisture content of pipe zone and backfill materials in accordance with ASTM D698.
 - 2) Determination of density control backfill materials shall be in accordance with ASTM D2922.
 - b. Compaction Test Frequency:
 - 1) For trench lengths less than 300 feet, around structures and manholes, minimum of one test for each layer of backfill.
 - 2) For trench lengths in excess of 300 feet, perform a minimum of one test for every 300 linear feet for each layer of backfill.

3.6 DISPOSAL

- A. Dispose of waste material, trash, and debris off-site. Disposal of surplus excavation materials shall be off-site, unless otherwise requested or specified by the ENGINEER or OWNER.

3.7 DENSITY CONTROL

- A. Areas Subjected to or Influenced by Vehicular Traffic. Unless otherwise indicated on the Drawings, compact backfill to a minimum 100 percent of maximum dry density as determined in accordance with ASTM D698, with required moisture content within minus 2 to plus 5 of optimum.
- B. Areas Not Subjected to or Influenced by Vehicular Traffic. Unless otherwise indicated on the Drawings, compact backfill to a minimum 95 percent of maximum dry density as determined in accordance with ASTM D698, with required moisture content within minus 2 to plus 4 of optimum.

3.8 FIELD QUALITY CONTROL

- A. Field / Site Tests and Inspections

3.9 FIELD QUALITY CONTROL

- A. Test Method:
 - 1. Determine the maximum density and the optimum moisture content of pipe zone and backfill materials in accordance with ASTM D698.
 - 2. In-place density testing of backfill materials shall be in accordance with ASTM D2922.

B. Compaction Test Frequency:

1. For trench lengths less than 100 feet, minimum of two (2) tests for each lift of backfill.
2. For trench lengths in excess of 100 feet, perform a minimum of two (2) tests for every 150 linear feet for lift of backfill.
3. Test pipe bedding prior to placement in trench.

END OF SECTION

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SECTION 31 23 10
STRUCTURAL EXCAVATION AND BACKFILL

PART 1 - GENERAL

1.1 WORK INCLUDED

- A. Furnish labor, materials, equipment and incidentals necessary to complete structural excavation, filling, backfilling, and compacting; to provide protection to equipment and cuts; to include backfill material; the construction or installation of cofferdams, and other similar facilities which may be necessary to perform excavations and/or backfilling; to include the necessary pumping, bailing, or associated drainage; to remove and dispose of surplus materials, cofferdams, and debris; and to provide final grading, as required.
- B. The work does not include excavation, filling, and backfilling for utility lines, manholes, vaults, valve boxes, and related structures. Work shall be performed in accordance with Section 31 23 00 "Excavation, Trenching, and Backfill for Utilities."

1.2 QUALITY ASSURANCE; DEFINITIONS

- A. Cofferdams: Cofferdam designates any temporary or removable structure constructed to hold the surrounding earth and/or water out of the excavation, whether the structure is formed of soil, timber, steel, concrete, or a combination thereof. It shall be understood also to include the use of pumping wells or well points.

1.3 SUBMITTALS

- A. Submittals shall be in accordance with Section 01 33 00 "Submittal Procedures" and shall include:
 - 1. Structural calculations for cofferdams. Submit calculations for approval by the Engineer prior to the start of the cofferdam construction. The calculations shall be sealed by a registered professional engineer in accordance with the laws of the state where the project is constructed. The calculations shall be site specific.
 - 2. Submit qualifications of independent testing laboratory for approval.
 - 3. Backfill material classifications. Provide certification by an approved independent testing laboratory.
 - 4. Compaction test results. Provide compaction test results within 24 hours.

1.4 STANDARDS

- A. The following publications, referred to hereafter by basic designation only, form a part of this specification as if written herein in their entirety:
 - 1. American Society for Testing and Materials (ASTM) Standards:
 - a. ASTM D698 - Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft³ (600 kN-m/m³))
 - b. ASTM D6938 - Standard Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)
 - c. ASTM D4253 - Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table
 - d. ASTM D4254 - Test Methods for Minimum Index Density and Unit Weight of

Soils and Calculation of Relative Density

- B. Any other testing required by these specifications and not specifically referenced to a standard shall be performed under ASTM or other appropriate standards as designated by the Engineer.
- C. References herein or on the drawings to soil classifications shall be understood to be according to ASTM D2487, "Standard Classification of Soils for Engineering Purposes (Unified Soil Classification System)" unless indicated otherwise.

1.5 DELIVERY AND STORAGE

- A. Deposit material to be used for backfill in storage piles at points convenient for handling of the material during the backfilling operations.

1.6 JOB CONDITIONS

- A. Review subsurface investigations. A limited subsurface investigation has been performed by Kumar & Associates, Inc. This Technical Data is attached to the Project Manual. However, the precise profile of soil and rock strata beneath this site is not known.
- B. Review the site and determine the conditions which may affect the structural excavation, prior to the commencement of the excavation.

PART 2 - PRODUCTS

2.1 SOIL MATERIALS

- A. Structural Fill Beneath Structures and Backfill:
 - 1. On-site, natural soils or imported non-expansive soils for structural fill shall meet the following criteria:
 - a. Less than 50% passing the No. 200 sieve,
 - b. A maximum Plasticity Index of 12, and
 - c. A maximum Liquid Limit of 30.
 - d. Fill source materials, including on-site soils, not meeting these criteria may be acceptable if they meet the swell criteria listed below.
 - 1) A fill source material is considered non-expansive if the swell potential of the material, once remolded to 95 percent of the standard Proctor (ASTM D698) maximum dry density at optimum moisture content, does not exceed 0.5 percent when wetted under a 200 psf surcharge pressure.
 - 2. On-site soils:
 - a. On-site, natural soils, are acceptable for structural fill beneath structures provided that they do not contain organic material, including vegetation, brush, sod, trash, and debris, or other deleterious materials and should not contain rocks or lumps having diameter of more than four inches.
 - 1) It is anticipated that on-site soils will be suitable for reuse but may require screening of larger particle sizes.
 - b. Existing fills, if encountered, are not suitable for structural fill beneath structures in their current condition, unless properly prepared. Proper preparation includes complete removal and replacement of exiting fill from

- beneath foundations and floor slabs.
- c. If subgrade is allowed to freeze, all frozen material shall be removed prior to additional fill placement for footing or slab construction.
3. Compaction for Shallow Foundations or Slab on Grade Backfill:
- a. Structural fill shall be compacted at moisture content within two percentage points of the optimum moisture content. The moisture content requirement is waived if the material falls under compaction criteria associated with the relative density. Some of the on-site materials may be too granular and not conducive to a Proctor test.
 - 1) Compaction requirements as percentage of maximum modified proctor density (ASTM D1557) are as follows: Below Foundations and Concrete Structures: 97 percent
 - 2) Beneath Settlement Sensitive Flatwork Areas
 - a) Fill less than 8 Feet below final ground surface: 93 percent
 - b) Fill more than 8 feet below final ground surface: 97 percent
- B. General Site Fill:
1. On-site natural soils are suitable for general site fill, provided that they do not contain organic material or other deleterious material.
 2. Compaction requirements as percentage of maximum modified proctor density (ASTM D1557):
- C. Landscape and Other Areas: 93 percent
1. If grading is performed during times of freezing weather, fill shall not contain frozen materials.
- D. Retaining Structure Backfill:
1. To reduce the surface water infiltration into the backfill, the upper two feet of the backfill shall consist of a relatively impervious imported soil containing at least 30% passing the No. 200 sieve, or the backfill zone shall be covered by a slab or pavement structure.
 2. Compaction: Backfill for retaining structures should be compacted to at least 95 percent of the standard Proctor (ASTM D698) maximum dry density at moisture content within two percentages of optimum. Materials with less than 12% passing the No. 200 sieve should be compacted to at least 75 percent of the relative density (ASTM D4253 and D4254). Care should be taken not to over compact the backfill since this could cause excessive pressure on the wall. Hand compaction procedures, if necessary, should be used to prevent lateral pressures from exceeding the design values in the Geotechnical Investigation prepared by Kumar & Associates, Inc.

2.2 COMPACTION EQUIPMENT

- A. Compaction equipment shall conform to the following requirements and shall be utilized as specified herein.
1. Pneumatic Rollers: Pneumatic rollers shall have a minimum of four wheels equipped with pneumatic tires. The tires shall be such size and ply as can be maintained at tire pressures between 80 and 100 pounds per square inch for a 25,000-pound wheel load

during roller operations. The roller wheels shall be located abreast and be designed so that each wheel will carry approximately equal load in transversing uneven ground. The spacing of the wheels shall be such that the distance between the nearest edges of adjacent tires will not be greater than 50 percent of the tire width of a single tire at the operating pressure of a 25,000-pound wheel load. The roller shall be provided with a body suitable for ballast loading such that the load per wheel may be varied, from 18,000 to 25,000 pounds. The roller shall be towed at speeds not to exceed 10 miles per hour. The character and efficiency of this equipment shall be subject to the approval of the Engineer.

2. Vibratory Rollers: Vibratory rollers shall have a total static weight of not less than 20,000 pounds, with at least 90 percent of the weight transmitted to the ground through a single smooth drum when the roller is standing in a level position. The diameter of the drum shall be between 5 and 5-1/2 feet and the width between 6 and 9 feet. The unsprung weight of the drum, shaft, and internal mechanism shall not be less than 12,000 pounds. The frequency of vibration during operation shall be between 1100 and 1500 i.e., and dynamic force shall not be less than 40,000 pounds at 1400 i.e. No backing of the vibratory roller will be allowed on the embankment unless the vibrating mechanism is capable of being reversed. Self-propelled and towed vibratory rollers shall be operated at speeds not exceeding 3 miles per hour and 1-1/2 miles per hour, respectively.
3. Power Hand Tampers and Vibratory Plate Hand Compactors: Compaction of material in areas where it is impracticable to use a roller or tractor shall be performed with approved power hand tampers, vibratory plate hand compactors, or other approved equipment. Approval shall be based upon performance in a test section.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Clear and grub the area to be excavated prior to the start of excavation in accordance with Section 31 12 00 "Selective Clearing, Grubbing Trees and Shrubs".

3.2 EXCAVATION

- A. For slabs on grade: Excavate back to natural soils or bedrock.
- B. For shallow foundations: If underlain by properly compacted soils, excavate back to natural soils or bedrock.
- C. When footing concrete or masonry is to rest upon rock, remove the rock to a depth sufficient to expose sound rock. Level off or cut the rock to approximate grades, and roughen the area. When footing concrete or masonry is to rest on an excavated surface other than rock, take care not to disturb the bottom of the excavation, and do not make final removal of the foundation material to grade until just before the concrete or masonry is placed. Foundation material shall be protected, after exposure, with a concrete seal slab.
- D. When the material encountered at footing grade is found to be partially rock or incompressible material, but otherwise satisfactory for the foundation, remove the incompressible material to a depth of 6 inches below the footing grade and backfill with compacted select fill.

- E. For footings where the soil encountered at established footing grade is an unstable material, use the following procedure unless other methods are specified: Remove unstable soil. Carry the excavation at least 1 foot beyond the horizontal limits of the structure on all sides. Replace the unstable soil with compacted select fill. Place in uniform layers at a suitable depth for compaction. Wet each layer if necessary and compact by rolling or tamping to provide a stable foundation for the structure.
- F. When unfeasible to construct a stable footing as outlined above, construct footing by the use of special materials, such as flexible base, cement stabilized base, cement stabilized backfill, or other material, as directed by the Engineer.
- G. Perform excavation to permit surfaces to be brought to final line and grade within plus or minus 0.1 foot. Restore over-break at the Contractor's expense. In general, perform excavation in open-cut from the surface of the ground and at the line and grade indicated.
- H. The sides of the excavation, from the bottom of the excavation to the top of the ground shall be supported in accordance with OSHA requirements. Maintain the supports throughout construction. Remove supports after the completion of the work.
- I. For unauthorized excavation, Fill by extending bottom elevation of concrete foundation or footing to excavation bottom, without altering top elevation. Lean concrete fill, with 28-day compressive strength of 2500 psi, may be used when approved by ENGINEER. Fill unauthorized excavations under other construction or utility pipe as directed by ENGINEER.
- J. Place Subsurface Drainage Geotextile across the bottom of the excavated area if indicated on the Drawings.

3.3 DEWATERING OF SITE

- A. Follow dewatering requirements as specified in Section 31 23 19 "Dewatering".
- B. Pumping or bailing from the interior of any foundation enclosure shall be done in a manner which precludes the possibility of movement of water through or alongside any concrete being placed. No pumping or bailing shall be permitted during the placing of structural concrete, or for a period of at least 24 hours thereafter, unless from a suitable sump separated from the concrete work by a water-tight wall. Pumping or bailing during placement of seal concrete shall be only to the extent necessary to maintain a static head of water within a cofferdam. Do not start pumping or bailing to de-water a sealed cofferdam until the seal has aged at least 36 hours.
- C. The water table shall be lowered to a depth a minimum of 2 feet below the proposed excavation during construction.

3.4 PLACEMENT OF MATERIAL

- A. Shallow Foundations (spread footing, mat, or raft) shall be placed on undisturbed natural soils, if suitable, or properly compacted structural fill.
- B. Slabs on Grade (floor slabs) shall be placed on properly compacted structural fill.
- C. General:
 - 1. Backfill excavated spaces and areas not occupied by the permanent structure, except that no backfill shall be placed against any structure until the concrete has reached its 28-day compressive strength or 7 days whichever is longer. Do not place backfill

- adjacent to support walls until the top slab has been in place at least 4 days.
2. Take care to prevent wedging action when placing backfill around structures. If backfill is to be placed on two or more sides of the structure or facility, simultaneously place the backfill on all sides to avoid uneven loading on the structure. Backfill sides simultaneously so that the difference in backfill does not exceed 1 foot.
 3. Do not permit rollers to operate within 3 feet of structures.
 4. Maximum placement lifts measured in the loose condition are as follows:
 - a. 8 inches when heavy compaction equipment is used.
 - b. 4 inches when hand-directed compaction equipment is used.
- E. Subgrade Preparation for all Areas:
- a. Unless stated otherwise in the Geotechnical Report prepared by Kumar & Associates, Inc., scarify to a depth of at least eight (8) inches and recompact to at least 95 percent of the modified Proctor (ASTM D1557) maximum dry density at the moisture content specified herein and in the Geotechnical Report.
- F. Retaining Structure Backfill:
1. The zone of backfill placed behind below grade walls (referred to as Retaining Structures in the Geotechnical Investigation), to within two feet of the ground surface should be sloped upward from the base of the structure at an angle not steeper than 45 degrees measured from the horizontal.
 2. Refer to the Geotechnical Investigation prepared by Kumar & Associates, Inc. for further information.
- G. Moisture Control:
1. General: The materials in each layer of the fill shall uniformly contain the amount of moisture within the limits specified below necessary to obtain the maximum dry density for the soil. The moisture content ranges specified above for the various classes of earth fill represent maximum upper and lower limits of the particular range. Determination of the maximum dry density-optimum moisture shall be by one or more of the following ASTM procedures D 1556 or D 6938, unless stated otherwise. Completely cohesionless materials which are to be compacted to a specified relative density shall be at a moisture content which will allow use of the specified compaction equipment and consistent achievement of the specified density.
 2. Moisture Control During Placement: After spreading the soil, adjust the moisture content of the soil if necessary by either aeration or the addition of water to bring the moisture content within the range specified. Uniformly distribute the moisture content throughout the layer of soil to be compacted. In order to accomplish this distribution, thoroughly mix the layer of soil by disking, harrowing, or by the use of a power-driven pulverizer. Should the surface of a previously compacted layer become dry due to exposure to the elements, appropriately wet surface of the compacted layer prior to placing the succeeding layer of soil, and properly disk or harrow the surface. Should a layer of soil be over wet, allow the layer to dry to a proper moisture content prior to compacting. Should the surface of a layer become smooth and hard, roughen the surface by scarifying, and wet the surface if necessary prior to placing the next layer of soil. Reprocess any layer which becomes damaged by weather

conditions to meet the specification requirements. There shall be no additional payment made for such reprocessing.

- H. Vapor Barrier: If shown on the Drawings, place polyethylene sheeting below the concrete slabs on grade. If the subgrade underlying the vapor barrier contains sharp or angled particles, then a layer of cushion sand (1 to 2-inches thick) should be placed in contact with the sheet to provide protection against puncture. Note that the elevation and thickness of the slab shall not be changed to adjust for the layer of cushion sand.
- I. Compaction:
 - 1. Compaction shall be by power hand equipment or rubber-tired equipment, provided the rubber tired equipment does no damage. Compaction by power hand equipment or rubber tired equipment shall be completed such that there will be a 24-inch overlap by roller compaction.
 - 2. Compact the by a minimum of three passes with vibratory. A pass shall consist of one trip over the area being compacted. The front and rear axle rollers on self-propelled models shall only be considered as one pass per trip. The initial and final area to be rolled shall each have eight passes. Stagger passes between the initial and final area in order to establish overlapping with at least eight passes at all locations. Approve the exact method based upon the test section. Dumping, spreading, sprinkling, and compacting may be performed at the same time at different points along a section where there is sufficient area to permit these operations to proceed simultaneously.
 - 3. Areas of the fill being compacted with power hand tampers or vibratory plate hand compactors shall receive a minimum of eight passes of the equipment with an overlap of 50 percent of the equipment base plate width.
 - 4. If necessary, to achieve the specified density, increase the number of passes of the compaction equipment, and/or modify the weight of the compaction equipment.
 - 5. Regardless of the density achieved, the number of passes of the compaction equipment shall not be less than eight, unless otherwise specified.

3.5 FIELD QUALITY CONTROL

- A. The Contractor is responsible for the costs involved in providing an approved testing laboratory to perform quality control testing of backfill operations. The testing laboratory shall make tests of in-place density in accordance with ASTM Standards. The testing laboratory shall monitor backfill operation continuously or at intervals acceptable to the Owner and Engineer at structures. It shall be the responsibility of the Contractor to notify the testing laboratory before backfill operations begin.
 - 1. Field density tests should be taken as each lift of fill material is placed. As a guide, one field density test per lift for each 5,000 square feet of compacted area is recommended. For small areas or critical areas, the frequency of testing may need to be increased to one test per 2,500 square feet. A minimum of 2 tests per lift shall be required.
 - 2. Paved and Building Slab Areas: At subgrade and at each compacted fill and backfill layer, at least 1 test for every 2500 sq. ft., but in no case fewer than 2 tests at each layer.
 - 3. Foundation Wall Backfill: At each compacted backfill layer, at least 1 test for each 100 feet or less of wall length, but no fewer than 2 tests.

4. Pavement Areas: At subgrade and at each compacted fill and backfill layer, least 1 test for every 5,000 sq. ft.
5. In-place density tests shall be conducted at a rate acceptable to the Owner's Representative and/or the Geotechnical Engineer.

END OF SECTION

SECTION 31 23 19
DEWATERING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section includes construction dewatering.
- B. Related Sections:
 - 1. Section 31 20 00 "Earthwork" for excavating, backfilling, site grading, and for site utilities.
 - 2. Section 31 23 00 "Excavation, Trenching, and Backfilling for Utilities" for excavation, trenching and backfilling for utilities.
 - 3. Section 31 23 10 "Structural Excavation and Backfill"

1.3 PERFORMANCE REQUIREMENTS

- A. Dewatering Performance: Design, furnish, install, test, operate, monitor, and maintain dewatering system of sufficient scope, size, and capacity to control hydrostatic pressures and to lower, control, remove, and dispose of ground water and permit excavation and construction to proceed on dry, stable subgrades.
 - 1. Delegated Design: Design dewatering system, including comprehensive engineering analysis by a qualified professional engineer in the state where the Project is to be constructed, using performance requirements and design criteria indicated.
 - 2. Continuously monitor and maintain dewatering operations to ensure erosion control, stability of excavations and constructed slopes, that excavation does not flood, and that damage to subgrades and permanent structures is prevented.
 - 3. Prevent surface water from entering excavations by grading, dikes, or other means.
 - 4. Accomplish dewatering without damaging existing buildings, structures, and site improvements adjacent to excavation.
 - 5. Remove dewatering system when no longer required for construction.

1.4 SUBMITTALS

- A. Action Submittal. Provide shop drawings for dewatering system. Show arrangement, locations, and details of wells and well points; locations of risers, headers, filters, pumps, power units, and discharge lines; and means of discharge, control of sediment, and disposal of water. The design shall be by a dewatering specialist with experience in dewatering for utility projects.
- B. Delegated-Design Submittal: For dewatering system indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
- C. Informational submittals

1. Qualification Data: For qualified Installer, land surveyor, and engineer as applicable.
2. Field quality-control reports.
3. Other Informational Submittals:
 - a. Photographs or Videotape: Show existing conditions of adjoining construction and site improvements that might be misconstrued as damage caused by dewatering operations, if applicable.

1.5 QUALITY ASSURANCE

- A. Installer Qualifications: An experienced installer that has specialized in design of dewatering systems and dewatering work.
- B. Regulatory Requirements: Comply with governing notification regulations before beginning dewatering. Comply with hauling and disposal regulations of authorities having jurisdiction.

1.6 PROJECT CONDITIONS

- A. Interruption of Existing Utilities: As applicable, do not interrupt any utility serving facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility according to requirements indicated:
 1. Notify Engineer no fewer than two (2) days in advance of proposed interruption of utility.
 2. Do not proceed with interruption of utility without ENGINEER's written permission.
- B. Project-Site Information: A geotechnical report has been prepared for this Project and is available for information only. The opinions expressed in this report are those of geotechnical engineer and represent interpretations of subsoil conditions, tests, and results of analyses conducted by geotechnical engineer. OWNER/ENGINEER will not be responsible for interpretations or conclusions drawn from this data.
 1. Make additional test borings and conduct other exploratory operations necessary for dewatering.
 2. The geotechnical report is referenced elsewhere in the Project Manual.
- C. Survey Work: If applicable, engage a qualified land surveyor or professional engineer to survey adjacent existing buildings, structures, and site improvements, establishing exact elevations at fixed points to act as benchmarks. Clearly identify benchmarks and record existing elevations.
 1. During dewatering, regularly resurvey benchmarks, maintaining an accurate log of surveyed elevations for comparison with original elevations. Promptly notify ENGINEER if changes in elevations occur or if cracks, sags, or other damage is evident in adjacent construction.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 PREPARATION

- A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by dewatering operations.

1. Prevent surface water and subsurface or ground water from entering excavations, from ponding on prepared subgrades, and from flooding site and surrounding area.
 2. Protect subgrades and foundation soils from softening and damage by rain or water accumulation.
- B. Install dewatering system to ensure minimum interference with roads, streets, walks, and other adjacent occupied and used facilities.
1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction. Provide alternate routes around closed or obstructed traffic ways if required by authorities having jurisdiction.
- C. Provide temporary grading to facilitate dewatering and control of surface water.
- D. Monitor dewatering systems continuously.
- E. Promptly repair damages to adjacent facilities caused by dewatering.
- F. Protect and maintain temporary erosion and sedimentation controls, which are specified in Section 31 12 00 "Site Clearing, Grubbing, Trees, and Shrubs" during dewatering operations.

3.2 INSTALLATION

- A. Install dewatering system utilizing wells, well points, or similar methods complete with pump equipment, standby power and pumps, filter material gradation, valves, appurtenances, water disposal, and surface-water controls.
1. Space well points or wells at intervals required to provide sufficient dewatering.
 2. Use filters or other means to prevent pumping of fine sands or silts from the subsurface.
- B. Before excavating below ground-water level, place system into operation to lower water to specified levels. Operate system continuously until drains, sewers, and structures have been constructed and fill materials have been placed or until dewatering is no longer required.
- C. Provide an adequate system to lower and control ground water to permit excavation, construction of structures, and placement of fill materials on dry subgrades. Install sufficient dewatering equipment to drain water-bearing strata above and below bottom of foundations, drains, sewers, and other excavations.
1. Do not permit open-sump pumping that leads to loss of fines, soil piping, subgrade softening, and slope instability.
- D. Reduce hydrostatic head in water-bearing strata below subgrade elevations of foundations, drains, sewers, and other excavations.
1. Unless otherwise specified in the Geotechnical Report, maintain piezometric water level a minimum of 24 inches below surface of excavation.
- E. Dispose of water removed by dewatering in a manner that avoids endangering public health, property, and portions of work under construction or completed. Dispose of water and sediment in a manner that avoids inconvenience to others. Provide sumps, sedimentation tanks, and other flow-control devices as required by authorities having jurisdiction.

- F. Provide standby equipment on site, installed and available for immediate operation, to maintain dewatering on continuous basis if any part of system becomes inadequate or fails. If dewatering requirements are not satisfied due to inadequacy or failure of dewatering system, restore damaged structures and foundation soils at no additional expense to Owner.
 - 1. Remove dewatering system from Project site on completion of dewatering. Plug or fill well holes with sand or cut off and cap wells a minimum of 36" below overlying construction.
- G. Damages: Promptly repair damages to adjacent facilities caused by dewatering operations.

3.3 FIELD QUALITY CONTROL

- A. Observation Wells: When shown on Drawings, provide, take measurements, and maintain at least the minimum number of observation wells or piezometers indicated; additional observation wells may be required by authorities having jurisdiction.
 - 1. Observe and record daily elevation of ground water and piezometric water levels in observation wells.
 - 2. Repair or replace, within 24 hours, observation wells that become inactive, damaged, or destroyed. In areas where observation wells are not functioning properly, suspend construction activities until reliable observations can be made. Add or remove water from observation-well risers to demonstrate that observation wells are functioning properly.
 - 3. Fill observation wells, remove piezometers, and fill holes when dewatering is completed.
- B. Provide continual observation to ensure that subsurface soils are not being removed by the dewatering operation.

END OF SECTION

SECTION 31 50 00
EXCAVATION SUPPORT AND PROTECTION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section includes temporary excavation support and protection systems.
- B. Related Sections:
 - 1. Section 31 23 19 "Dewatering" for dewatering system for excavations.

1.3 PERFORMANCE REQUIREMENTS

- A. Design, furnish, install, monitor, and maintain excavation support and protection system capable of supporting excavation sidewalls and of resisting soil and hydrostatic pressure and superimposed and construction loads.
 - 1. Delegated Design: Design excavation support and protection system, including comprehensive engineering analysis by a qualified professional engineer, licensed to practice in the state where the Project will be constructed, using performance requirements and design criteria indicated.
- B. As a minimum, the Excavation Support and Protection Plan shall address the following items:
 - 1. Provide details of shoring, bracing, sheet piling, soldier piles and lagging, tie backs, and other support systems and provisions for worker protection from hazards of caving ground.
 - 2. Methods and sequencing of installing excavation support.
 - 3. Proposed locations for excavated materials.
 - 4. Minimum lateral distance from the crest of slopes for vehicles, equipment, and stockpiled materials.
 - 5. Prevent surface water from entering excavations by grading, dikes, or other means.
 - 6. Install excavation support and protection systems without damaging existing buildings, structures, and site improvements adjacent to excavation.
 - 7. Monitor vibrations, settlements, and movements.

1.4 SUBMITTALS

- A. Delegated-Design Submittal: For excavation support and protection system indicated to comply with performance requirements and design criteria, include analysis data and engineering drawings signed and sealed by the qualified professional engineer, licensed to practice in the state where the Project is constructed, responsible for their preparation.

1.5 PROJECT CONDITIONS

- A. Project-Site Information: A geotechnical report has been prepared for this Project and is

available for information only. The opinions expressed in this report are those of the geotechnical engineer and represent interpretations of subsoil conditions, tests, and results of analyses conducted by geotechnical engineer. OWNER and ENGINEER will not be responsible for interpretations or conclusions drawn from the data.

1. Make additional test borings and conduct other exploratory operations necessary for excavation support and protection.
- B. Survey Work: Engage a qualified land surveyor or professional engineer to survey adjacent existing buildings, structures, and site improvements; establish exact elevations at fixed points to act as benchmarks. Clearly identify benchmarks and record existing elevations.
 1. During installation of excavation support and protection systems, regularly resurvey benchmarks, maintaining an accurate log of surveyed elevations and positions for comparison with original elevations and positions. Promptly notify ENGINEER if changes in elevations or positions occur or if cracks, sags, or other damage is evident in adjacent construction.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 PREPARATION

- A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards that could develop during excavation support and protection system operations.
 1. Shore, support, and protect utilities encountered.
- B. Install excavation support and protection systems to ensure minimum interference with roads, streets, walks, and other adjacent occupied and used facilities.
 1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from OWNER and authorities having jurisdiction. Provide alternate routes around closed or obstructed traffic ways if required by authorities having jurisdiction.
- C. Locate excavation support and protection systems clear of permanent construction so that forming and finishing of concrete surfaces are not impeded.
- D. Monitor excavation support and protection systems daily during excavation progress and for as long as excavation remains open. Promptly correct bulges, breakage, or other evidence of movement to ensure that excavation support and protection systems remain stable.
- E. Promptly repair damages to adjacent facilities caused by installing excavation support and protection systems.

3.2 TRENCHES

- A. For excavations exceeding 5 feet in depth, provide adequate safety system meeting requirements of applicable state and local construction safety orders, and Federal requirements.

3.3 REMOVAL AND REPAIRS

- A. Remove excavation support and protection systems when construction has progressed

sufficiently to support excavation and bear soil and hydrostatic pressures. Remove in stages to avoid disturbing underlying soils or damaging structures, pavements, facilities, and utilities.

1. Fill voids immediately with approved backfill compacted to density specified in Section 31 20 00 "Earthwork."
 2. Repair or replace, as approved by ENGINEER, adjacent work damaged or displaced by removing excavation support and protection systems.
- B. If the support or stability of existing structures or site improvements is dependent, leave excavation support and protection systems permanently in place. Remove excavation support and protection systems to a minimum depth of 48 inches below overlaying construction and abandon remainder.

END OF SECTION

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SECTION 32 11 23
AGGREGATE BASE COURSES

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Crushed rock base course.
- B. Related Sections:
 - 1. Division 1 - General Requirements.
 - 2. Section 31 12 00 – Selective Clearing, Grubbing, Tree, and Shrub Removal
 - 3. Section 31 23 00 – Excavation, Trenching, and Backfilling for Utilities
 - 4. Section 31 23 10 - Structural Excavation and Backfill

1.2 REFERENCES

- A. Abbreviations and Acronyms:
 - 1. American Association of State Highway and Transportation Officials (AASHTO)
 - 2. American Society for Testing and Materials (ASTM)
 - 3. Colorado Department of Transportation (CDOT)
- B. Standards:
 - 1. Colorado Department of Transportation (CDOT):
 - a. Standard Specifications for Road and Bridge Construction, current edition.
 - 2. American Association of State Highway and Transportation Officials (AASHTO)
 - a. T99 – The Moisture Density Relations of Soils Using a 5.5-Pound (2.5-kg) Rammer and a 12-Inch (305-mm) Drop.
 - 3. American Society for Testing and Materials (ASTM) International
 - a. D1557 – Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort 56,000 ft-lbf/ft³ (2,700 kN-m/m³)

1.3 SUBMITTALS

- A. Design Data:
- B. Test and Evaluation Reports:
 - 1. Certified Gradation Analysis: Submit not less than 30 days prior to delivery for imported materials or anticipated to be used for trench stabilization, bedding, backfill within the pipe zone, and backfill above the pipe zone.
 - 2. Certified Testing Analysis: Liquid limits, plasticity index, and other parameters for materials showing compliance with specified limits.
- C. Contamination Certification:
 - 1. Obtain a written, notarized certification from the Supplier of each proposed Aggregate Base Course source stating that to the best of the Supplier's knowledge and belief there has never been contamination of the source with hazardous or toxic materials.

2. Submit these certifications to the ENGINEER prior to proceeding to furnish Aggregate Base Course to the site. The lack of such certification on a potential Aggregate Base Course source shall be cause for rejection of that source.
3. When materials are suspected of contamination, the CONTRACTOR shall arrange and pay for the services of an EPA approved laboratory to perform a toxic contaminant scan of composite borrow material samples.

PART 2 - PRODUCTS

2.1 MATERIALS

A. General

1. Crushed rock base course shall consist of Class 2 and Class 6 Aggregate Base Course conforming to the requirements of the CDOT Specifications for Road and Bridge Construction, AASHTO M 147 and the Classification Table below:

Sieve Size	Mass Percent Passing Square Mesh Sieves						
	LL not greater than 35			LL not greater than 30			
	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7
150 mm (6")			100				
100 mm (4")		100					
75 mm (3")		95-100					
60 mm (2 1/2")	100						
50 mm (2")	95-100			100			
37.5 (2")				90-100	100		
25 mm (1")					95-100	100	100
19 mm (3/4")				50-90		95-100	
4.75 mm (#4)	30-65			30-50	30-70	30-65	
2.36 mm (#8)						25-55	20-85
75 µm (#200)	3-15	3-15	20 max	3-12	3-15	3-12	5-15
Note: Class 3 material shall consist of bank or pit run material							

B. Aggregate Base Material

1. Aggregate base material shall be 1-inch or smaller material that conforms to the CDOT Class 6 aggregate base course specifications and have an R-value of 78 or greater.
2. Aggregate base material shall be crushed stone or crushed gravel, free from lumps or balls of clay, dirt, or other objectionable matter and reasonably free from thin and elongated pieces of aggregate. Aggregates shall consist of angular fragments, durable and sound, and shall be reasonably uniform in density and quality.
3. Other materials may be suitable for use as aggregate base, but materials different than those listed in this section should be observed and approved by the Geotechnical Engineer prior to use in construction.

C. Aggregate Sub-Base Material

1. Aggregate sub-base material shall conform to the CDOT Class 2 aggregate base

course specifications and have an R-value of 70 or greater.

2. Aggregate sub-base material shall be crushed stone or crushed gravel, free from lumps or balls of clay, dirt, or other objectionable matter and reasonably free from thin and elongated pieces of aggregate. Aggregates shall consist of angular fragments, durable and sound, and shall be reasonably uniform in density and quality.
3. Other materials may be suitable for use as aggregate sub-base, but materials different than those listed in this section should be observed and approved by the Geotechnical Engineer prior to use in construction.

2.2 EQUIPMENT

A. General Requirements:

1. All equipment, tools, and machines used in the execution of the Work required by this Section shall be maintained in satisfactory working condition at all times.
2. Equipment shall be subject to the approval of the ENGINEER.
3. Adjust and clean equipment and parts for smooth, uniform operation. Vibration of installed equipment shall be within manufacturer's specified tolerances.

B. Stationary Mixing Plants:

1. Plants shall be designed to accurately proportion and thoroughly mix the material and water.
2. Plants shall be equipped with weighing and measuring devices for proportioning on a weight basis or by volume based on weight.

C. Power Rollers:

1. Rollers shall be self-propelled, 3-wheel, or tandem-type with wheels equipped with adjustable scrapers.
2. Weight shall not be less than 8 tons.

D. Tamping Rollers:

1. Rollers shall consist of one or more units arranged to adapt to uneven ground surfaces.
2. Rolling units of multiple type shall be pivoted on the main frame.
3. When fully loaded, rollers shall exert at least 300 psi on the combined areas of tamping feet in contact with the ground.
4. Each unit shall be equipped with a watertight cylindrical drum with length 48 inches or greater.
5. Tamping feet shall project not less than 7 inches from drum surface, with feet spaced

not less than 10 inches, nor more than 10 inches measured diagonally from center to center.

- E. Rubber-Tired Rollers:
 - 1. Rollers shall consist of two axles on which are mounted not less than nine pneumatic-tired wheels, mounted so the rear group of tires do not follow in the tracks of the forward wheels but will be centered between the forward wheels.
 - 2. The axles shall be mounted in a rigid frame provided with a loading
 - 3. Inflate tires uniformly.
 - 4. May be self-propelled.
 - 5. Tow with pneumatic-tired tractors or other pneumatic-tired equipment.
- F. Blade graders shall be self-propelled with a wheelbase of not less than 15 feet, and a blade of not less than 10 feet.
- G. Sprinkling equipment shall consist of tank trucks, pressure distributors, or other similar equipment designed to apply water uniformly and in controlled quantities to variable width of surface.
- H. Hauling equipment shall consist of pneumatic-tired vehicles and dump bodies suitable for dumping materials in windrows or layers on the subgrade.
- I. Tampers shall be mechanical (of an approved type) and hand-operated, weight not less than 50 pounds, and have a face area of not more than 100 square inches.
- J. Miscellaneous equipment shall consist of scarifiers, tractors, spring-tooth or spike-tooth harrows, windrow equalizers, spreaders, and other equipment suitable for construction of select material base course.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Stockpiles:
 - 1. Clear and level storage sites prior to stockpiling in accordance with Section 31 12 00 "Selective Clearing, Grubbing, Tree, and Shrub Removal".
 - 2. Place in the manner and at locations designated by the ENGINEER, providing separate stockpiles for materials from separate sources.
- B. Cold Weather Limitations:
 - 1. Base course construction shall be prohibited when atmospheric temperature is below 35 degrees F.
 - 2. Do not place base course on frozen subgrade.
 - 3. Protect base course and subgrade in freezing weather and repair areas damaged by freezing, by reshaping, and recompact.
- C. Preparation of Subgrade:
 - 1. Clean of all foreign substances.
 - 2. Subgrade soils shall be removed to a depth of 12 inches, moisture conditioned, and compacted prior to the placement of overlying aggregate material.

3. Subgrade shall be moisture conditioned to optimum moisture content (+/-2%) and compacted to at least 90% maximum dry density, per the modified Proctor test, ASTM D1557.
 4. Surface of subgrade soils shall be graded and contoured to be approximately parallel to the finished grade roadway and parking areas.
 5. ENGINEER will inspect for adequate compaction, moisture, and surface tolerances.
- D. Structural Fill
1. If additional fill is required below the sub-base, provide and compact Granular Compacted Structural Fill per Section 31 23 10 up to the sub-base elevation.
 2. Areas where fill will support vehicular traffic including under access roadway or concrete flatwork, Granular Compacted Structural Fill shall be compacted to at least 95 percent of the maximum dry density as defined by ASTM D1557, modified Proctor test.
- E. Grade Control
1. Establish and maintain by means of grade stakes placed in lanes parallel to the centerline of the area to be paved and spaced so string lines may be stretched between stakes.
- F. Proof Roll
1. Subgrade soils shall be proof-rolled prior to any operations.
 2. Proof roll subgrade to identify soft pockets and areas of excess yielding using rollers that when loaded weigh at least 25 tons and no more than 50 tons.
 3. Do not proof-roll wet or saturated subgrades.
 4. Make at least two passes, offsetting each pass one tire width. Operate at speed between 2 and 6 miles per hour.
 5. Excavate soft pockets, unsatisfactory soils, and areas of excessive pumping or rutting, as determined by ENGINEER, and replace with select or granular fill as directed.
 6. Following proof rolling and replacement of unsatisfactory soil with satisfactory soil, the following preparations shall be made to the subgrade in the following order.
 - a. Scarify the site
 - b. Any soft areas observed during proof-rolling shall be removed and replaced with Class 6 aggregate base course.
 - c. Moisture condition to above optimum moisture content
 - d. Recompect to a minimum 95 percent dry density Standard Proctor (ASTM D 698)

3.2 FIELD / SITE QUALITY CONTROL

- A. Mixing and placing shall conform to Colorado DOT Standard Specifications for Road and Bridge Construction, paragraphs 304.04 and 304.05.
- B. Shaping and Compacting Mixed Materials:
1. Compact in layers no less than 3 inches nor more than 6 inches thick.
 2. Roll to specified compaction requirements throughout full depth of layer with tamping rollers, power rollers, rubber-tired rollers, or combination.

3. Shape and smooth by blading and rolling with power roller or rubber-tired roller or both.
 4. Hand-tamp in places not accessible to rolling equipment.
 5. Aerate by blade graders, harrows, or other approved equipment when mixture is moistened by rain.
- C. Degree of Compaction:
1. Compaction of each layer shall continue until a density of not less than 90% of maximum dry density (modified proctor, ASTM D1557) within the moisture content range from 2 percent below optimum to 2 percent above optimum. Under asphaltic, crushed aggregate, and concrete pavement, the top 8 inches of Class 2 and 4 inches of Class 6 shall be compacted until a density of not less than 95% of the maximum dry density determined in accordance with ASTM D1557 (modified proctor) has been achieved. The surface of each layer shall be maintained during the compaction operations so that a uniform texture is produced, and the aggregates are firmly keyed. Water shall be uniformly applied during compaction in the quantity necessary for proper consolidation.
- D. Smoothness Test:
1. The finished base course surface shall be smooth and free of ruts and irregularities and true to grade and crown as shown on the plans. The final surface shall be finished with a surface smoothness tolerance of 1/4 inch measured as vertical ordinate from the face to a ten-foot straightedge laid parallel or 3/8 inch perpendicular to the station line. The base course shall be maintained in this condition by watering, drying, rolling, or blading, as necessary until the surfacing is placed.
 2. Correct any deviation in excess of this amount by loosening, adding or removing material, reshaping, watering, and compacting as requested by the ENGINEER.

3.3 MAINTENANCE

- A. Maintain finished base course in a condition satisfactory to the ENGINEER.
- B. Maintain finished base course as necessary to control rutting and general section drainage.

END OF SECTION

SECTION 32 14 23
PAVEMENT

PART 1 GENERAL

1.1 SUMMARY

- A. Section includes asphalt pavement for recreation path repair.
- B. Related Sections:
 - 1. Division 1 - General Requirements.
 - 2. Section 31 12 00 – Selective Clearing, Grubbing Trees and Shrubs .
 - 3. Section 31 23 00 – Excavation, Trenching, and Backfilling for Utilities.
 - 4. Section 31 23 10 – Structural Excavation and Backfill.
 - 5. Section 32 11 23 – Aggregate Base Courses.
 - 6. Section 32 16 00 – Curbs, Gutters, Sidewalks, and Driveways.

1.2 REFERENCES

- A. 2017 Colorado Department of Transportation (CDOT) Standard Specifications Book:
 - 1. Standard Specifications for Road and Bridge Construction.
 - a. Section 301 - Plant Mix Bituminous Base Course.
 - b. Section 401 - Plant Mix Pavements – General.
 - c. Section 403 - Hot Bituminous Pavement.
 - d. Section 407 - Prime Coat, Tack Coat, and Rejuvenating Agent.
 - e. Section 411 - Bituminous Materials.
 - f. Section 703 - Aggregates.
 - g. Section 712 - Miscellaneous.
 - 2. Lab Procedure.
 - a. CP-L 5103 - Bulk Specific Gravity of Compacted Bituminous Mixtures Using Saturated Surface-Dry Specimens.
 - b. CP-L 5109 - Resistance of Compacted Bituminous Mixture to Moisture Induced Damage.
 - 3. Testing Procedure.
 - a. CP-45 - Standard Method of Test for Determining Percent of Particles with Two of More Fractured Faces.
 - b. CP-48 - Standard Method of Test for Determination of the Voids in the Mineral Aggregate (VMA).
 - 4. American Association of State Highway and Transportation Officials (AASHTO):

- a. T84 - Specific Gravity and Absorption of Fine Aggregate.
 - b. T85 - Specific Gravity and Absorption of Coarse Aggregate.
 - c. M208 - Cationic Emulsified Asphalt.
5. American Society for Testing and Materials (ASTM):
- a. C110 - Standard Test Methods for Physical Testing of Quicklime, Hydrated Lime, and Limestone.
 - b. D946 - Penetration-Graded Asphalt Cement for Use in Pavement Construction.
 - c. D2950 - Test Method for Density of Bituminous Concrete in Place by Nuclear Method

1.3 SYSTEM DESCRIPTION

A. Design Requirements:

1. Completed pavement will be tested to determine density, gradation, and asphalt content (by extraction):
 - a. At Engineer's option, density may be tested by any of the following methods:
 - 1) As specified by CDOT Standard Specifications for Road and Bridge Construction – Section 401.
 - 2) ASTM D2950.
 - 3) Samples: Core or saw undamaged Samples from the completed pavement courses at locations designated by Engineer:
 - a) Core Samples shall be not less than 4-inch diameter.
 - b) Take core samples at the engineer's discretion in addition to samples required by ASTM D2950. Deliver Samples to the laboratory designated by Engineer. Samples may be tested for density and extraction.
 - 4) Replace pavement at Sample location with fresh bituminous mixture and thoroughly compact repaired area.
2. Contractor shall perform such other tests as Contractor deems necessary to assure production of asphaltic concrete conforming to specified quality.

B. Subgrade and Subbase:

1. Subgrade: Refer to Section 31 23 00 Excavation and Backfill.
2. Subbase Aggregate Base Courses (ABC) Class 6: Refer to Section 32 11 00 Aggregate Base Courses.
 - a. If native soils are used as structural fill and contain clayey soils, install geotextile filter fabric between the subgrade and the subbase.

C. Asphalt Pavement:

1. Hot Mix Asphalt (HMA) shall meet the requirements of CDOT Standard Specifications for Road and Bridge Construction, Section 400, with asphalt binder grade of PG 64-22 or PG 58-28, N design of 50 or 75.
2. Aggregate base course to be Class 6, in accordance with Section 32 11 00.
3. The pavement section recommendation is:

Pavement Type	Hot Mix Asphalt (inches)	Aggregate Base Course (inches)
Layered HMA over ABC For Recreation Path Repair	3.0	6.0

D. Performance Requirements:

1. Density tolerance shall conform to the requirements of CDOT Standard Specifications for Road and Bridge Construction – Section 401.
2. Surface:
 - a. Surface shall be of uniform texture and appearance.
 - b. Surface smoothness tolerance shall conform to the requirements of CDOT Standard Specifications for Road and Bridge Construction – Sections 301 and 401.

1.4 SUBMITTAL

A. General: Submit as specified in Section 01 33 00.

B. Quality Assurance / Control Submittals

1. Design Data
 - a. Contractor shall provide mix designs and prepare a job mix formula for each mixture specified. Mix designs shall be accomplished by a qualified, independent, commercial testing laboratory.
2. Test Reports
 - a. Furnish seven copies of the proposed job mix formula, including the laboratory test report, to Engineer for approval not less than 30 days prior to beginning production of paving mixture. Test reports shall indicate the following:
 - 1) Gradation: Each component aggregate and combined aggregates.
 - 2) Asphalt cement content in percent of total mix by weight.
 - 3) Graphic plots of:
 - 4) Density versus asphalt content.
 - 5) Stability versus asphalt content.
 - 6) Percent voids total mix versus asphalt content.
 - 7) Flow versus asphalt content.
3. Certificates
 - a. Submit certificates accompanied by a copy of the refinery test report for bituminous materials for:
 - 1) Tack coat.
 - 2) Asphalt cement
4. Striping

- a. Provide a CDOT Certificate of Compliance (COC) of the epoxy striping material.
- b. Provide manufacturers certification that all of the thermoplastic marking material meets the requirements of AASHTO M 249 specification.

1.5 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing products specified in this Section with minimum 5 years documented experience.
- B. Fabricator Qualifications: Company specializing in fabricating work specified in this Section with minimum 5 years documented experience.
- C. Installer Qualifications: Acceptable to manufacturer with documented experience on at least 5 projects of similar nature in the past 5 years.
- D. Regulatory Requirements
 1. In accordance with all local codes and ordinances, laws and regulations of the state.
 2. In case of apparent conflict, state and local requirements govern over these specifications.

1.6 PROJECT / SITE CONDITIONS

- A. Project / Site Environmental Requirements:
 1. Tack Coats: Minimum surface temperature of 60 deg F (15.5 deg C).
 2. Asphalt Base Course: Minimum Surface temperature of 40 deg F (4 deg C) and rising at the time of placement unless otherwise required by the Colorado Department of Transportation (CDOT) specification as listed herein.
 3. Asphalt Surface Course: Minimum Surface temperature of 60 deg F (15.5 deg C) at the time of placement unless otherwise required by the Colorado Department of Transportation (CDOT) specification as listed herein.

PART 2 PRODUCTS

2.1 GENERAL

- A. Equipment and Materials shall conform to the requirements of CDOT Standard Specifications for Road and Bridge Construction – Sections 301, 401, 403, 407, 411, 703 and 712, except as modified herein.

2.2 MATERIALS

- A. Bituminous Material – **NOT USED, REFER TO RECLAIMED ASPHALT PAVEMENT:**
 1. Asphalt Cement: PG 58-28.
 2. Tack Coat:
 - a. CSS-1h or SS-1h; Emulsified asphalt conforming to AASHTO M208 or M140, respectively.
 - b. Emulsified asphalt shall be diluted 1:1 with water.
- B. Asphaltic Concrete Mixture – **NOT USED, REFER TO RECLAIMED ASPHALT PAVEMENT:**
 1. Aggregate Properties:
 - a. Base Course Gradation: Grading S.

- b. Surface Course Gradation: Grading SX.
- c. For Gradings S and SX, a percentage of the aggregate retained on the No. 4 sieve shall have at least two mechanically induced fractured faces when tested in accordance with CP-45:
 - 1) Top and middle lift: 80% minimum.
 - 2) Bottom lifts: 70% minimum.
- d. Void in the Mineral Aggregate (VMA) Criteria:
 - 1) All mixes shall meet the minimum VMA specified in the table below.
 - 2) VMA shall be based on tests of the Bulk Specific Gravity of the Compacted Mix (Colorado Department of Transportation Lab Procedure CP-L 5103) and Aggregate (AASHTO T84 & T85) and calculated according to Colorado Department of Transportation Testing Procedure CP-48.

Minimum VMA, %			
Nominal Maximum ¹ Particle Size	Air Voids ²		
	3.5%	4.0%	4.5%
1"	12.5	13.0	13.5
3/4"	13.5	14.0	14.5
1/2"	14.5	15.0	15.5
1) Nominal Maximum Particle Size is defined as one sieve size larger than the first sieve to retain more than 10% but shall not exceed the 100% passing size. The Nominal Maximum Particle Size can vary during mix production even when the 100% passing size is constant. 2) Minimum VMA criteria apply to the mix design only. The minimum VMA criteria shall be linearly interpolated based on actual air voids.			

- 2. Reclaimed Asphalt Pavement (RAP):
 - a. RAP material to be provided by Owner and used at the Owner's discretion. Contractor is responsible for the associated transporting, preparing, installing, and disposal. Refer to **Exhibit A** of this section, which shows stockpile location.
- 3. Additives:
 - a. Hydrated Lime.
 - 1) Lime shall be added at a rate of 1% by dry weight of the aggregate and shall be included in the amount of material passing the No. 200 sieve. Hydrated lime for aggregate pretreatment shall conform to the requirements of ASTM C207, Type N. In addition, the residue retained on the 200 mesh sieve shall not exceed 10% when determined in accordance with ASTM C110. Drying of the test residue in an atmosphere free from carbon dioxide will not be
- 4. Mix Properties:
 - a. Design Gradation (Air Voids 3.5% to 4.5%): 75.
 - b. Lottman, Tensile Strength, % Retained: 80 minimum in accordance with CP-L 5109, Method B.
 - c. Lottman: 30 minimum in accordance with CP-L 5109.
 - d. VMA %: Minimum VMA shall conform to the table above.

5. Stripping:
 - a. Pavement marking materials shall comply with the CDOT Standard Specifications for Road and Bridge Construction – Sections 708 Paints and specifically 708.05 Pavement Marking Materials.
6. Dowel Bars and Tie Bars:
 - a. Tie bars for longitudinal and transverse joints shall conform to AASHTO M 284 and shall be grade 40, epoxy-coated, and deformed. Bar size shall be as designated on the Standard Plan M-412-1.
 - b. Dowel bars for transverse joints shall conform to AASHTO M 254 for the coating and to ASTM A 615, grade 60 for the core material and shall be epoxy-coated, smooth, and lightly greased, precoated with wax or asphalt emulsion, or sprayed with an approved material for their full length. Bar configuration, installation, and size shall be as designated on the CDOT Standard Plan M-412-1

PART 3 EXECUTION

3.1 EXAMINATION

- A. Site verification of conditions.
 1. Verify that subgrade is dry and in suitable condition to support paving and imposed loads.
 2. Proof-roll subbase using heavy, pneumatic-tired rollers to locate areas that are unstable or that require further compaction.
 3. Notify Engineer of any unsatisfactory conditions. Do not begin paving installation until conditions have been satisfactorily corrected.

3.2 PREPARATION

- A. Surface Preparation
 1. General: Immediately before placing asphalt materials, remove loose and deleterious material from substrate surfaces. Ensure that prepared subgrade is ready to receive paving.
 - a. Sweep loose granular particles from surface of unbound-aggregate base course. Do not dislodge or disturb aggregate embedded in compacted surface of base course.

3.3 INSTALLATION

- A. Placement of Materials
 1. HMA material shall be placed in maximum lifts below and compacted to 92% to 96% maximum theoretical density (ASTM D2041), within 0.3% of optimum asphalt content.

Grade	Lift Thickness
S	2 to 3
SX	1 to 2

- B. Compaction
 1. Asphalt shall be compacted to 92% to 96% of the maximum theoretical density.

C. Tack Coat:

1. Apply tack coat to the surface of all existing pavement and all previously placed asphaltic concrete lifts or courses before placing the succeeding lift.
2. Apply tack coat to the exposed vertical sides of existing pavement adjacent to areas to be patched.
3. Apply at the following rates:
 - a. Emulsion asphalt: 0.10 : 0.01 gallons per square yard.

D. Stripping

1. Pavement marking shall conform to the requirements of CDOT Standard Specifications for Road and Bridge Construction – Sections 627.

END OF SECTION



Exhibit A: Recycled Asphalt Stockpile Location

SECTION 32 16 00
CURBS, GUTTERS, SIDEWALKS, AND DRIVEWAYS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Cast-in-place concrete for curbs gutters, sidewalks, and driveways identified within the Contract Drawings.
- B. Related Specification Sections include, but are not necessarily limited to:
 - 1. Section 03 30 00 – Cast-In-Place Concrete
 - 2. Section 03 20 00 – Concrete Reinforcement

1.2 REFERENCES

- A. Abbreviations and Acronyms:
 - 1. American Concrete Institute (ACI).
 - 2. American Society for Testing and Materials International (ASTM).
- B. Definitions:
 - 1. In accordance with ACI 116R.
 - 2. Concrete shall be in accordance with Section 03 30 00 “Cast-In-Place Concrete.”
- C. Standards:
 - 1. American Concrete Institute (ACI).
 - a. 211.1 – Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete.
 - b. 304 – Guide for Transporting Concrete.
 - c. 304.2R – Placing Concrete by Pumping Methods.
 - d. 305 – Hot-Weather Concreting.
 - e. 306 – Cold-Weather Concreting.
 - f. 309 – Guide for Consolidation of Concrete.
 - g. 347 – Recommended Practice for Concrete Formwork.
 - h. 350 – Code Requirements for Environmental Engineering Concrete Structures.
 - i. 546 – Concrete Repair Guide.
 - 2. American Society for Testing and Materials International (ASTM):
 - a. A82 – Steel Wire, Plain, for Concrete Reinforcement.
 - b. A185 – Steel Welded Wire Reinforcement, Plain, for Concrete.
 - c. A615 – Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
 - d. C33 – Standard Specification for Concrete Aggregates.
 - e. C94 – Standard Specification for Ready-Mixed Concrete.
 - f. C128 – Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Fine Aggregate.
 - g. C127 – Standard Test Method for Density, Relative Density (Specific Gravity),

- and Absorption of Coarse Aggregate.
- h. C150 – Standard Specification for Portland Cement.
 - i. C171 – Standard Specification for Sheet Materials for Curing Concrete.
 - j. C260 – Standard Specification for Air-Entraining Admixtures for Concrete.
 - k. C309 – Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete.
 - l. C311 – Standard Test Methods for Sampling and Testing Fly Ash or Natural Pozzolans for Use in Portland-Cement Concrete.
 - m. C494 – Standard Specification for Chemical Admixtures for Concrete.
 - n. C595 – Standard Specification for Blended Hydraulic Cements.
 - o. C618 – Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.
 - p. C666 – Standard Test Method for Resistance of Concrete to Rapid Freezing and Thawing.
 - q. C1012 – Standard Test Method for Length Change of Hydraulic-Cement Mortars Exposed to a Sulfate Solution.
 - r. C1260 – Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method).
 - s. C1293 – Standard Test Method for Determination of Length Change of Concrete Due to Alkali-Silica Reaction.
 - t. D994 – Standard Specification for Preformed Expansion Joint Filler for Concrete (Bituminous Type).
 - u. D1751 – Paving and Structural Construction (Non-extruding and Resilient Bituminous Types).
 - v. D1752 – Standard Specification for Preformed Sponge Rubber Cork and Recycled PVC Expansion Joint Fillers for Concrete Paving and Structural Construction.
3. Colorado Department of Transportation: Standard Specifications for Road and Bridge Construction (CDOT).
- a. CDOT Item 412.42 “Removal and Replacement of Concrete Pavement”

1.3 SUBMITTALS

A. Action Submittals:

1. Product Data:

- a. Submit manufacturer’s descriptive literature and product specifications for each product.
- b. Admixtures:
 - 1) Indicate admixtures added to concrete at ready mix batch plant.
 - 2) Indicate field available admixtures.
- c. Reinforcing steel:
 - 1) Indicate complete reinforcing bar schedule, reinforcing bar details, and erection drawings to conform to ACI 315.

- 2) Indicate each type of reinforcing bar marked with identification corresponding to identification tag on bar.
 - 3) Indicate bar sizes, spacing, locations, and quantities of reinforcing steel.
 - 4) System fabrication, dimensions, bar sizes, locations of connections, connection details, quantities of reinforcing steel and wire fabric bending and cutting schedules.
 - 5) Indicate dimensions, materials, bracing, and arrangement of joints and ties.
 - d. Accessories:
 - 1) Void form, forms, chamfer strips, form coating, form ties.
 - 2) Expansion joint filler.
 - 3) Membrane curing compound.
 - 4) Bonding admixture and agent.
 - 5) Flood hardener.
 - 6) Expansion and contraction joint shear bar grease.
2. Design Data:
- a. Reports of tentative concrete mix design for structural concrete, concrete topping, and concrete fill as well as testing for each tentative mix design including:
 - 1) Slump and tolerance.
 - 2) Air content and tolerance.
 - 3) Water/cementitious material ratio and tolerance.
 - 4) Total volume of water per cubic yard of ready-mix concrete.
 - 5) Brand, type, composition, and quantity of cement with manufacturer and plant location identified.
 - 6) Brand, type, composition and quantity of fly ash.
 - 7) Specific gravity and gradation of each aggregate.
 - 8) Ratio of fine to total aggregate.
 - 9) Surface-dry weight of each aggregate per cubic yard.
 - 10) Brand, type, ASTM designation, active chemical ingredients and quantity of each admixture.
 - 11) Compressive strength based at 7- and 28-day compression tests.
 - 12) Time of initial set.
 - 13) Existing data on proposed design mixes are acceptable if certified and complete.
 - b. Cold weather Curing and Protection: Detailed plan for cold weather curing and protection of concrete. Include requirements and recommendations of ACI 306 and ACI 318.
 - c. Defective Concrete Repair Procedures: As necessary to repair defective concrete.
 - d. Placement Schedule:
 - 1) Placement schedule no later than 48 hours prior to intended placement

- date.
- 2) Indicate placement location, quantity, penetration locations, and embedment types and locations.
3. Shop Drawings:
 - a. Indicate typical layout including dimensions:
 - 1) Erection drawings clear, easily legible, and to a minimum scale of:
 - a) 1/4 inch = 1 foot.
 - b) 1/8 inch = 1 foot if bars in each face are shown in separate views.
 - 2) Indicate size and location of pipe penetrations, wall sleeves and embedded conduit.
 - 3) Indicate pertinent dimensions, materials, bracing, and arrangement of joints and ties.
 - 4) Include erection drawings for structural steel.
 - 5) Fabricator's detailed requirements for system foundations
 - 6) Construction joints: Drawing indicating location of construction joints.
 - b. Submit detail drawings of special accessory components not included in the manufacturer's product data.
 4. Test and Evaluation Reports:
 - a. Cylinder Compression Test Reports: Submit 2 copies of certified test reports to Contracting Officer for air content and concrete compression testing.
 - b. Fly ash certified test reports:
 - 1) Submit suppliers certified fly ash test reports for each shipment delivered to concrete supplier:
 - a) Physical and chemical characteristics.
 - b) Certification of compliance with the specifications.
 - c) Signed by Contractor and concrete supplier.
 - c. Provide field quality control testing reports detailing results of the tests. Indicate compliance or non-compliance with Contract Documents. Identify corrective action for materials and equipment which fails to pass field tests.

1.4 QUALITY ASSURANCE

- A. Testing Agency Qualifications: An independent testing agency, acceptable to authorities having jurisdiction and the ENGINEER. The OWNER will select and pay for this service.
 1. The independent testing agency shall be responsible for testing of materials, ready mix, transit mix or central plant concrete.
- B. Regulatory Agency Sustainability Approvals:
 1. In accordance with all local codes and ordinances, laws and regulations of the state.
 2. In case of apparent conflict, state and local requirements govern over these specifications.
- C. Qualifications:
 1. Manufacturers

- a. Company specializing in manufacturing products specified in this Section with minimum 5 years documented experience.
 - b. Acquire cement and aggregate from same source for all work.
- 2. Fabricators
 - a. Company specializing in fabricating work specified in this Section with minimum 5 years documented experience.
- 3. Installers / Applicators / Erectors
 - a. Acceptable to manufacturer and with documented experience on at least 5 projects of similar nature in the past 5 years.
 - b. Pre-Installation Meeting:
 - 1) Prior to placement of concrete, conduct a jobsite meeting with the Contracting Officer or designated representative, Engineer, Contractor, concrete subcontractor, installers of related work, concrete ready-mix supplier / quality control, 3rd party testing agencies / consultants, and other pertinent entities.
 - 2) Agenda shall include:
 - a) Mix designs, test of mixes, and Submittals.
 - b) Placement methods, techniques, equipment, and consolidation.
 - c) Performance requirements.
 - d) Placement time from ready mix batch plant to site placement.
 - e) Finishing and curing procedures.
 - f) Admixture types, dosage, performance, and re-dosing.
 - g) Chain of command.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Delivery and Acceptance Requirements
 - 1. Ready-Mix Delivery Tickets. Submit delivery tickets for each load at the time of delivery indicating the following:
 - a. Quantity delivered, batch plant name, and batch time.
 - b. Ready mix truck arrival to site.
 - c. Ready mix truck begin placement.
 - d. Ready mix truck leave site.
 - e. Mix design including design strength.
 - f. Ready mix batch temperature.
 - g. Amount of initial water added at batch plant.
 - h. Amount of supplemental field water that may be added without exceeding specified water/cement ratio.
 - i. Amount of supplemental field water added after arrival to site.
 - j. Elapsed time between when supplemental field water was added and concrete load was in place.
 - k. Name of individual authorizing supplemental water and quantity of supplemental water added.

- l. Numerical sequence of delivery by indicating cumulative yardage delivered on each ticket.
 - m. Executed copies (signature and date) by CONTRACTOR.
 - B. Storage and Handling Requirements
 - 1. Cement and fly ash: Store in moisture proof enclosures, discard if caked or lumpy.
 - 2. Aggregate: Prevent segregation and inclusion of foreign materials; do not use the bottom 6 inches of piles in contact with the ground.
 - 3. Reinforcing steel: Store on supports preventing contact with ground and cover to prevent surface corrosion and contamination.
 - 4. Rubber and plastic materials: Store in a cool place, do not expose to direct sunlight.

1.6 SITE CONDITIONS

- A. Ambient Conditions
 - 1. Do not place concrete during rain, sleet, or snow.
 - 2. Do not allow rain water to increase mixing water or damage surface finish.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

- A. Design Requirements:
 - 1. In accordance with ASTM C94.
 - 2. Design concrete in accordance with this Section, Article 2.7.
- B. Performance Requirements:
 - 1. In accordance with ASTM C94.
 - 2. Ready-mix concrete:
 - a. Minimum compressive strength conforming to ASTM C39.
 - 1) 7-day: 3,000 pounds per square inch.
 - 2) 28 day: 4,000 pounds per square inch.
 - b. Maximum slump at point of placement:
 - 1) 4 inches.
 - c. Maximum volumetric air content at point of placement:
 - 1) 5 to 7 percent.
 - 2) Omit air from trowel finished interior slabs.
 - 3. Topping and fill concrete:
 - a. Minimum compressive strength.
 - 1) 28-day: 3,000 pounds per square inch.
 - b. Maximum slump:
 - 1) 2 inches.

2.2 MATERIALS

- A. Forms:

1. Form Materials: Plywood, metal, metal-framed plywood, or other approved panel-type materials to provide full-depth, continuous, straight, and smooth exposed surfaces.
 - a. Use flexible or uniformly curved forms for curves with a radius of 100 feet or less.
 2. Form Release Agent: Commercially formulated form-release agent that will not bond with, stain, or adversely affect concrete surfaces and that will not impair subsequent treatments of concrete surfaces.
- B. Concrete:
1. Concrete shall be in accordance with Section 03 30 00 "Cast-In-Place Concrete."
 2. Cementitious Material: Use the following cementitious materials, of same type, brand, and source throughout Project:
 - a. Portland Cement: ASTM C 150, gray portland cement Type I or Type II.
 - b. Fly Ash: ASTM C618, Class C or Class F, except loss on ignition not more than 5 percent.
 3. Normal-Weight Aggregates: ASTM C 33, Class 4M, uniformly graded. Provide aggregates from a single source.
 - a. Maximum Coarse-Aggregate Size: 1-inch nominal.
 - b. Fine Aggregate: Free of materials with deleterious reactivity to alkaline conditions. No manufactured or artificial sand.
 4. Water: Potable and complying with ASTM C 94/C 94M.
 5. Air-Entraining Admixture: ASTM C 260.
 6. Chemical Admixtures: Admixtures certified by manufacturer to be compatible with other admixtures and to contain not more than 0.1 percent water-soluble chloride ions by mass of cementitious material.
 - a. Water-Reducing Admixture: ASTM C 494/C 494M, Type A.
 - b. Retarding Admixture: ASTM C 494/C 494M, Type B.
 - c. Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type D.
 7. Membrane-Forming Curing Compound: ASTM C 309, Type 2, Class B, dissipating.
- C. Concrete Mixtures:
1. Prepare design mixtures, proportioned according to ACI 301, for each type and strength of normal-weight concrete, and as determined by either laboratory trial mixtures or field experience.
 - a. Use a qualified independent testing agency for preparing and reporting proposed concrete design mixtures for the trial batch method.
 2. Proportion mixtures to provide normal-weight concrete with the following properties:
 - a. Compressive Strength (28 Days): 3000 psi unless otherwise indicated.
 - b. Slump Limit: 4 inches, plus or minus 1 inch.
 3. Add air-entraining admixture at manufacturer's prescribed rate to result in normal-weight concrete at point of placement having an air content as follows:
 - a. Air Content: 4-1/2 percent plus or minus 1.5 percent for 1-inch nominal maximum aggregate size.

4. Chemical Admixtures: Use admixtures according to manufacturer's written instructions.
 - a. Use water-reducing admixture in concrete as required for placement and workability.
 - b. Use water-reducing and retarding admixture when required by high temperatures, low humidity, or other adverse placement conditions.
 5. Cementitious Materials: Do not use cementitious materials other than portland cement in concrete mixes.
- D. Related Materials:
1. Joint Fillers: ASTM D 1751, asphalt-saturated cellulosic fiber or ASTM D 1752, cork or self-expanding cork in preformed strips.
 2. Bonding Agent: ASTM C 1059, Type II, non-redispersible, acrylic emulsion or styrene butadiene.
 3. Joint Sealants:
 - a. Compatibility: Provide joint sealants, backing materials, and other related materials that are compatible with one another and with joint substrates under conditions of service and application, as demonstrated by joint-sealant manufacturer based on testing and field experience.
 - b. Multicomponent, Pourable, Traffic-Grade, Urethane Joint Sealant for Concrete: ASTM C 920, Type M, Grade P, Class 25, for Use T.
 - c. Colors of Exposed Joint Sealants: As selected by the Owner from manufacturer's full range.
 - d. Round Backer Rods for Joint Sealants: ASTM D 5249, Type 3, of diameter and density required to control joint-sealant depth and prevent bottom-side adhesion of sealant.
 - e. Backer Strips for Joint Sealants: ASTM D 5249; Type 2; of thickness and width required to control joint-sealant depth, prevent bottom-side adhesion of sealant, and fill remainder of joint opening under sealant.
 - f. Primers for Joint Sealants: Product recommended by joint-sealant manufacturer where required for adhesion of sealant to joint substrates indicated, as determined from preconstruction joint-sealant-substrate tests and field tests.

2.3 SYSTEMS COMPONENTS

- A. Steel Reinforcement:
1. Plain-Steel Welded Wire Reinforcement: ASTM A 185/A 185M, fabricated from as-drawn steel wire cut into flat sheets.
 2. Reinforcing Bars: ASTM A 615/A 615M, Grade 60; deformed.
 3. Steel Bar Mats: ASTM A 184/A 184M; with ASTM A 615/A 615M, Grade 60, deformed bars; assembled with clips.
 4. Plain-Steel Wire: ASTM A 82/A 82M, as drawn.
 5. Joint Dowel Bars: ASTM A 615/A 615M, Grade 60 plain-steel bars. Cut bars true to length with ends square and free of burrs.

6. Tie Bars: ASTM A 615/A 615M, Grade 60, deformed.
7. Bar Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars, welded wire reinforcement, and dowels in place. Manufacture bar supports according to CRSI's "Manual of Standard Practice" from steel wire, plastic, or precast concrete of greater compressive strength than concrete specified.

2.4 FINISHES

A. Shop Selections:

1. Finish: Color and finish as selected by OWNER from samples submitted by CONTRACTOR.
2. Primer: Where only a factory prime coat is included, Color and prime as selected by OWNER from samples submitted by CONTRACTOR.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Preinstallation Testing

1. Examine exposed subgrades and subbase surfaces for compliance with requirements for dimensional, grading, and elevation tolerances.
2. Proof-roll prepared subbase surface below concrete equipment pads to identify soft pockets and areas of excess yielding.
 - a. Correct subbase with soft spots and areas of pumping or rutting exceeding depth of 1/2 inch as directed by the Owner.
3. Examine excavations for footings to verify correct depth and diameter of footing.
4. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Surface Preparation

1. Remove loose material from compacted subbase surface immediately before placing concrete.

3.3 CONCRETE APPLICATION

- A. Install in accordance with manufacturer's instructions and requirements.
- B. Install units plumb, level, square and free from warp or twist while maintaining dimensional tolerances and alignment with surrounding construction / adjacent surfaces
- C. Edge Forms and Screed Construction:
 1. Set, brace, and secure edge forms, bulkheads, and intermediate screed guides to required lines, grades, and elevations. Install forms to allow continuous progress of work and so forms can remain in place at least 24 hours after concrete placement.
 2. Clean forms after each use and coat with form-release agent to ensure separation from concrete without damage.
- D. Steel Reinforcement:

1. General: Comply with CRSI's "Manual of Standard Practice" for fabricating, placing, and supporting reinforcement.
2. Clean reinforcement of loose rust and mill scale, earth, ice, or other bond-reducing materials.
3. Arrange, space, and securely tie bars and bar supports to hold reinforcement in position during concrete placement. Maintain minimum cover to reinforcement.
4. Install welded wire reinforcement in lengths as long as practicable. Lap adjoining pieces at least one full mesh, and lace splices with wire. Offset laps of adjoining widths to prevent continuous laps in either direction.
5. Install fabricated bar mats in lengths as long as practicable. Handle units to keep them flat and free of distortions. Straighten bends, kinks, and other irregularities, or replace units as required before placement. Set mats for a minimum 2-inch overlap of adjacent mats.

E. Joints:

1. General: Form construction, isolation, and contraction joints and tool edges true to line, with faces perpendicular to surface plane of concrete. Construct transverse joints at right angles to centerline unless otherwise indicated.
 - a. When joining existing concrete work, place transverse joints to align with previously placed joints unless otherwise indicated.
2. Construction Joints: Set construction joints at side and end terminations of concrete work and at locations where concrete operations are stopped for more than one-half hour unless concrete work terminates at isolation joints.
 - a. Continue steel reinforcement across construction joints unless otherwise indicated. Do not continue reinforcement through sides of concrete strips unless otherwise indicated.
 - b. Provide tie bars at sides of concrete strips where indicated.
 - c. Butt Joints: Use bonding agent at joint locations where fresh concrete is placed against hardened or partially hardened concrete surfaces.
 - d. Keyed Joints: Provide preformed keyway-section forms or bulkhead forms with keys unless otherwise indicated. Embed keys at least 1-1/2 inches into concrete.
 - e. Doweled Joints: Install dowel bars and support assemblies at joints where indicated. Lubricate or coat with asphalt one-half of dowel length to prevent concrete bonding to one side of joint.
3. Isolation Joints: Form isolation joints of preformed joint-filler strips abutting concrete curbs, catch basins, manholes, inlets, structures, other fixed objects, and where indicated.
 - a. Locate expansion joints at intervals of 50 feet unless otherwise indicated.
 - b. Extend joint fillers full width and depth of joint.
 - c. Terminate joint filler not less than 1/2 inch or more than 1 inch below finished surface if joint sealant is indicated.
 - d. Place top of joint filler flush with finished concrete surface if joint sealant is not indicated.

- e. Furnish joint fillers in one-piece lengths. Where more than one length is required, lace or clip joint-filler sections together.
 - f. During concrete placement, protect top edge of joint filler with metal, plastic, or other temporary preformed cap. Remove protective cap after concrete has been placed on both sides of joint.
4. Contraction Joints: Form weakened-plane contraction joints, sectioning concrete into areas as indicated. Construct contraction joints for a depth equal to at least one-fourth of the concrete thickness, as follows:
- a. Where new concrete work is placed adjacent to existing paving, curbs, or sidewalks, match jointing of existing adjacent concrete paving:
 - b. Grooved Joints: Form contraction joints after initial floating by grooving and finishing each edge of joint with grooving tool to a 1/4-inch radius. Repeat grooving of contraction joints after applying surface finishes.
 - 1) Tolerance: Ensure that grooved joints are within 3 inches either way from centers of dowels.
 - c. Sawed Joints: Form contraction joints with power saws equipped with shatterproof abrasive or diamond-rimmed blades. Cut 1/8-inch-wide joints into concrete when cutting action will not tear, abrade, or otherwise damage surface and before developing random contraction cracks.
 - 1) Tolerance: Ensure that sawed joints are within 3 inches either way from centers of dowels.
 - d. Doweled Contraction Joints: Install dowel bars and support assemblies at joints where indicated. Lubricate or coat with asphalt one-half of dowel length to prevent concrete bonding to one side of joint.
5. Edging: After initial floating, tool edges of gutters, curbs, equipment pads, and joints in concrete with an edging tool to a 1/4-inch radius. Repeat tooling of edges after applying surface finishes.
- F. Concrete Placement:
- 1. Before placing concrete, inspect and complete formwork installation, steel reinforcement, and items to be embedded or cast-in.
 - 2. Remove snow, ice, or frost from subbase surface and steel reinforcement before placing concrete. Do not place concrete on frozen surfaces.
 - 3. Moisten subbase to provide a uniform dampened condition at time concrete is placed. Do not place concrete around manholes or other structures until they are at required finish elevation and alignment.
 - 4. Comply with ACI 301 requirements for measuring, mixing, transporting, and placing concrete.
 - 5. Do not add water to concrete during delivery or at Project site. Do not add water to fresh concrete after testing.
 - 6. Deposit and spread concrete in a continuous operation between transverse joints. Do not push or drag concrete into place or use vibrators to move concrete into place.
 - 7. Consolidate concrete according to ACI 301 by mechanical vibrating equipment supplemented by hand spading, rodding, or tamping.
 - a. Consolidate concrete along face of forms and adjacent to transverse joints with

an internal vibrator. Keep vibrator away from joint assemblies, reinforcement, or side forms. Use only square-faced shovels for hand spreading and consolidation. Consolidate with care to prevent dislocating reinforcement, dowels, and joint devices.

8. Screed concrete surface with a straightedge and strike off.
 9. Commence initial floating using bull floats or darbies to impart an open-textured and uniform surface plane before excess moisture or bleed water appears on the surface. Do not further disturb concrete surfaces before beginning finishing operations or spreading surface treatments.
 10. Curbs and Gutters: Use design mixture for automatic machine placement. Produce curbs and gutters to required cross section, lines, grades, finish, and jointing.
 11. Cold-Weather Placement: Protect concrete work from physical damage or reduced strength that could be caused by frost, freezing, or low temperatures. Comply with ACI 306.1 and the following:
 - a. When air temperature has fallen to or is expected to fall below 40 deg F, uniformly heat water and aggregates before mixing to obtain a concrete mixture temperature of not less than 50 deg F and not more than 80 deg F at point of placement.
 - b. Do not use frozen materials or materials containing ice or snow.
 - c. Do not use calcium chloride, salt, or other materials containing antifreeze agents or chemical accelerators unless otherwise specified and approved in design mixtures.
 12. Hot-Weather Placement: Comply with ACI 301 and as follows when hot-weather conditions exist:
 - a. Cool ingredients before mixing to maintain concrete temperature below 90 deg F at time of placement. Chilled mixing water or chopped ice may be used to control temperature, provided water equivalent of ice is calculated in total amount of mixing water. Using liquid nitrogen to cool concrete is Contractor's option.
 - b. Cover steel reinforcement with water-soaked burlap so steel temperature will not exceed ambient air temperature immediately before embedding in concrete.
 - c. Fog-spray forms, steel reinforcement, and subgrade just before placing concrete. Keep subgrade moisture uniform without standing water, soft spots, or dry areas.
- G. Concrete Protection and Curing
1. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures.
 2. Comply with ACI 306.1 for cold-weather protection.
 3. Evaporation Retarder: Apply evaporation retarder to concrete surfaces if hot, dry, or windy conditions cause moisture loss approaching 0.2 lb/sq. ft. x h before and during finishing operations. Apply according to manufacturer's written instructions after placing, screeding, and bull floating or darbying concrete but before float finishing.
 4. Begin curing after finishing concrete but not before free water has disappeared from

concrete surface.

5. Curing Methods: Cure concrete by moisture curing, moisture-retaining-cover curing, curing compound, or a combination of these as follows:

- a. Moisture Curing: Keep surfaces continuously moist for not less than seven days with the following materials:
 - 1) Water.
 - 2) Continuous water-fog spray.
 - 3) Absorptive cover, water saturated and kept continuously wet. Cover concrete surfaces and edges with 12-inch lap over adjacent absorptive covers.
- b. Moisture-Retaining-Cover Curing: Cover concrete surfaces with moisture-retaining cover, placed in widest practicable width, with sides and ends lapped at least 12 inches and sealed by waterproof tape or adhesive. Immediately repair any holes or tears occurring during installation or curing period using cover material and waterproof tape.
- c. Curing Compound: Apply uniformly in continuous operation by power spray or roller according to manufacturer's written instructions. Recoat areas that have been subjected to heavy rainfall within three hours after initial application. Maintain continuity of coating, and repair damage during curing period.

H. Special Techniques

1. Joint Sealant Installation

- a. General: Comply with joint-sealant manufacturer's written installation instructions for products and applications indicated unless more stringent requirements apply.
- b. Cleaning of Joints: Clean out joints immediately before installing joint sealants.
- c. Joint-Sealant Installation Standard: Comply with recommendations in ASTM C 1193 for use of joint sealants as applicable to materials, applications, and conditions indicated.
- d. Install joint-sealant backings of kind indicated to support joint sealants during application and at position required to produce cross-sectional shapes and depths of installed sealants relative to joint widths that allow optimum sealant movement capability.
 - 1) Do not leave gaps between ends of joint-sealant backings.
 - 2) Do not stretch, twist, puncture, or tear joint-sealant backings.
 - 3) Remove absorbent joint-sealant backings that have become wet before sealant application and replace them with dry materials.
 - 4) Install joint sealants using proven techniques that comply with the following and at the same time backings are installed:
 - 5) Place joint sealants so they directly contact and fully wet joint substrates.
 - 6) Completely fill recesses in each joint configuration.
 - 7) Produce uniform, cross-sectional shapes and depths relative to joint widths that allow optimum sealant movement capability.
- e. Provide joint configuration to comply with joint-sealant manufacturer's written

instructions unless otherwise indicated.

- f. Clean off excess joint sealant or sealant smears adjacent to joints as the Work progresses, by methods and with cleaning materials approved in writing by manufacturers of joint sealants and of products in which joints occur.

I. Interface with Other Work

1. Float Finishing:

- a. General: Do not add water to concrete surfaces during finishing operations.
- b. Float Finish: Begin the second floating operation when bleed-water sheen has disappeared, and concrete surface has stiffened sufficiently to permit operations. Finish surfaces to true planes. Cut down high spots and fill low spots. Refloat surface immediately to uniform granular texture.
 - 1) Medium-to-Fine-Textured Broom Finish: Draw a soft-bristle broom across float-finished concrete surface perpendicular to line of traffic to provide a uniform, fine-line texture.

J. Tolerances

1. Concrete

- a. Comply with tolerances in ACI 117 and as follows:
 - 1) Elevation: 3/4 inch.
 - 2) Thickness: Plus 3/8 inch, minus 1/4 inch.
 - 3) Surface: Gap below 10-foot-long, unlevelled straightedge not to exceed 1/2 inch.
 - 4) Alignment of Tie-Bar End Relative to Line Perpendicular to Paving Edge: 1/2 inch per 12 inches of tie bar.
 - 5) Lateral Alignment and Spacing of Dowels: 1 inch.
 - 6) Vertical Alignment of Dowels: 1/4 inch.
 - 7) Alignment of Dowel-Bar End Relative to Line Perpendicular to Concrete Edge: 1/4 inch per 12 inches of dowel.
 - 8) Joint Spacing: 3 inches.
 - 9) Contraction Joint Depth: Plus 1/4 inch, no minus.
 - 10) Joint Width: Plus 1/8 inch, no minus.

3.4 CURBS

- A. For damaged curbs, saw cut and removed damaged curb and gutter section. Prepare subgrade. Dowel in sides of existing pavement and place concrete, shaping curb section. Seal joint between new curb and existing.

3.5 SIDEWALKS

- A. For damaged sidewalks, saw cut at adjacent expansion of tooled joints, remove and replace damaged portion of sidewalk.

3.6 DRIVEWAYS, PARKING AREAS, AND MEDIANS

- A. When construction requires cutting a concrete area; saw cut (full depth) pavement two (2)

feet wider than the width of trench required for installation of the utility. Leave a minimum of one foot of undisturbed subgrade on each side of the trench to support the concrete pavement.

- B. Unless otherwise specified, backfill the trench using flowable above the pipe zone.
- C. Drill existing pavements, epoxy grout dowels in existing pavement, and provide cast-in-place concrete construction, reinforced, matching existing pavement surface, as indicated on the Drawings. Saw cut control joints as applicable and place sealing compound in all joints.
- D. Type of finish for the replaced section shall be the same as existing pavement.

3.7 CONCRETE PAVEMENT

- A. When construction requires cutting a concrete or concrete base roadway, saw cut (full depth) pavement two (2) feet wider than the width of trench required for installation of the utility. Leave a minimum of one foot of undisturbed subgrade on each side of the trench to support the concrete pavement.
- B. Unless otherwise specified, backfill the trench using flowable fill above the pipe zone.
- C. Drill existing pavements, epoxy grout dowels in existing pavement, and provide cast-in-place concrete construction, reinforced, matching existing pavement surface, as indicated on the Drawings. Saw cut control joints as applicable and place sealing compound in all joints.
- D. Type of finish for the replaced section shall be the same as existing pavement.
- E. For damaged concrete pavements, remove and replace damaged portion in accordance with TxDOT Item 361.

3.8 REPAIR

- A. Remove and replace concrete work that is broken, damaged, or defective or that does not comply with requirements in this Section. Remove work in complete sections from joint to joint unless otherwise approved by the OWNER.

3.9 PROTECTION

- A. Protect concrete work from damage.
- B. Maintain concrete work free of stains, discoloration, dirt, and other foreign material. Sweep paving not more than two days before date scheduled for Substantial Completion inspections.

END OF SECTION

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SECTION 32 92 13 HYDROMULCHING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Hydromulch seeding of grass is required as shown on the Plans. Establishment of a uniform, full-coverage of grass is required in all disturbed areas, and other areas indicated on the Plans. Hydromulch seeding is specified for these areas where grass establishment is required.
2. Hydromulch seeding includes mixing grass seed and mulch material with water and spraying the mixture onto tilled topsoil. Seeding includes spreading grass seed onto tilled topsoil.
3. Furnish all materials, labor and equipment including watering system to establish full coverage grass where specified and to maintain the established areas for 60 days.

B. Related Sections:

1. Section 31 10 00 "Site Clearing"
2. Section 31 23 00 "Excavation, Trenching and Backfilling for Utilities"
3. Section 31 23 10 "Structural Excavation and Backfill"

1.2 DEFINITIONS

- A. Weeds:** Includes, but not limited to, Dandelion, Jimsonweed, Quackgrass, Horsetail, Morning Glory, Rush Grass, Mustard, Lambsquarter, Chickweed, Cress, Crabgrass, Canadian Thistle, Nutgrass, Poison Oak, Blackberry, Tansy Ragwort, Johnson Grass, Poison Ivy, Nut Sedge, Nimble Will, Bindweed, Bent Grass, Wild Garlic, Perennial Sorrel, and Brome Grass.

1.3 SUBMITTALS

- A. Submit data on seed and mulch as necessary to show compliance with these specifications. Include source of supply for materials as well as:**
1. Name, type, germination, purity, germination test results with date of test for seed.
 2. Name, type, components and coverage for mulch.
- B. Submit maintenance instructions, cutting method, minimum and maximum mowing grass height; types, application frequency, and recommended coverage of mulch.**

1.4 REGULATORY REQUIREMENTS

- A. Comply with regulatory agencies for above mentioned products.**

1.5 QUALITY ASSURANCE

- A. Provide seed in containers showing name and type of seed, year of production, net weight, date of packaging, date of germination test, and location of packaging.**
- B. It shall be the sole responsibility of the CONTRACTOR to establish uniform stand of grass which is defined as 80 percent coverage of seeded area. No bare spots greater than 2 square**

feet are allowed, regardless of adverse climatic or other conditions. The ENGINEER may stop work if unfavorable conditions are likely until favorable conditions are present.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Deliver grass seed mixture in sealed containers. Seed in damaged, wet, or moldy packaging is not acceptable. Store in dry location.

1.7 MAINTENANCE SERVICE

- A. For areas where establishment is required per the Plans, maintain the hydromulched areas for 60 days beginning immediately after placement and watering as required until grass is well established and exhibits a vigorous growing condition. Coordinate water requirements with availability of water from OWNER and areas to be seeded at one time.

PART 2 - PRODUCTS

2.1 SEED MIXTURE

- A. Frisco Nordic Mixture for the tops and slopes of berms as well as all specified areas, will include all of the following species and be applied at the specified rate for each species in lbs per acre:

Common Name	Seeding Rate: PLS lbs/Acre
Mountain Brome	6.56
Slender Wheatgrass	3.35
Streambank Wheatgrass	3.14
Western Wheatgrass	4.30
Rocky Mountain Fescue	1.03
Canby Bluegrass	0.53
Blue Flax (Lewisii)	1.30
Blackeyed Susan	0.33

- B. Seed Quality: All seed shall meet the requirements of the Colorado Seed Act including labeling requirements for showing PLS (PLS = purity x germination), name and type of seed. All seed shall be treated with a fungicide. Seed, which has become wet, moldy or otherwise damaged in transit or storage, will not be acceptable. Seed shall be new crop seed (harvested within 1 year prior to planting), free of other weed seed to the limits allowable under the Colorado Seed Act. The seed shall have a germination and purity that will produce a pure live seed content of not less than 85 percent.

2.2 HYDROMULCH

- A. Hydromulch material for areas requiring grass establishment shall be Second Nature Hydroseeding Mulch as manufactured by Central Fiber Corporation, or approved equivalent. Mulch shall be manufactured of natural fiber stock free of plastics and foreign materials. Mulch shall have a green non-toxic dye, disperse rapidly in water to form a homogeneous slurry and shall remain in suspension. It shall have a water holding capacity of not less than

1300 grams water per 100grams fiber.

2.3 MULCH

- A. Furnish straw mulch free of weeds and spread at the recommended rate to adequately cover all areas which are broadcast seeded and indicated to be mulched.

2.4 SOIL MATERIALS

- A. Topsoil: Contractor to use the topsoil reserved from clearing activities and reserved in accordance with "Section 31 10 00 Site Clearing".

2.5 ACCESSORIES

- A. Water: Clean, fresh and free of substances or matter which could inhibit vigorous growth of grass.
- B. Erosion Fabric: Jute matting, open weave, where shown on Plans or where slope is steeper than 3:1.

PART 3 - EXECUTION

3.1 INSPECTION

- A. Verify that prepared soil base is ready to receive the work of this Section that topsoil has been placed and final grading is acceptable to OWNER.
- B. Beginning of installation means acceptance of existing site conditions.

3.2 FINAL GRADING

- A. Prepare final grading, subsoil preparation, and placement of topsoil prior to seeding. All areas to be seeded shall have at least 4 inches of topsoil placed prior to seeding and seed shall be planted no greater than 0.125-inches below the soil surface.

- B. Comply with the requirement in Division 31 for final grading, subsoil preparation and placement of topsoil prior to seeding. All areas to be seeded shall have sufficient topsoil placed prior to seeding.
- C. Smooth areas that have become gullied; and loosen or refill areas that have become compacted since completion of grading to a depth of 6 inches.

3.3 SEEDING

- A. For hydromulch (grass establishment) areas, hydromulch mixture containing the seed, mulch and water shall be prepared in accordance with the quantities specified herein or as recommended by the manufacturer. Mixture shall be applied to planting area using conventional "Hydromulch" equipment. For seeded areas, seed shall be spread with mechanical spreaders to obtain the specified rates. After planting, the planting area shall be rolled with a corrugated roller of the "Cultipacker" type. All rolling of the sloped areas shall be on the contour.
 - 1. Component: Rate per 1000 square feet
 - 2. Grass seed: See Section 2.1
 - 3. Water: As recommended by Manufacturer
 - 4. Paper Fiber Mulch: As recommended by Manufacturer
- B. For areas to be established, apply water with a fine spray immediately (within 24 hours) after each area has been seeded and mulched. Saturate to 4 inches of soil. Water daily as often as necessary for 4 weeks to establish grass.

3.4 SEED PROTECTION

- A. Cover seeded slopes where grade is steeper than 4 inches per foot with erosion fabric. Roll fabric onto slopes without stretching or pulling. Cover hydromulched areas as recommended to obtain establishment of grass.
- B. Lay fabric smoothly on surface, bury top end of each section in 6 inch deep excavated topsoil trench. Provide 12-inch overlap of adjacent rolls. Backfill trench and rake smooth, level with adjacent soil.
- C. Secure outside edges and overlaps at 36-inch intervals with stakes.
- D. Lightly dress slopes with topsoil to ensure close contact between fabric and soil.
- E. At sides of ditches, lay fabric laps in direction of water flow. Lap ends and edges minimum 6 inches.
- F. No heavy equipment shall be moved over planted area unless area is to be retilled and reseeded.

3.5 MAINTENANCE FOR HYDROMULCHED AREAS

- A. The CONTRACTOR shall mow grass as required.
- B. CONTRACTOR shall water as required to establish grass and to prevent grass and soil from drying out for the initial 60-day period.
- C. CONTRACTOR shall control growth of weeds. Apply herbicides in accordance with manufacturer's instructions. Remedy damage resulting from improper use of herbicides.

- D. CONTRACTOR shall reseed areas which show bare spots of 2 square feet or larger. Minimum of 95 percent coverage shall be required for OWNER acceptance.
- E. CONTRACTOR shall maintain grass and reseed as required to establish 95 percent coverage (within a minimum of 60 days) or 150 plants per square foot.
- F. Protect seeded areas with warning signs during maintenance period, if necessary.

END OF SECTION

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SECTION 33 01 10.58
DISINFECTION OF POTABLE WATER PIPING AND TANKS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Disinfection of water piping, basins, and tanks for potable water.
 - 2. Testing.
 - 3. Bacteriological and Disinfection Reports.

1.2 REFERENCES

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.
- B. Standards
 - 1. American Water Works Association (AWWA):
 - a. C651 – Standard for Disinfecting Water Mains.
 - b. C652 – Standard for Disinfection of Water Storage Facilities.
 - c. C653 – Standard for Disinfection of Water Treatment Plants.

1.3 ADMINISTRATIVE REQUIREMENTS – NOT USED

1.4 SUBMITTALS

- A. Submit a schedule of the proposed sequence for cleaning and method of sterilization to be used or list of the equipment to be used, and the sterilizing agent and quantities to be used, location and/or sizes of fill, blow down connections, sources of test water, and proposed plan to dispose of test water.
- B. Disinfection Report: Accurately record the items listed below and submit an electronic copy of the report.
 - 1. Type and form of disinfection used.
 - 2. Date and time of disinfectant injection start and time of completion.
 - 3. Test locations.
 - 4. Initial and 24-hour disinfectant residuals (quantity in treated water) in ppm for each outlet tested.
 - 5. Date and time of flushing in ppm for each outlet tested.
- C. Bacteriological Report: Accurately record the items listed below and submit an electronic copy of the report.
 - 1. Data issued, project name, and testing laboratory name, address, and telephone number.
 - 2. Time and date of water sample collection.
 - 3. Name of person collecting samples.
 - 4. Test locations.
 - 5. Initial and 24-hour disinfectant residuals in ppm for each outlet tested.
 - 6. Coliform bacteria test results for each outlet tested.

7. Certification that water conforms, or fails to conform, to bacterial standards of Colorado Department of Public Health and Environment.
8. Bacteriologist's signature.

1.5 QUALITY ASSURANCE

- A. Testing Laboratory: State Health Department certified approved for examination of drinking water in compliance with applicable legislation of the State of Colorado.
- B. Piping, tanks, and equipment to be cleaned and disinfected shall be isolated from the finished water (potable water) at all times and shall be placed into service by the OWNER following receipt of acceptable test reports.
- C. Regulatory Requirements: Conform to applicable Colorado Department of Public Health and Environment Rules and Regulations for Public Water Systems for work of this section.
- D. The OWNER will collect the sample and have it tested. Results of tests may take up to 48 hours. Samples may not be collected on Friday or the day before a holiday without prior approval from the OWNER.

1.6 DELIVERY, STORAGE, AND HANDLING – NOT USED

1.7 SITE CONDITIONS – NOT USED

1.8 WARRANTY – NOT USED

PART 2 - PRODUCTS

2.1 SYSTEM REQUIREMENTS

- A. Provide all equipment, temporary connections, taps, valves, piping, pumps, hoses, chemicals, and test equipment to accomplish the work, including taps to line. Provide adequate provisions to the line for sampling.
- B. Disinfection agents shall be chlorine solution prepared from sodium hypochlorite, or calcium hypochlorite.
- C. After completion of purging and disinfection, remove surplus pipe at the chlorination and sampling locations, plug the remaining pipe, back, and complete all appurtenant work required to secure the pipeline.

2.2 PERFORMANCE REQUIREMENTS

- A. Water Quality Testing Requirements
 1. Notify Owner at least 48 hours (2 working days) in advance to arrange for a bacterial quality and for free or total chlorine concentration test.
 2. Requirements for demonstration of compliance with the Maximum Contaminant Level (MCLs) of the Safe Drinking Water Act:
 - a. Total chlorine concentration of less than 4 mg/L (4 ppm).
 - b. The absence of any coliform bacteria.
 - c. Less than 200 non-coliform bacteria per 100 mL sample.

PART 3 - EXECUTION

3.1 GENERAL

- A. CONTRACTOR shall exercise care at all times during construction to prevent contaminated material from entering the structures and pipelines in the raw, settled, filtered, finished, and potable water system.
- B. All facilities and piping designed to hold or transport process water shall be cleaned, including piping, basins, and channels, prior to disinfection.
- C. Treatment basins, storage tanks, pump columns, finished water piping, together with valves and meters, all potable water, service water, and chemical piping shall be disinfected with chlorine solution as specified herein following cleaning and testing. Vertical pumps may be disinfected immediately prior to installation. All surfaces shall be cleaned or washed and disinfected, even though there is no visible evidence of necessity thereof.
- D. Disinfection shall be in accordance with the applicable disinfection procedure described in AWWA C651, AWWA C652, AWWA C653, and AWWA C654, as well as in accordance with the Rules and Regulations for Public Water Systems of the Colorado Department of Public Health and Environment and the requirements of this section. Where conflicts exist, the ENGINEER shall determine the appropriate procedures.

3.2 PIPELINE DISINFECTION

- A. Preparation: Verify that piping system has been cleaned, inspected, and pressure tested. Flush out line, completely replacing its entire volume with potable water.
- B. Purging: Purging may be accomplished by flushing.
 - 1. Flushing Method: If the "flushing" method of purging is used, the CONTRACTOR shall be required to prepare the main by installing blow-offs at locations and sized as directed by the Resident Project Representative.
 - a. In general, this shall consist of furnishing all equipment, material and labor to satisfactorily install blow-offs of sizes shown in Table 1:

Table 1	
Flushing Method Blow-Off Requirements	
Size Main	Size Blow-Off
2 to 8 inches	1-1/2 inches
10 to 12 inches	4 inches
16 inches to 24 inches	6 inches
30 inches and greater	10 inches

- b. Before disinfection, flush all foreign matter from the pipeline. Provide hoses, temporary pipes, ditches, etc., as required to dispose of flushing water without damage to adjacent properties. Flushing velocities shall be at least 2.5 fps. For large diameter pipe where it is impractical or impossible to flush the pipe at 2.5 fps velocity, clean the pipeline in-place from the inside by brushing and sweeping, then flush the line at a lower velocity.
 - c. After flushing is complete and satisfactory test results are received at the direction of the Resident Project Representative, the CONTRACTOR shall

proceed with disinfection.

- C. Disinfection: Disinfection of the pipeline shall be accomplished by the “continuous feed” method or the “slug” method in accordance with the OWNER or regulatory agency requirements. The free chlorine amounts shown are the minimum and calcium hypochlorite granulated shall be used as the source of chlorine.
1. Acceptable Disinfectants:
 - a. Sodium hypochlorite solution (bleach) containing approximately 5 – 6 percent available chlorine, or 50,000 to 60,000 ppm.
 - b. Calcium hypochlorite [Ca(OCl)₂] granules and tablets per AWWA B300 containing approximately 65 percent available chlorine by weight. Water temperature below 41 degrees F will prevent tablets from dissolving. Store in a cool, dry and dark environment to minimize its deterioration. Direct placement of solid phase into piping is not permitted. Do not use calcium hypochlorite intended for swimming pools (e.g., HTH).
 - 1) Calcium hypochlorite is corrosive and is a strong oxidizer. Reducing agents (e.g., sodium ascorbate or thiosulfate), concentrated acids, and organic compounds (e.g., antifreeze, gasoline), can oxidize, burn or explode if they come into contact with solid-phase calcium hypochlorite.
 - 2) Do not use calcium hypochlorite on solvent-welded plastic pipe or on screwed-joint steel pipe due to danger of fire or explosion from reaction with joint compounds (exception: PTFE “Teflon” tape).
 2. Continuous Feed Method:
 - a. Water from the existing disinfection system or other approved source shall be controlled to flow into the section to be sterilized at a constant rate.
 - b. Inject treatment disinfectant at a point not more than 10-feet downstream from the beginning of the new conduit through a corporation stop or other approved connection inserted in the horizontal axis of the newly laid pipe.
 - c. The water being used to fill the line shall be controlled to flow into the section to be sterilized very slowly, and the rate of application of the chlorinating agent shall be in such proportion of the rate of water entering the line that the chlorine dose applied to the water entering the line and released at the opposite end shall have a minimum chlorine concentration of 100-mg/L or a level determined by TCEQ.
 - d. Valves shall be manipulated so that the strong chlorine solution in the line being treated will not flow back into the line supplying the water. Use check valves if necessary.
 - e. All valves shall then be closed and the chlorine solution shall remain in the line for a minimum of 24 hours.
 - f. Operate all valves, hydrants, and other appurtenances during disinfection to assure that the disinfecting mixture is dispersed into all parts of the line, including dead ends, and similar areas that otherwise may not receive the disinfecting solution.
 - g. Do not allow the chlorinated water to flow into conduits in ‘active’ services.
 - h. A minimum residual of 25-mg/L free chlorine shall be present in the main following the 24-hour holding period.

- i. The water shall remain in the conduit until the chlorine residual is less than 4 mg/L. After this residual is achieved the water may be discharged into the drainage system.
 - j. Remove the chlorine solution and flush the line with potable water. Comply with regulations and obtain necessary approvals for disposal or discharge of chlorine solution and flushing water.
- 3. Slug Method:
 - a. Water from the existing disinfection system or other approved source shall be controlled to flow into the section to be sterilized at a constant rate.
 - b. Inject treatment disinfectant at a point not more than 10-feet downstream from the beginning of the new conduit through a corporation stop or other approved connection inserted in the horizontal axis of the newly laid pipe.
 - c. Water entering the conduit shall receive a dose of chlorine such that the water shall have not less than 100-mg/L free chlorine. The chlorine shall be applied continuously and for a sufficient time to develop a solid column or "slug" of chlorinated water that shall expose all interior surfaces to the "slug" for at least 3-hours.
 - d. Operate all valves, hydrants, and other appurtenances during disinfection to assure that the disinfecting mixture is dispersed into all parts of the line, including dead ends, and similar areas that otherwise may not receive the disinfecting solution.
 - e. Do not allow the chlorinated water to flow into conduits in 'active' services.
 - f. The heavy chlorinated water shall be flushed from the system and disposed of in an approved manner.
- D. Sampling:
 - 1. The OWNER will take samples from the sterilized line through a suitable point in accordance with AWWA C651 (not at a fire hydrant) and submit to the testing laboratory.
 - 2. Provide analysis and testing of treated water for bacteriological quality in accordance with AWWA C651.
 - 3. Two (2) consecutive set of acceptable samples shall be, taken at least 24 hours apart, shall be collected from the new conduit.
 - 4. At least 1 set of samples shall be collected from every 1000 linear-feet of new conduit, plus 1 set from the end of the line and at least 1 set from each branch.
 - 5. The sterilized portion of the line shall be placed in service, if the results of two consecutive tests conform to the bacterial standards.
 - 6. If the samples show unsatisfactory quality, the sterilization process shall be repeated until satisfactory results are obtained.
- E. Replace permanent system devices removed for disinfection.
- F. Scheduling: Perform scheduling and disinfection activity with startup, testing, adjusting, and balancing, and demonstration procedures, including coordination with related systems.

3.3 BASIN OR TANK DISINFECTION

- A. Preliminary cleaning:

1. Prior to disinfection, all scaffolding, planks, tools, rags and other materials not part of the structural or operating facilities of the basin or tank shall be removed.
 2. All interior surfaces of the basin or tank shall be cleaned by a high-pressure water jet, scrubbing, sweeping or other equally effective means.
 3. All water, dirt, and foreign material accumulated during cleaning will be removed from the basin or tank.
 4. Once cleaned, care will be taken to prevent the intrusion of dirt or other foreign material into the basin or tank.
 5. Any material, equipment or instrumentation, required to be in the operating basin or tank will be thoroughly cleaned and sanitized before being placed into the clean basin or tank.
 6. Obtain verification from Owner that system has been thoroughly cleaned (flushed) and is ready for chlorination.
- B. Disinfection:
1. Install in accordance with manufacturer's instructions and requirements.
 2. Install units plumb, level, square and free from warp or twist while maintaining dimensional tolerances and alignment with surrounding construction / adjacent surfaces
 3. Chlorination of the Basin or Storage Tank:
 - a. Chlorination will be carried out by one or more of the three methods described in AWWA C652-19 Section 4.3.

3.4 DISPOSAL OF DISINFECTING WATER

- A. The disinfecting water shall be dechlorinated before being released to natural drainage ways in accordance with AWWA C652. Release neutralized disinfecting water at a controlled rate so as not to damage downstream facilities.
- B. Acceptable Dechlorination Agents:
1. Vitamin C salt (sodium ascorbate, Vita-D-Chlor brand or equal) for discharges to a live stream.
 2. Sodium thiosulfate (technical grade, prismatic rice) is acceptable for discharges elsewhere.
- C. CONTRACTOR shall coordinate with OWNER to dispose of disinfecting water to the sewer.

END OF SECTION

SECTION 33 05 05
BURIED PIPE INSTALLATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Installation for all types and sizes of buried piping, except where buried piping installations are specified under other Sections.
2. All buried piping Work required, beginning at the outside face of structures or structure foundations, including piping beneath structures, and extending away from structures.
3. Work on or affecting existing buried piping.
4. Installation of all jointing and gasket materials, specials, flexible couplings, mechanical couplings, harnessed and flanged adapters, sleeves, tie rods, and all Work required for a complete buried piping installation.
5. Supports and restraints.
6. Pipe encasements, with the exception of piping embedded in concrete within a structure or foundation.
7. Field quality control, including testing procedures.
8. Cleaning.
9. Incorporation of valves, meters, and special items shown or specified into the piping systems per the Contract Documents and as required.

B. Products Installed but Not Supplied Under This Section:

1. Section 33 05 09 - Piping Specials for Utilities.
2. Section 33 05 33 - Polyethylene Utility Pipe.
3. Section 40 05 19 - Ductile Iron Process Pipe.
4. Section 40 06 00 - Schedules for Process Interconnections.

C. Related Sections:

1. Section 09 97 00 - Special Coatings.
2. Section 31 23 00 - Excavation and Fill
3. Section 31 23 00 – Excavation Trenching and Backfilling for Utilities.
4. Section 33 05 09 - Piping Specials for Utilities.
5. Section 33 05 33 - Polyethylene Utility Pipe.
6. Section 40 05 19 - Ductile Iron Process Pipe.
7. Section 40 06 00 - Schedules for Process Interconnections.

1.2 REFERENCES

A. American National Standards Institute:

1. ANSI/AWS D11.2 - Guide for Welding Cast Iron.

B. American Society of Testing and Materials:

1. ASTM C924 - Practice for Testing Concrete Pipe Sewer Lines by Low Pressure Test Method.

2. ASTM D2321 - Practice for Underground Installation of Thermoplastic Pipe for Sewers and other Gravity-Flow Applications.
 3. ASTM D2774 - Practice for Underground Installation of Thermoplastic Pressure Piping.
 4. ASTM E1003 - Standard Practice for Hydrostatic Leak Testing.
 5. ASTM F1417 - Test Method for Installation Acceptance of Plastic Gravity Sewer Lines using Low-Pressure Air.
- C. American Water Works Association:
1. AWWA C105 - Polyethylene Encasement for Ductile-Iron Pipe Systems.
 2. AWWA C600 - Installation of Ductile Iron Water Mains and Their Appurtenances.
 3. AWWA C605 - Underground Installation of Polyvinyl Chloride (PVC) Pressure Pipe and Fittings for Water.
- D. Colorado Springs Utilities Wastewater Line Extension and Service Standards.

1.3 SUBMITTALS

- A. Product Data:
1. Manufacturer's literature and specifications, as applicable, for products specified in this Section.
- B. Shop Drawings:
1. Laying schedules for pipe and piping with restrained joints.
 2. Details of piping, specials, joints, harnessing, and connections to piping, structures, equipment, and appurtenances.
 3. Testing Plans, Procedures, and Testing Limitations:
 - a. Submit proposed testing procedures, methods, apparatus, and sequencing. Obtain ENGINEER's approval prior to commencing testing.
- C. Quality Assurance / Control Submittals:
1. Test Reports:
 - a. Results of each specified field test.
 2. Certificates:
 - a. Submit a certificate, signed by manufacturer of each product, certifying that product complies with applicable referenced standards.
- D. Closeout Submittals:
1. Record Documentation:
 - a. Maintain accurate and up-to-date record documents showing field and Shop Drawing modifications. Record documents for buried piping Work shall show actual location of all piping and appurtenances on a copy of the Contract Drawings.
 - b. Record documents shall show piping with elevations referenced to the project datum and dimensions from permanent structures. For straight runs of pipe provide offset dimensions as required to document pipe location.
 - c. Include profile drawings with exposed piping record documents when the Contract Documents include profile Drawings.

1.4 QUALITY ASSURANCE

- A. Regulatory Requirements:
 - 1. Conform to all municipal (or County) codes and ordinances, laws and regulations of the State.
- B. Manufacturer's name and pressure rating marked on piping and fittings.
- C. Same manufacturer to provide all piping, fittings, jointing materials and accessories.

1.5 DELIVERY, STORAGE AND HANDLING

- A. Packing, Shipping, Handling and Unloading:
 - 1. In accordance with manufacturer's instructions.
- B. Acceptance at Site:
 - 1. Obtain bill of lading for each material and/or product.
 - 2. Reject damaged materials.
 - 3. Ensure shop coatings were not compromised during delivery and handling.
- C. Storage and Protection:
 - 1. Provide temporary end caps and closures on piping and fittings. Maintain in place until installation.
 - 2. Store all material on wood pallets or timbers.
 - 3. Cover material and ensure remains free of moisture.
 - 4. Cover PVC and CPVC pipe and fittings stored outdoors.
 - 5. Protect interior linings and exterior coatings of pipe and fittings from damage. Replace pipe and fittings with damaged lining regardless of cause of damage.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Warning Marker Tapes:
 - 1. Brady Corporation.
 - 2. Seton Identification Products.
 - 3. Or ENGINEER Approved Equivalent.

2.2 MATERIALS

- A. Polyethylene Underground Warning Tape for Metallic Pipelines:
 - 1. Tracer tape: Inert, acid- and alkali-resistant, polyethylene, 4 mils thick, 6 inches wide, suitable for direct burial.
 - 2. Lettering, "CAUTION "POTABLE WATER", "SANITARY SEWER", "CHLORINE GAS", or other appropriate service, as indicated in the Contract Drawings and "PIPE BURIED BELOW" with bold letters approximately 2 inches high. Print at maximum intervals of 2 feet.
- B. Detectable Underground Warning Tape for Non-Metallic Pipelines:
 - 1. Marker tape: Inert, acid- and alkali-resistant, polyethylene, 5 mils thick, 6 inches wide, with aluminum backing, and have 15,000 psi tensile strength and 80 percent elongation capability. Tape shall be suitable for direct burial. 2. Message shall read,

"CAUTION "POTABLE WATER", "SANITARY SEWER", "CHLORINE GAS", or other appropriate service, as indicated in the Contract Drawings "PIPE BURIED BELOW" with bold letters approximately 2 inches high. Print at maximum intervals of 2 feet.

- C. Tracer Wire:
 - 1. See Contract Drawings.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. General:
 - 1. Excavation and fill is specified in Section 31 23 00.
 - 2. Trenching and backfilling is specified in Section 31 23 00.
 - 3. Install piping as shown, specified, and as recommended by pipe and fittings manufacturer.
 - 4. In event of conflict between manufacturer's recommendations and the Contract Documents, request interpretation from ENGINEER before proceeding.
 - 5. ENGINEER will observe excavations and bedding prior to laying pipe by CONTRACTOR. Notify ENGINEER 48 hours in advance of excavating, bedding, pipe laying, and backfilling operations.
 - 6. Minimum cover over buried piping shall be 6 feet, unless otherwise approved by ENGINEER.
 - 7. Excavation in excess of that required or shown, and that is not authorized by ENGINEER shall be filled at CONTRACTOR's expense in accordance with the Contract Documents.
 - 8. Comply with NFPA 24 for "Outside Protection", where applicable to water piping systems used for fire protection.
- B. Separation of Sewers and Potable Water Piping:
 - 1. Horizontal Separation:
 - a. Existing and proposed potable water mains and service lines, and sanitary, combined, and storm sewers shall be separated horizontally by clear distance of at least 10 feet.
 - 2. Vertical Separation:
 - a. Provide minimum vertical distance of 18 inches between outside of potable water main and outside of sewer when sewer crosses over potable water main.
 - b. Center a section of potable water main pipe at least 20 feet long over sewer so that sewer joints are equidistant from potable water main joints.
 - c. Provide adequate structural support where potable water main crosses under sewer. At minimum, provide compacted select backfill for 10 feet on each side of crossing.
- C. Plugs:
 - 1. Temporarily plug installed pipe at end of each day of work or other interruption of pipe installation to prevent entry of animals, liquids, and persons into pipe, and entrance or insertion of deleterious materials into pipe.
 - 2. Install standard plugs in bells at dead ends, tees, and crosses. Cap spigot and plain

ends.

3. Fully secure and block plugs, caps, and bulkheads installed for testing to withstand specified test pressure.
4. Where plugging is required for phasing of the Work or subsequent connection of piping, install watertight, permanent type plugs, caps, or bulkhead acceptable to ENGINEER.

D. Bedding Pipe:

1. Trench excavation and backfill, and bedding materials shall conform to Section 31 23 00.
2. Where ENGINEER deems existing bedding material unsuitable, remove and replace existing bedding with approved granular material furnished, placed, and compacted.
3. Where pipe is installed in rock excavation, provide minimum of 3 inches of granular bedding material underneath pipe smaller than 4 inch nominal diameter, and minimum of 6 inches of granular bedding material underneath pipes 4 inch nominal diameter and larger.
4. Excavate trenches below bottom of pipe by amount shown and indicated in the Contract Documents. Remove loose and unsuitable material from bottom of trench.
5. Carefully and thoroughly compact pipe bedding with hand held pneumatic compactors.
6. Do not lay pipe until ENGINEER approves bedding condition.
7. Do not bring pipe into position until preceding length of pipe has been bedded and secured in its final position.

E. Laying Pipe:

1. Conform to manufacturer's instructions and requirements of standards and manuals listed below, as applicable:
 - a. Ductile Iron Pipe: ANSI/AWWA C600, ANSI/AWWA C105, AWWA M41.
 - b. Concrete Pipe: AWWA M9.
 - c. Steel Pipe: ANSI/AWWA C206, AWWA M11.
 - d. Thermoplastic Pipe: ASTM D2321, ASTM D2774, ANSI/AWWA C605, AWWA M23, AWWA M45, AWWA, M55.
 - e. Sanitary and Storm Sewers: ASCE 37.
2. Install pipe accurately to line and grade shown and indicated in the Contract Documents, unless otherwise approved by ENGINEER. Remove and reinstall pipes that are not installed correctly.
3. Slope piping uniformly between elevations shown.
4. Keep groundwater level in trench at least 12 inches below bottom of pipe before laying pipe. Do not lay pipe in water. Maintain dry trench conditions until jointing and backfilling are complete. Keep clean and protect interiors of pipe, fittings, valves, and appurtenances.
5. Start laying pipe at lowest point and proceed towards higher elevations, unless otherwise approved by ENGINEER.
6. Place bell and spigot-type pipe so that spigots face the direction of laying, unless otherwise approved by ENGINEER.
7. Place concrete pipe containing elliptical reinforcement with minor axis of

reinforcement in vertical position.

8. Excavate around joints in bedding and lay pipe so that pipe barrel bears uniformly on trench bottom.
9. Deflections at joints shall not exceed 75 percent of amount allowed by pipe manufacturer, unless otherwise approved by ENGINEER.
10. For PVC and CPVC piping with solvent welded joints, 2.5-inch diameter and smaller, and copper tubing, snake piping in trench to compensate for thermal expansion and contraction.
11. Carefully examine pipe, fittings, valves, and specials for cracks, damage, and other defects while suspended above trench before installation. Immediately remove defective materials from the Site and replace with acceptable products.
12. Inspect interior of all pipe, fittings, valves, and specials and completely remove all dirt, gravel, sand, debris, and other foreign material from pipe interior and joint recesses before pipe and appurtenances are moved into excavation. Bell and spigot-type mating surfaces shall be thoroughly wire brushed, and wiped clean and dry immediately before pipe is laid.
13. Field cut pipe, where required, with machine specially designed for cutting the type of pipe being installed. Make cuts carefully, without damage to pipe, coating or lining, and with smooth end at right angles to axis of pipe. Cut ends on push-on joint type pipe shall be tapered and sharp edges filed off smooth. Do not flame-cut pipe.
14. Do not place blocking under pipe, unless specifically approved by ENGINEER for special conditions.
15. Touch up protective coatings in manner satisfactory to ENGINEER prior to backfilling.
16. Notify ENGINEER in advance of backfilling operations.
17. On steep slopes, take measures acceptable to ENGINEER to prevent movement of pipe during installation.
18. Exercise care to avoid flotation when installing pipe in cast-in-place concrete, and in locations with high groundwater.

F. Jointing Pipe:

1. Ductile Iron Mechanical Joint Pipe:
 - a. Immediately before making joint, wipe clean the socket, plain end, and adjacent areas. Taper cut ends and file off sharp edges to provide smooth surface.
 - b. Lubricate plain ends and gasket with soapy water or manufacturer's recommended pipe lubricant, in accordance with ANSI/AWWA C111, just prior to slipping gasket onto plain end of the joint assembly.
 - c. Place gland on plain end with lip extension toward the plain end, followed by gasket with narrow edge of gasket toward plain end.
 - d. Insert plain end of pipe into socket and press gasket firmly and evenly into gasket recess. Keep joint straight during assembly.
 - e. Push gland toward socket and center gland around pipe with gland lip against gasket.
 - f. Insert bolts and hand-tighten nuts.
 - g. If deflection is required, make deflection after joint assembly and prior to tightening bolts. Alternately tighten bolts approximately 180 degrees apart to

- seat gasket evenly. Bolt torque in accordance with manufacturer's tolerances.
- h. Bolts and nuts, except those of stainless steel, shall be coated with 2 coats, minimum dry film thickness of 8 mils each, of high build solids epoxy or bituminous coating manufactured by Tnemec, or ENGINEER approved equivalent.
 - i. Install restrained mechanical joints in accordance with Section 33 05 09 and with manufacturer's instructions.
2. Ductile Iron Push on Joint Pipe:
- a. Prior to assembling joints, thoroughly clean with wire brush the last 8 inches of exterior surface of spigot and interior surface of bell, except where joints are lined or coated with a protective lining or coating.
 - b. Wipe clean rubber gaskets and flex gaskets until resilient. Conform to manufacturer's instructions for procedures to ensure gasket resiliency when assembling joints in cold weather.
 - c. Insert gasket into joint recess and smooth out entire circumference of gasket to remove bulges and to prevent interference with proper entry of spigot of entering pipe.
 - d. Immediately prior to joint assembly, apply thin film of pipe manufacturer's recommended lubricant to surface of gasket that will come in contact with entering spigot end of pipe, or apply a thin film of lubricant to outside of spigot of entering pipe.
 - e. For assembly, center spigot in pipe bell and push pipe forward until spigot just makes contact with rubber gasket. After gasket is compressed and before pipe is pushed or pulled in the rest of the way, carefully check gasket for proper position around the full circumference of joint. Final assembly shall be made by forcing spigot end of entering pipe past gasket until spigot makes contact with base of the bell. When more than a reasonable amount of force is required to assemble the joint, remove spigot end of pipe to verify proper positioning of gasket. Do not use gaskets that have been scored or otherwise damaged.
 - f. Maintain an adequate supply of gaskets and joint lubricant at the Site when pipe jointing operations are in progress.
3. Thermoplastic Pipe Joints:
- a. Bell and Spigot Joints:
 - 1) Bevel pipe ends, remove all burrs, and provide a reference mark at correct distance from pipe end before making joints.
 - 2) Clean spigot end and bell thoroughly before making the joint. Insert O-ring gasket while ensuring that gasket is properly oriented. Lubricate spigot with manufacturer's recommended lubricant. Do not lubricate bell and O-ring. Insert spigot end of pipe carefully into bell until reference mark on spigot is flush with bell.
 - b. Mechanical Coupling Joints:
 - 1) Mechanical couplings include:
 - a) Sleeve-type flexible couplings, split flexible couplings, ANSI/AWWA C606 grooved or shouldered end couplings, plasticized PVC couplings, and other mechanical couplings specified in Section 33 05 09.

- 2) Prior to installing and assembling mechanical couplings, thoroughly clean joint ends with wire brush to remove foreign matter.
 - 3) For mechanical couplings that incorporate gaskets, after cleaning apply lubricant to rubber gasket or inside of coupling housing and to joint ends. After lubrication, install gasket around joint end of previously installed piece and mate joint end of subsequent piece to installed piece. Position gasket and place coupling housing around gasket and over grooved or shouldered joint ends. Insert bolts and install nuts tightly by hand. Tighten bolts uniformly to produce an equal pressure on all parts of housing. When housing clamps meet metal to metal, joint is complete and further tightening is not required.
 - 4) For plasticized PVC couplings, loosen the stainless steel clamping bands and remove clamps from coupling. Slide coupling over plain ends of pipes to be joined without using lubricants. Place clamps over each end of coupling at grooved section and tighten with torque wrench to torque recommended by manufacturer.
4. Bedding:
 - a. Reference Section 31 23 33.
5. Backfilling:
 - a. Conform to applicable requirements of Section 31 23 33.
 - b. Place backfill as Work progresses. Backfill by hand and use power tampers until pipe is covered by at least 1 foot of backfill.
6. Connections to Valves and Hydrants:
 - a. Install valves and hydrants as shown and indicated in the Contract Documents.
 - b. Provide suitable adapters when valves or hydrants and piping have different joint types.
 - c. Provide thrust restraint at all hydrants and at valves located at pipeline terminations.
7. Transitions from One Type of Pipe to Another:
 - a. Provide necessary adapters, specials, and connection pieces required when connecting different types and sizes of pipe or connecting pipe made by different manufacturers.
8. Closures:
 - a. Provide closure pieces shown or required to complete the Work.
- G. Tracer Pipe Installation:
 1. Polyethylene Underground Warning Tape for Metallic Pipelines:
 - a. Provide polyethylene tracer tape for buried metallic piping, which includes pipe that is steel, ductile iron, cast iron, concrete, copper, and corrugated metal.
 - b. Provide tracer tape 18 inches below finished grade, above and parallel to buried pipe.
 - c. For pipelines buried 8 feet or greater below finished grade, provide second line of magnetic tracer tape 2.5 feet above crown of buried pipe, aligned along pipe centerline.

- d. Tape shall be spread flat with message side up before backfilling.
- 2. Detectable Underground Warning Tape for Non-Metallic Pipelines:
 - a. Provide polyethylene tracer tape with aluminum backing for buried, nonmetallic piping, which includes pipe that is PVC, CPVC, polyethylene, HDPE, FRP, ABS, and vitrified clay.
 - b. Provide magnetic tracer tape 18 inches below finished grade, above and parallel to buried pipe.
 - c. For pipelines buried 8 feet or greater below finished grade, provide second line of magnetic tracer tape 2.5 feet above crown of buried pipe, aligned along the pipe centerline.
 - d. Tape shall be spread flat with message side up before backfilling.
- H. Thrust Restraint:
 - 1. At each fitting and joint, provide mechanical and concrete block thrust restraint on pressure piping systems.
 - a. Install mechanical joint restraint devices as specified in Section 33 05 09 at all fittings.
 - 2. Restrained Pipe Joints:
 - a. Pipe joints shall be restrained by means suitable for the type of pipe being installed.
 - 1) Ductile Iron, Push-on Joints and Mechanical Joints: Restrain with proprietary restrained joint system as specified in Section 33 05 09, lugs and tie rods, or other joint restraint systems approved by ENGINEER.
 - 2) Thermoplastic Joints: Where bell and spigot-type or other non-restrained joints are utilized, provide tie rods across joint or other suitable joint restraint system, subject to the approval of ENGINEER.
- I. Work Affecting Existing Piping:
 - 1. Location of Existing Underground Facilities:
 - a. Locations of existing Underground Facilities shown on the Contract Drawings should be considered approximate.
 - b. Determine the actual location of existing Underground Facilities by physical field investigation to which connections are to be made, crossed, and that could be disturbed, and determine location of Underground Facilities that could be disturbed during excavation and backfilling operations, or that may be affected by the Work.

3.2 FIELD QUALITY CONTROL

- A. Testing:
 - 1. General:
 - a. Test all piping.
 - b. All tests paid for by CONTRACTOR.
 - c. Test each pipe in accordance with the type of test identified in the piping schedule specified in Section 40 06 00.
 - d. Notification:
 - 1) Notify ENGINEER at least 48 hours prior to testing.

- 2) When authorities having jurisdiction are to witness tests, notify ENGINEER and authorities having jurisdiction in writing at least 48 hours in advance of testing.
 - e. Conduct all tests in presence of ENGINEER.
 - f. Remove or protect pipeline-mounted devices that could be damaged by testing.
 - g. Provide all apparatus and services required for testing, including:
 - 1) Test pumps, compressors, hoses, calibrated gages, meters, test containers, valves, fittings, and temporary pumping systems required to maintain OWNER's operations.
 - 2) Temporary bulkheads, bracing, blocking, and thrust restraints.
 - h. Provide air if an air test is required, power if pumping is required, and gases if gases are required.
 - i. Unless otherwise specified, OWNER will provide fluid required for hydrostatic testing. CONTRACTOR shall provide means to convey fluid for hydrostatic testing into the pipe being tested. CONTRACTOR shall provide fluid for other types of testing required.
 - j. Repair observed leaks and repair pipe that fails to meet acceptance criteria. Retest after repair.
 - k. Unless otherwise specified, testing shall include existing piping systems that connect with new piping system. Test existing pipe to nearest valve. Existing piping not installed by CONTRACTOR and that fails the test shall be repaired upon authorization of ENGINEER or OWNER. Repair of existing piping will be paid as extra work unless otherwise specified.
 - l. Repair and retest pipelines that fail the test.
2. Test Schedule:
- a. Refer to Section 40 06 00 for type of test required and required test pressure.
 - b. Unless otherwise specified, the required test pressures are at lowest elevation of pipeline segment being tested.
 - c. For piping not listed in pipe schedule:
 - 1) Hydrostatically test pipe that will convey liquid at a pressure greater than 5 psig. Provide process air pipe test for pipe that will convey air or gas under pressure or vacuum, except chlorine gas, which requires a separate test.
 - 2) Disinfect for bacteriological testing piping that conveys potable water.
3. Test Duration:
- a. 120 minutes.
4. Test Pressure:
- a. Use test pressures listed in Section 40 06 00.
 - b. If test pressure is not listed in pipe schedule, or if a test is required for piping not listed in the pipe schedule, test pressure will be determined by the ENGINEER based on the maximum anticipated sustained operating pressure and the methods described in the applicable ANSI/AWWA manual or standard that applies to the piping system.
5. Hydrostatic Testing for Pressure Pipe:
- a. Ductile iron pipe: AWWA C-600, Section 4.1.5, 4.1.6.

- b. Thermoplastic pipe: Section 7 of ANSI/AWWA Standard C605.
- 6. Sewer Testing with Low Pressure Air:
 - a. Plug and bulkhead ends and lateral connections of pipe segment to be tested.
 - b. Required test pressure shall be increased by an amount equal to the elevation of groundwater above invert of lowest point of pipe segment being tested.
 - c. Test in accordance with requirements of authority having jurisdiction.
 - d. If there are no Laws and Regulations covering the test, use test procedures described in the following standards:
 - 1) Thermoplastic and HDPE Pipe: ASTM F1417.
 - 2) Concrete Pipe: ASTM C924.
- 7. Vertical Deflection Test for Thermoplastic, FRP, and HDPE Pipe:
 - a. Conduct vertical deflection test at least thirty days after backfill has been placed.
 - b. Manually pull pin-type vertical gauge mounted on sled through pipe. Gauge shall be manufactured by Quality Test Products, or ENGINEER approved equivalent. Set gauge so that sled will stop if vertical deflection of pipe exceeds 5 percent. Excavate and re-install piping that fails deflection test, and retest.
 - c. Use rigid ball or mandrel for deflection test, which shall have diameter of at least 95 percent of base inside diameter or average inside diameter of piping, depending on which is specified in applicable ASTM standard, including appendix, to which pipe is manufactured. Perform test without mechanical pulling devices. Re-install and retest pipe segments that exceed deflection of 5 percent.

3.3 PROTECTION

- A. Painting: As specified in Section 09 90 00.

3.4 SCHEDULES

- A. Section 40 06 00.

END OF SECTION

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SECTION 33 05 31
THERMOPLASTIC (POLYVINYL CHLORIDE) UTILITY PIPE

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Gasketed Polyvinyl Chloride (PVC) utility pipe for buried applications.
 - 2. Push on joint lubrication.
- B. Related Sections:
 - 1. Section 31 23 00 - Excavation, Trenching, and Backfilling for Utilities
 - 2. Section 33 05 05 - Buried Piping Installation

1.2 REFERENCES

- A. American Society of Testing and Materials (ASTM):
 - 1. ASTM D3139 - Standard Specification for Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals.
 - 2. ASTM F477 - Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe.
- B. American Water Works Association (AWWA):
 - 1. AWWA C900-16 - Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 4 inch through 60 inch, for Water Transmission and Distribution.
- C. National Sanitation Foundation (NSF)
 - 1. NSF 61: Drinking Water System Components – Health Effects

1.3 COORDINATION:

- A. Coordinate installation of associated poured-in-place and/or cast-in-place concrete and other structural components as they are constructed.

1.4 SUBMITTALS

- A. Product Data:
 - 1. Submit manufacturer's descriptive literature and product specifications for each product. Product data to include at minimum:
 - a. Pressure ratings.
 - b. Process connection type(s) and details.
 - c. Dimensions and weights.
 - d. Materials of construction.
 - 2. Surface preparation and application reports and procedures as required for lining and coating of pipe and fittings.
- B. Shop Drawings:
 - 1. Indicate typical layout and alignment including dimensions.
 - 2. Shop drawings shall reference stationing on the plan/profile sheets and shall

incorporate changes necessary to avoid conflicts with existing utilities and structures and adjustments necessary to make tie-ins.

3. Submit detail drawings of special accessory components not included in the manufacturer's product data.
 4. Provide modified vertical profile as needed to incorporate standard fitting angles required in the plans. This includes at minimum a markup of the plan and profile drawings with revised pipe elevations, fitting locations (stations) and angles. Pipe shall maintain a minimum cover of 5 feet, unless otherwise indicated in the Contract Drawings, and not introduce any new high points in the profile.
- C. Manufacturer's Certificates:
1. Certify that products meet or exceed specified requirements.
 2. Submit certificate signed by applicator of the linings and coatings, if other than pipe manufacturer, stating that product to be applied conforms to applicable referenced standards and that the applicator shall conform to the Contract Documents.
- D. Manufacturer's Instructions: Submit pipe and fitting joining instructions.
- E. Source Quality-Control Submittals: Indicate results of shop tests and inspections.
- F. Field Quality-Control Submittals:
1. Pressure Testing Plan:
 - a. Submit prior to testing for ENGINEER approval. Include at minimum:
 - 1) Testing date(s).
 - 2) Piping systems and specific sections to be tested.
 - 3) Test type.
 - 4) Method of isolation.
 2. Certifications of calibration: Testing equipment.
 3. Certified test report.
- G. Qualifications Statements: Submit qualifications for Manufacturer.

1.5 CLOSEOUT SUBMITTALS

- A. Provide final executed warranty information including terms and conditions with warranty period and start date clearly indicated.
- B. Project Record Documents:
1. Maintain accurate and up-to-date record documents showing Contract and Shop Drawing modifications. Record documents shall show actual location of all piping and appurtenances on a copy of the Contract Drawings.
 2. Record documents shall show piping with elevations referenced to the project datum and dimensions from permanent structures. For straight runs of pipe provide offset dimensions as required to document pipe location.

1.6 QUALITY ASSURANCE

- A. Manufacturer Qualifications:
1. Manufacturer shall have a minimum of 5 years successful experience producing polyvinyl chloride pipe and fittings and shall be able to show evidence of at least 5

installations in satisfactory operation in the United States that are similar applications to the specified service.

- B. Regulatory Requirements:
 - 1. Conform to all municipal (or County) codes and ordinances, laws and regulations of the State.
 - 2. In case of apparent conflict, State and local requirements govern over these Specifications.
- C. Permanently mark each length of pipe with manufacturer's name or trademark and indicate conformance to standards.
- D. Materials in Contact with Potable Water: Certified according to NSF 61.

1.7 QUALIFICATIONS

- A. Manufacturers:
 - 1. Manufacturer shall have a minimum of 5-years successful experience producing ductile iron pipe and fittings and shall be able to show evidence of at least 5- installations in satisfactory operation in the United States that are similar applications to the specified service.
 - 2. Lining and coating products shall be manufactured by a firm with a minimum of 5- years successful experience in protecting pipe exposed to the specified service conditions and shall be able to show evidence of at least 5 installations in satisfactory operation in the United States that are similar applications to the specified service.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Packing, Shipping, Handling and Unloading:
 - 1. In accordance with manufacturer's instructions.
- B. Delivery and Acceptance Requirements
 - 1. Obtain bill of lading for each material and/or product.
 - 2. Reject damaged materials.
 - 3. Ensure shop coatings were not compromised during delivery and handling.
- C. Storage and Handling Requirements
 - 1. In accordance with manufacturer's instructions.
 - 2. Provide temporary end caps and closures on piping and fittings. Maintain in place until installation.
 - 3. Store all material on wood pallets or timbers.
 - 4. Cover material and ensure it remains free of moisture.
 - 5. Cover pipe and fittings stored outdoors.
 - 6. Protect interior linings and exterior coatings of pipe and fittings from damage. Replace pipe and fittings with damaged lining regardless of cause of damage.

1.9 EXISTING CONDITIONS

- A. Field Measurements:
 - 1. CONTRACTOR shall verify actual dimensions of openings, adjacent facilities and

equipment, utilities, and related items by field measurements before procurement, as applicable.

2. Indicate field measurements on Shop Drawings.

1.10 WARRANTY

- A. Extended Project Warranty: Per Section 01 78 36 - Warranties.
- B. Product Warranty:
 1. Manufacturer's Warranty: Submit, for OWNER's acceptance, manufacturer's standard warranty document executed by authorized company official. Manufacturer's warranty is in addition to, and not a limitation of, other rights OWNER may have under Contract Documents.
 2. Warranty Period: One year commencing on Date of Substantial Completion.
 3. Special Warranty: None.

PART 2 - PRODUCTS

2.1 PVC UTILITY PIPE

- A. Manufacturers:
 1. JM Eagle.
 2. Westlake Pipe & Fittings
 3. Or ENGINEER approved equivalent.
- B. General:
 1. Locations and nominal diameters as indicated in the Contract Drawings.
 2. Flexible water-tight connections approved by the OWNER / ENGINEER, shall be used at PVC pipe connections to manholes and other rigid structures.
- C. Performance and Design Requirements:
 1. Dimension Ratio, Classes, and Pipe Stiffness: As indicated in Section 40 06 00.
 2. Utilize standard 20-foot lying length pipe sections unless otherwise indicated on the contract Drawings.
- D. Gasketed Joint Integral Bell Pipe:
 1. Pipe four inch through 60 inch shall conform to AWWA C900-16 and ASTM D1784.
 2. Pipe Joints:
 - a. Pipe shall have a gasketed Integral Bell (IB) joint conforming to ASTM D3139. The bell shall consist of an integral wall section with a solid cross-section elastomeric ring.
 - b. Pipe Joint Gaskets:
 - 1) Per ASTM F477.
 - 2) Elastomer: SBR.
 - c. Joint installation lubricant shall be a heavy vegetable soap solution, brush applied. Spray on lubricants shall not be accepted.
 - 1) Manufacturer: Oatey or OWNER / ENGINEER approved equivalent.

2.2 SOURCE QUALITY CONTROL

- A. Markings for Identification:
 - 1. Stamp, mark, and identify pipe with:
 - a. Manufacturer's identification (name or trademark).
 - b. Class or Pressure rating.
 - c. Pipe Size.
 - d. Country of origin.
 - e. Year of production.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Inspect pipe materials for defects in material and workmanship.
- B. Verify that field dimensions are as indicated on Contract and Shop Drawings.
- C. Location of Existing Piping:
 - 1. Locations of existing piping shown on the Contract Drawings are approximate.
 - 2. Determine the true location of existing piping to which connections are to be made, crossed, and that could be disturbed.
 - 3. Stop Work and request Interpretation by OWNER / ENGINEER upon conflicting horizontal locations or vertical elevations.
- D. Verify compatibility of new pipe and fittings.

3.2 INSTALLATION

- A. Trenching, Bedding, and Backfill:
 - 1. Reference Section 31 23 00 - Excavation, Trenching, and Backfilling for Utilities
- B. Buried Piping Installation:
 - 1. Reference Section 33 05 05 - Buried Piping Installation.
 - 2. Verify pipe loading during construction. Pipe design is based on final installation depth and required cover.

3.3 FIELD QUALITY CONTROL

- A. Refer to Section 33 05 05 - Buried Piping Installation.

3.4 CLEANING

- A. Clean as recommended by manufacturer. Do not use materials or methods which may damage the pipe finish or surface.
- B. Keep pipe interior clean as installation progresses.
- C. After installation, clean pipe interior of soil, grit, and other debris.

END OF SECTION

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SECTION 33 05 31.11
POLYVINYL CHLORIDE GRAVITY SEWER PIPE

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Polyvinyl Chloride (PVC) gravity pipe.
 - 2. Includes push on joint lubrication.
 - 3. Restraints and specials specified under Section 40 05 01.
- B. Products Supplied but Not Installed Under This Section:
 - 1. Polyvinyl Chloride (PVC) Gravity Sewer pipe.
- C. Related Sections:
 - 1. Section 31 23 00 – Excavation, Trenching, and Backfilling for Utilities
 - 2. Section 33 05 05 – Buried Piping Installation.
 - 3. Section 40 08 00 – Field Testing of Process Interconnections.

1.2 REFERENCES

- A. American Society of Testing and Materials:
 - 1. ASTM D 3034 - Standard Specification for Type PSM Poly (Vinyl Chloride) (PVC) Sewer Pipe and Fittings.
 - 2. ASTM F 679 - Standard Specification for Poly (Vinyl Chloride) (PVC) Large-Diameter Plastic Gravity Sewer Pipe and Fittings.
 - 3. ASTM D 3212 - Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals.
- B. Product Data:
 - 1. Manufacturer's descriptive literature and product specifications for each product.
 - 2. Pressure ratings.
 - 3. Provide data on pipe materials, pipe fittings, and accessories. Provide manufacturer's catalog information with dimensions, material and assembled weight.
- C. Quality Assurance / Control Submittals:
 - 1. Test Reports:
 - a. When requested by Engineer, submit results of specified shop tests for pipe.
 - 2. Certificates:
 - a. Submit manufacturer's certificate of compliance with standards referenced in this Section.

1.3 QUALITY ASSURANCE

- A. Manufacturer Qualifications:
 - 1. Manufacturer shall have a minimum of 5 years successful experience producing polyvinyl chloride pipe and fittings and shall be able to show evidence of at least 5 installations in satisfactory operation in the United States that are similar applications

to the specified service.

- B. Regulatory Requirements:
 - 1. Conform to all municipal (or County) codes and ordinances, laws and regulations of the State.
 - 2. In case of apparent conflict, State and local requirements govern over these Specifications.
- C. Manufacturer's name and pressure rating marked on piping and fittings.
- D. Same manufacturer to provide all piping, fittings, materials and accessories.

1.4 DELIVERY, STORAGE AND HANDLING

- A. Packing, Shipping, Handling and Unloading:
 - 1. In accordance with manufacturer's instructions.
 - 2. Remove all materials from the Site that are found to be unsatisfactory.
 - 3. Use hooks, forks, chains, straps, and other lifting devices only on exterior of pipe and fittings. Pipe and fittings with damaged lining shall be replaced regardless of cause of damage.
- B. Acceptance at Site:
 - 1. Obtain bill of lading for each material and/or product.
 - 2. Reject damaged materials.
 - 3. Ensure shop coatings were not compromised during delivery and handling.
- C. Storage and Protection:
 - 1. Provide temporary end caps and closures on piping and fittings. Maintain in place until installation.
 - 2. Store all material on wood pallets or timbers.
 - 3. Cover material and ensure remains free of moisture.

1.5 SEQUENCING

- A. Coordinate Work with local sewerage authority a minimum of one week prior to sanitary discharge. Permission from governing authority must be obtained prior to discharge.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Gravity Sewer Pipe:
 - 1. JM Eagle.
 - 2. Or Engineer approved equal.

2.2 MATERIALS

- A. Gravity Sewer Pipe and Fittings:
 - 1. PVC Gravity Pipe:
 - a. PVC Sewer Pipe, four inch through 15 inch in diameter, inclusive, shall have a standard dimension ratio (SDR) of 35, and conform to ASTM D 3034.
 - b. PVC Sewer Pipe greater than 15 inch in diameter shall conform to ASTM F 679.

- c. The pipe shall have integral wall bell and spigot joints conforming to ASTM D 3212. The bell shall consist of an integral wall section with a solid cross-section elastomeric ring, factory assembled, securely locked in place to prevent displacement.
- d. Flexible water-tight connections, approved by the Engineer, shall be used at PVC pipe connections to manholes and other rigid structures.

2.3 SOURCE QUALITY CONTROL

- A. Tests / Inspections:
 - 1. Pipe manufacturer shall maintain continuous quality control program.
 - 2. Where applicable and when requested by Engineer, submit results of source quality control tests specified in reference standards.
- B. Marking for Identification:
 - 3. Stamp, mark, and identify pipe with:
 - a. Name or trademark of manufacturer.
 - b. Weight, class or nominal thickness.
 - c. Country where manufactured.
 - d. Year the pipe was produced.
 - e. Pipe Size.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Stop Work and Request for Interpretation to Engineer upon conflicting horizontal locations and vertical elevations.
- B. Inspect pipe materials for defects in material and workmanship. Verify compatibility of pipe and fittings.

3.2 INSTALLATION

- A. Trenching, Bedding, and Backfill:
- B. Reference Section 31 23 00 "Excavation, Trenching, and Backfilling for Utilities."
- C. Buried Piping Installation:
- D. Reference Section 33 05 05 "Buried Piping Installation."
- E. Verify of pipe loading during construction. Pipe design is based on final installation depth and required cover.

3.1 FIELD QUALITY CONTROL

- F. Refer to Section 33 05 05 "Buried Piping Installation."

3.2 CLEANING

- G. Clean as recommended by manufacturer. Do not use materials or methods which may damage finish / surface or surrounding construction.

END OF SECTION

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SECTION 33 05 61
CONCRETE MANHOLES

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Modular precast concrete manhole sections with tongue-and-groove joints, transition, ring, cover, and accessories. This Section specifies manholes for storm sewer systems, sanitary sewer systems, and other utilities as required and shown on the Drawings. This section includes the following:
 - a. Precast reinforced concrete manholes
- B. Related Sections:
 - 1. Section 03 60 00 – Grouting
 - 2. Section 31 23 00 – Excavation, Trenching, and Backfilling for Utilities

1.2 REFERENCES

- A. Standards:
 - 1. American Society of Testing and Materials (ASTM) International:
 - a. ASTM A48-Gray Iron Castings
 - b. ASTM A185-Steel Welded Wire Fabric, Plain, for Concrete Reinforcement
 - c. ASTM C33-Concrete Aggregate
 - d. ASTM C39- Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
 - e. ASTM C76- Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe
 - f. ASTM C150-Portland Cement
 - g. ASTM C443- Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets
 - h. ASTM C478-Precast Reinforced Concrete Manhole Sections
 - i. ASTM C913-Precast Concrete Water and Wastewater Structures
 - j. ASTM C923-Resilient Connectors Between Reinforced Concrete Manhole Structures and Pipes
 - k. ASTM C990- Standard Specification for Joints for Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint Sealants
 - l. ASTM D2240- Standard Test Method for Rubber Property—Durometer Hardness
 - 2. American Associations of State Highway and Transportation Officials (AASHTO)
 - a. AASHTO M306-Specification for Drainage Structure Castings

1.3 SUBMITTALS

A. Action Submittals:

1. Product Data:

- a. Submit manufacturer's descriptive literature and product specifications for each product.
- b. Provide manhole covers, steps, component construction, features, configuration, and dimensions.
- c. Product data for precast riser sections, covers, frames, grade rings, and pipe sleeves.

2. Design Data:

- a. Provide design of joint or joints, including design and durometer hardness of the rubber gasket proposed.

3. Shop Drawings:

- a. Indicate typical layout including dimensions.
- b. Indicate manhole locations, rim elevations, piping, sizes, orientations, and elevations of penetrations.
- c. Submit detail drawings of special accessory components not included in the manufacturer's product data.

B. Informational Submittals:

1. Manufacturer's Instructions / Reports
2. For castings, furnish manufacturer's certification stating that casting meets the proof-load testing requirements of AASHTO M306.

1.4 QUALITY ASSURANCE

A. Regulatory Agency Sustainability Approvals:

1. In accordance with all local codes and ordinances, laws, and regulations of the state.
2. In case of apparent conflict, state and local requirements govern over these specifications.
3. Product suitable for use with raw wastewater and surface runoff.

B. Qualifications:

1. Manufacturers

- a. Company specializing in manufacturing products specified in this Section with minimum 5 years documented experience.

2. Fabricators

- a. Company specializing in fabricating work specified in this Section with minimum 5 years documented experience.

1.5 WARRANTY

A. Extended Project Warranty: Per Section 01 78 36 - Warranties.

B. Product Warranty:

1. Manufacturer's Warranty: Submit, for OWNER's acceptance, manufacturer's standard

warranty document executed by authorized company official. Manufacturer's warranty is in addition to, and not a limitation of, other rights OWNER may have under Contract Documents.

2. Warranty Period: One year commencing on Date of Substantial Completion.
3. Special Warranty: None.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Concrete: Division 3 except as modified herein:
 1. Minimum compressive strength: 4000 psi at 28 days
 2. Cement: ASTM C150, Portland Cement, Type II
 3. Aggregates: ASTM C33, free of deleterious substances

2.2 PRECAST CONCRETE MANHOLES

- A. Standard Precast Concrete Manholes: ASTM C478, precast, reinforced concrete, of depth indicated, with provision for sealant joints.
 1. Designed Precast Concrete Manholes: ASTM C913; designed according to ASTM C 890 for A-16 (AASHTO HS20-44), heavy-traffic, structural loading; of depth, shape, and dimensions indicated, with provision for sealant joints.
 2. Cement : ASTM C150, Type II.
 3. Reinforcement: Welded wire fabric, ASTM A185
 4. Diameter: 48 inches, unless otherwise indicated.
 5. Base Section: 5-inch minimum thickness for manholes 48-inch diameter, as shown on the Drawings.
 6. Precast base and first barrel section cast monolithically:
 - a. Provide with polyisoprene pipe penetration gaskets, #40 durometer A, ASTM D2240 and stainless-steel adjustable pipe clamps.
 - b. Preformed pipe inverts are acceptable, after approval from ENGINEER.
 7. Riser Sections: Minimum wall thickness shall be as listed under Wall "B" in the "Class Tables" of ASTM C76, and lengths to provide depth indicated.
 8. Top Section: Eccentric-cone type unless concentric-cone or flat-slab-top type is indicated. Top of cone of size that matches grade rings.
 9. Joint Sealant: ASTM C990, bitumen, or butyl rubber.
 10. Resilient Pipe Connectors: In accordance with ASTM C923, cast or fitted into manhole walls, for each pipe connection. The resilient connector shall provide an airtight seal that eliminates infiltration and exfiltration.
 11. Steps: Polypropylene coated 1/2-inch grade 60 steel step cast in place, manhole step style, MA Industries Inc. or ENGINEER approved equivalent.
 12. Joints: Conform to the joint specification of ASTM C478, use rubber gaskets of the round O-ring design complying with requirements of ASTM C443.
 13. Adjusting Rings: Interlocking rings with level or sloped edge in thickness and diameter matching manhole frame and cover. Include sealant recommended by ring

manufacturer.

14. Grade Rings: Reinforced concrete rings, maximum 18-inch total thickness, to match diameter of manhole frame and cover.
 15. Lifting Lugs: Manhole sections and cones may be furnished with lift lugs or lift holes. If lift holes are provided, they shall be plugged with a nonmetallic, non-shrink grout.
 16. Apply a bituminous water proofing coating to the exterior surfaces of the precast manhole sections.
- B. Manhole Sections: Integral concrete waterproofing: provide waterproofing admixture Xypex Admix C-1000, C-500 or C-2000; proprietary compound of Portland cement, silica sand and active chemicals; provide product and mix ratio that produce concrete that complies with the following:
1. Penetration: At least 2 inches (50 mm) penetration of crystal-forming material, evidenced by scanning electron microscope photographs.
 2. Permeability: No measurable leakage through waterproofed concrete, when tested in accordance with COE CRD-C 48 at 350 feet (106 m) of head or 150 psi (1034 kPa).
 3. Chemical Resistance: Weight loss significantly less than control samples, when tested as follows:
 - a. Test specimens consisting of concrete made with admixture dosage rates (to weight of cement) of 3 percent, 5 percent, and 7 percent, and a control sample prepared without admixture.
 - b. Immerse samples in sulfuric acid and weigh daily.
 - c. When weight loss of control sample reaches 50 percent, stop test and weight treated samples.
 4. Compressive Strength: At least 10 percent increase in strength compared to samples prepared without admixture, when tested in accordance with ASTM C39/C39M after 28 days.
- C. Preformed plastic gaskets:
1. Conformance: Fed. Spec. SS-S-00210 (GSA-FSS), Type 1, Rope Form. Primer required.
 2. Diameter: 1-1/2 inch for 48-inch manhole
 3. Acceptable manufacturers:
 - a. "Rub'r-Nek," Henry Company.
 - b. Kent Seal No.2," Hamilton-Kent Manufacturing Co.
 - c. Or ENGINEER approved Equivalent.
- D. Pipe penetration seals for precast sections: Neoprene rubber pipe penetration gaskets, #40 durometer A, ASTM D2240 and adjustable stainless steel pipe clamps, "A-Lok" or ENGINEER approved equivalent.
- E. Castings: ASTM A48 with asphalt varnish coating hot dip applied at foundry, 6mils thick.
- F. Manhole steps: Steel bar, 1/2-inch Grade 60, drop-front type with polypropylene coating applied by manufacturer, Type MA Industries Inc. "PS2-PFS" or ENGINEER approved equivalent.

- G. Manhole rings and covers:
 - 1. Standard:
 - a. Cast-iron, heavy-duty traffic type, ASTM A48, Class 30B. Grind bearing surfaces to ensure flat, true surfaces.
 - b. Covers to seat at all points on ring.
 - c. Un-lettered design unless otherwise indicated in Contract Documents or Contract Drawings.
 - 2. Watertight:
 - a. Cast-iron, heavy-duty traffic type, ASTM A48, Class 30B. Grind bearing surfaces to ensure flat, true surfaces.
 - b. Covers to seat at all points on ring.
 - c. Un-lettered design unless otherwise indicated.
 - d. 24-inch diameter cover or as otherwise shown on the Contract Drawings.
 - e. Bolt-on cover, minimum of 3 bolts.
 - f. Integral rubber sealing gasket in ring.
 - g. Manufacturers: Neenah, R-1916-D or ENGINEER approved equivalent.
- H. Cleanout rings and covers:
 - 1. Cast iron ASTM A48, Class 30B. Grind bearing surfaces to ensure flat, true surfaces.
 - 2. Covers to seat at all points on ring.
- I. Manhole Height Adjustment: Use precast concrete grade rings or HDPE adjusting rings as manufactured by Ladtech, Inc. or ENGINEER approved equivalent.
- J. Rock Subbase: 1-1/2-inch minus, well-graded gravel. Comply with provisions for embedment in Section 31 23 00 – Excavation, Trenching, and Backfilling for Utilities.
- K. Water: Clean and free of deleterious substances.
- L. Grout: Provide under provisions of Section 03 60 00 – Grouting.

2.3 FABRICATION / ASSEMBLY

- A. Shop Fabrication
 - 1. Manhole Section:
 - a. Precast concrete.
 - b. Minimum manhole inside diameter: 48-inch, where indicated.
 - c. Provide eccentric cones for all manholes except where indicated otherwise.
 - d. Cones: Same or greater reinforcement and wall thickness as manhole section.
 - e. Manhole steps: 12 inch on center, vertical alignment above largest bench, as indicated on Contract Drawings.
 - f. Joints: Keylock type with double mastic gaskets, each joint to set equally and tightly.
 - g. Manhole opening: 24 inch clear.
 - h. Drop structure: As indicated on Contract Drawings.

2.4 FINISHES

- A. Finish Materials
 - 1. Exterior coating: Bituminous damp proofing (all manholes).
 - 2. Interior coating: Xypex concrete admixture.
- B. Damp proof all exterior surfaces of manholes after installation.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Excavation and Backfill: Refer to Section 31 23 00 – Excavation, Trenching, and Backfilling for Utilities, for requirements.
- B. Coordinate placement of inlet and outlet pipe or duct sleeves required by other sections.
- C. Rock Subbase: Remove water, excavate, and place 1-1/2-inch rock 6-inch minimum depth, vibrate for compaction.

3.2 INSTALLATION

- A. Install in accordance with manufacturer's instructions and requirements.
- B. Install units plumb, level, square and free from warp or twist while maintaining dimensional tolerances and alignment with surrounding construction / adjacent surfaces
- C. Placing Manhole Section:
 - 1. Protect manhole sections from chipping while handling.
 - 2. Manhole sections chipped excessively in the opinion of the ENGINEER shall be rejected.
 - 3. Place manhole sections plumb and level, trim to correct elevations.
 - 4. Clean ends of sections and place double mastic gasket.
 - 5. Fill inside and outside of joint completely with non-shrink grout and trowel smooth.
 - 6. Cure non-shrink grout using approved methods outlined in Section 03 60 00.
 - 7. In over lot areas set top of cover rings and covers at 6-inches above highest finished grade elevation.
 - 8. In roads and gravel drive set cover rings and covers with slight tip to match cross slope of paved or finished surfaces.
 - 9. Completed manholes shall be rigid and watertight.
 - 10. Coordinate with other sections of work to provide correct size, shape, and location.
- D. Preformed Gaskets:
 - 1. Remove and replace manhole sections which have chipped or cracked joints.
 - 2. Thoroughly clean section joints.
 - 3. Install gasket in conformance with manufacturer's recommendations.
 - 4. Only use primer furnished by gasket manufacturer.
- E. Manhole Invert:
 - 1. Place concrete in bottom of manhole and form smooth transition. Trowel smooth and

- brush for non-skid finish. Slope bench 1-inch per foot for drainage to invert.
- 2. Invert shape to conform to radius of pipe it connects.
- 3. Remove all rough sections or sharp edges which tend to obstruct flow or cause material to snag.
- 4. Construct in conformance with Contract Drawings.
- 5. Remove all excess grout or concrete from invert.
- F. Drop Assemblies:
 - 1. Construct as shown on Contract Drawings.
- G. Flexible Joints:
 - 1. Provide joint in sewer pipe less than 2 feet from manhole.
 - 2. Where last joint to manhole is more than 2 feet away, place concrete cradle under pipe to within 2 feet.
- H. Permanent Plugs:
 - 1. Thoroughly clean contact surfaces of pipes to be abandoned or cut off.
 - 2. Pipes 18-inch diameter and less: Place 18-inch-deep concrete plug.
 - 3. Pipes greater than 18-inch diameter: Plugs can be cast-in-place concrete with outside face plastered with non-shrink grout.
 - 4. Plugs: Watertight and capable of withstanding all pressures.
- I. Temporary Plugs:
 - 1. Provide temporary plugs as necessary for bypassing flow during construction.
 - 2. Install 2-inch plywood plugs in joint.
 - 3. Make watertight as required by ENGINEER.
 - 4. Backfill against plug.
- J. Manhole Rings and Covers:
 - 1. Place rings in bed of non-shrink grout on top of manholes.
 - 2. Ensure no infiltration will enter manhole at this location.
 - 3. Carry non-shrink grout over flange of ring.
 - 4. Set top of ring flush with all surfaces subject to foot and vehicular traffic or as required by local jurisdiction.
 - 5. Set top of ring at grade.
 - 6. Use precast or HDPE grade rings for height adjustment.
- K. Manholes over Existing Sewers:
 - 1. Construct manhole base and install manhole sections as described herein.
 - 2. Maintain flow at all times.
 - 3. Prior approval of proposed method for maintaining flow must be obtained from ENGINEER.
 - 4. Break out crown of existing pipe and make invert.
 - 5. Cover the edges of the broken pipe with mortar and trowel smooth to the new invert.
 - 6. Provide cover over invert so debris does not enter existing pipelines.

3.3 FIELD / SITE QUALITY CONTROL

A. Field / Site Tests and Inspections

1. Test all manholes unless specified otherwise.
2. Vacuum test:
 - a. Perform vacuum test prior to grouting manhole joints.
 - b. Plug all inlets and outlets in such a manner as to prevent displacement of plugs.
 - c. Install and operate vacuum tester head assembly in accordance with equipment specifications and manufacturer instructions.
 - d. Attach vacuum pump assembly to proper connection on test head assembly.
 - e. Make sure vacuum inlet/outlet valve is in closed position.
 - f. Inflate sealing element to twice test pressure to be used. Do not over inflate.
 - g. Start vacuum pump assembly engine and allow preset RPM to stabilize.
 - h. Open inlet/outlet ball valve and evacuate manhole to 5 inches Hg. (mercury).
 - i. Close vacuum inlet/outlet ball valve, disconnect vacuum pump, and monitor vacuum. Record time for vacuum to drop to 3 inches Hg.
 - j. Acceptance for 5 ft diameter manhole is when time to drop from 5 inches Hg to 4 inches Hg meets or exceeds requirements as defined below:

Maximum Allowable Vacuum Drop		
Manhole Depth Rim to Invert	Diameter in Feet	Time to Drop 1 inch Mercury
10 ft. or less	5	150 seconds
10ft. to 15 ft.	5	180 seconds
15 ft. to 25 ft.	5	210 seconds

- k. Adjust time to drop from 5 inches Hg to 4 inches Hg for other manhole diameters as follows:
 - 1) 4-foot diameter MH: Subtract 30 seconds
 - 2) 6 feet diameter MH: Add 30 seconds
 - 3) 8-foot diameter MH: Add 75 seconds
 - l. Repair all manholes that fail leakage test and retest until manhole passes test at no additional cost to OWNER.
 - m. Method of repair subject to review by ENGINEER.
 - n. If joint mastic or gasket is displaced during vacuum test, disassemble manhole and replace seal.
 3. Hydrostatic test (Alternative to Vacuum Test):
 - a. Plug all inlets and outlets.
 - b. Fill manhole to minimum of 3/4 depth or to within 6 inches of top of cone section.
 - c. Allow water to stand for 24 hours.
 - d. Refill manhole to original depth before beginning leakage test.
 - e. Test leakage during following 24-hour period.

- f. Maximum allowable leakage: Less than 0.2 gph/ft above invert, and is represented by the following formula:

$$V = 0.025 \text{ DHT}/24$$

Where: V = Allowable loss in gallons
D = Manhole diameter in feet
H = Initial depth of water to invert in feet
T = Duration of test in hours.

- g. Repair all manholes that fail leakage test and retest until manhole passes test at no additional cost to OWNER.
- h. Method of repair subject to review by ENGINEER.
4. Test standard manholes prior to placement of grade rings.
5. Water-tight manholes shall be tested in their entirety, to include grade rings and casting.
6. Remove standing water in excavation which may affect test accuracy.
7. Perform all testing in presence of ENGINEER.

3.4 ADJUSTING

- A. Adjust parts for smooth, uniform operation. Vibration of installed equipment shall be within manufacturer's specified tolerances.
- B. Either adjusts manhole cover and frame or roadway surface to obtain a smooth transition if manhole located in roadway. Adjust surrounding grade, filling any depressions, around manhole.

3.5 CLEANING

- A. Clean as recommended by manufacturer. Do not use materials or methods which may damage finish / surface or surrounding construction. Remove construction debris, trash, and plugs from manhole prior to placing in service.

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SECTION 40 05 01
PIPING SYSTEMS, BASIC MATERIALS AND METHODS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section specifies piping materials and installation methods common to the piping system Sections of Division 40 and includes joining materials, piping specialties, and basic piping installation instructions. This Section includes:
 - 1. All exposed, submerged, and buried plant and station piping including modifications to existing systems as well as new pipe systems, except systems specified in related work.
 - 2. Potable water and raw water mains, sanitary sewers, backwash recycle and settled solids piping, ozone piping, chemical conveyance piping, storm drains and culverts serving plant or station and shown on Drawings.
 - 3. Floor and sanitary drain systems within building limits are not included.
 - 4. Domestic water distribution systems, sanitary sewage systems, and storm drainage systems are covered in other Sections.
 - 5. Contractor shall mark actual flowline or top of pipe elevations and actual coordinates on record drawings when pipelines are being installed.
- B. Related Sections:
 - 1. Section 09 90 00 "Painting and Protective Coatings".
 - 2. Section 31 23 00 "Excavation, Trenching, and Backfilling for Utilities" for the excavation, trenching, and backfilling for buried piping systems.

1.3 REFERENCES AND DEFINITIONS

- A. References:
 - 1. American National Standards Institute (ANSI):
 - a. B9.1 Standard Safety Code for Mechanical Refrigeration
 - b. B31.3 Process Piping Code
 - 2. ASTM International (ASTM):
 - a. A 53 – Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
 - b. B 32 – Specification for Solder Metal
 - c. B117 – Salt Spray Test
 - d. B 813 – Specification for Liquid and Paste Fluxes for Soldering Copper and Copper Alloy Tube
 - e. B 828 – Practice for Making Capillary Joints by Soldering of copper and Copper Alloy Tube and Fittings
 - f. C 1173 – Specification for Flexible Transition Couplings for underground Piping Systems

- g. D 1785 – Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120
- h. D 2564 – Specification for Solvent Cements for Poly (Vinyl Chloride) (PVC) Plastic Piping systems
- i. D 2672 – Specification for Joints for IPS PVC Pipe Using Solvent Cement
- j. D 2846 – Specification for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Hot- and Cold-Water distribution Systems
- k. D 2855 – Practice for Making Solvent-Cemented Joints with Poly (Vinyl Chloride) (PVC) Pipe and Fittings
- l. D 3139 – Specifications for Joints for Pressure Pipes Using Flexible Elastomeric Seals
- m. D 3212 – Specification for Joints for Drain and Sewer Pipes using Flexible Elastomeric Seals
- n. E 814 Test Method for Fire Tests of Through-Penetration Fire Stops
- o. F 402 – Practice for Safe Handling of Solvent Cements, Primers, and Cleaners Used for Joining thermoplastic Pipe and Fittings
- p. F 656 – Specifications for Primers for Use in Solvent Cement Joints of Poly (Vinyl Chloride) (PVC) Plastic Pipe and Fittings
- q. F 493 – Specification for Solvent Cements for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe and Fittings
- r. F 593 – Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs
- s. F 594 – Specification for Stainless Steel Nuts
- 3. American Society of Mechanical Engineers (ASME):
 - a. A13.1 Scheme for Identification of Piping Systems
 - b. B1.20.1 Pipe Threads, General Purpose, Inch
 - c. B16.21 Nonmetallic Flat Gaskets for Pipes Flanges
 - d. B18.2.1 Square and Hex Bolts and Screws, Inch Series
- 4. American Welding Society (AWS):
 - a. A5.8 Specification for Filler Metals for brazing and Braze Welding
 - b. D1.1 Structural Welding Code Steel
 - c. D10.12 Guide for Welding Mild Steel Pipe
- 5. American Waterworks Association (AWWA):
 - a. C110 – Standard for Ductile-Iron and Gray-Iron Fittings, 3 In. Through 48 In. (76 mm Through 1,219 mm) for Water
 - b. C200 – Steel Water Pipe, 6 In. (150 mm) and Larger
 - c. C219 – Bolted, Sleeve-Type Couplings for Plain-End Pipe
 - d. C900 – Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 4 In. Through 60 In. (100 mm Through 1,500 mm)
- 6. National Sanitation Foundation (NSF):
 - a. NSF/ANSI 61 – Drinking Water Components – Health Effects
- 7. Design Criteria for Potable Water Systems – Colorado Department of Public Health and Environment
- B. Definitions:
 - 1. Piping Systems: Includes all piping, fittings, valves, specials, hangers and supports, and related items required for a complete piping system.
 - 2. Ferrous Metal: Iron, steel, stainless steel, and alloys with iron as principal component.

3. Nonmetallic: PVC, CPVC, Polyethylene (PE), High-Density Polyethylene (HDPE), and fiberglass reinforced plastic (FRP).
4. Nonferrous Metals: Copper
5. Wetted or Submergence:
 - a. Submerged, or less than one foot above the maximum liquid surface of water holding structures.
 - b. Below top of channels, under cover of slabs of channels or tanks.
 - c. In other damp or covered locations (e.g., vaults, wetwells, utility corridors, etc.)
6. Exposed or Atmospherically Exposed Piping Systems: All piping systems exposed to the atmosphere (not buried, submerged, wetted or embedded). This designation includes insulated piping inside chases, or piping hidden from view.

1.4 SYSTEM DESIGN DESCRIPTION

A. General:

1. The Drawings and Specifications are not all inclusive of explicit piping details; provide piping in accordance with the laws and regulations and intended use, including:
 - a. Power Plant Piping: ANSI/ASME B31.1 Code.
 - b. Building Service Piping: ANSI/ASME B31.9 Code, as applicable.
 - c. Sanitary Building Drainage and Vent Systems: ICC/IAPMO Uniform Plumbing Code.
2. Buried Piping: Provide to be suitable for design conditions as follows:
 - a. H20-S16 traffic load (AASHTO Standard Highway Specifications for Bridges) with 1.5 impact factor.
 - b. Piping both with and without internal pressure.
3. Hangers and Support Systems: Provide an engineered system in accordance with Division 40 Section 40 05 07 "Hangers and Supports for Process Piping."
4. Pressure Testing and Disinfection of Pipelines: Refer to Division 40 Section 40 08 00 "Field Testing of Process Interconnections" for testing of gravity and pressure piping systems; the disinfection of potable water systems; and to the individual piping system Sections for specific requirements.

B. Design Requirements:

1. The configuration and layout of various piping systems are shown in the Drawings. The types of pipe and joints, and embedment (if buried) to be used for each system are shown on the Drawings or included in the appropriate specification Sections.
2. In certain locations, pipe supports, anchors, and expansion joints have been indicated on the Drawings, but no attempt has been made to indicate every pipe support, anchor, and expansion joint.
3. It shall be the Contractor's responsibility to provide a complete system of pipe supports, to provide expansion joints, and to provide restraints and anchor all piping, in accordance with the requirements set forth herein. Additional pipe supports may be required adjacent to expansion joints, couplings, or valves.
4. Pipe and fittings shown on yard piping drawings are general in nature. Contractor shall determine exact lengths and fittings required and make field adjustments necessary to complete piping and avoid conflicts.
5. Changes to the plan and profile of piping shall be submitted to Engineer for approval.

C. Restrained Pipe and Fitting Joints, Buried Piping:

1. Restrained joints shall be used for a sufficient distance from each bend, tee, elbow, plug, or other fitting to resist thrust that will develop at the design pressure.
2. Contractor shall provide restraint length calculations in accordance with AWWA M41 Ductile Iron Pipe and Fittings based on the laying conditions, soil conditions, depth of cover, and pressures to determine the number of restrained joints that will be required.
3. For the purposes of thrust restraint, design pressures shall be the working pressure shown, plus the additional surge allowance for potable water, service water, and pump discharge piping, unless indicated otherwise on the Drawings. The design pressure shall be 1.5 times the design test pressure indicated for all other piping, unless indicated otherwise on the Drawings.

1.5 SUBMITTALS

- A. Product Data: Submit product data on each product item to be installed.
- B. Shop Drawings: Provide shop drawings for piping systems, organized by plant areas or individual piping systems. Prepare drawings to scale (1/4-inch = 1-foot 0-inch minimum), with the following information:
 1. Type of piping including materials, fittings, weights, linings, and coatings. A code or key to product data sheet may be used.
 2. Location and type of joints, fittings, taps, supports, restraint systems, kickers, and blocking (as applicable). Identify by catalog number or shop drawing detail number.
 3. Provide information on interior linings and exterior coatings.
 4. Identify the exact number of restrained joints, as well as the length of restrained joint piping for pressure buried piping.
- C. Specials: Provide fabrication drawings for specials including fabricated fittings, wall pipes, and wall sleeves. Show dimensions and materials of construction.
- D. Before starting fabrication, Contractor shall provide Engineer with pipe design calculations, the proposed engineered hanger and support systems, and specials, which shall incorporate the following information:
 1. Laying plan identifying all restrained joints, details of standard pipe section, special fittings, pipe supports, and bends.
 2. Piping components shall be numbered or otherwise sequence designated.
 3. Outlets and bends shall be made up into special lengths so that, when installed, they will be located as indicated.
 4. Each pipe and fitting shall be marked indicating class of pipe and location number in pipe laying plan. Markings shall be coded to the shop drawings.
- E. Quality Control Submittals:
 1. Welding certificates.
 2. Field Test Reports: For each pressure testing of piping systems and field-testing specified in other piping systems sections.
 3. Affidavits:
 - a. Manufacturer's Certificate of Compliance with reference standards.
 - b. Laboratory Testing Equipment: Certified calibrations, manufacturer's product data and test procedures.
 - c. Certified welding inspection and test results.

1.6 QUALITY ASSURANCE

- A. Steel Support Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code."
- B. Steel Piping Welding: Perform in accordance with Section 40 17 26 "Field Welding of Stainless Steel Piping." Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
 - 1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
 - 2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.
 - 3. Welding procedures and testing shall comply with ANSI B31.1.0, "Standard Code for Pressure Piping, Power Piping," and the AWS Welding Handbook.
 - 4. Soldering and Brazing Procedures shall conform to ANSI B9.1, "Standard Safety Code for Mechanical Refrigeration."
- C. Comply with ASME A13.1 for lettering size, length of color field, colors, and viewing angles of identification devices. Comply with Section 10 40 00 "Safety Signs."

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Comply with the requirements of Division 01 Section 01 60 00 "Product Requirements" and as described in the following paragraphs.
- B. Acceptance at Site:
 - 1. General: Comply with manufacturer's instructions for unloading, storage, and handling at Project site.
 - 2. Delivery and Handling:
 - a. Do not deliver piping materials to project site prior to Engineer's review of required submittals.
 - b. Unload and handle piping materials using proper material handling equipment. Use heavy canvas or nylon slings to lift pipe and fittings to protect coatings.
 - c. Do not drop, roll, or skid piping materials.
 - d. Take such additional precautions as necessary to avoid damaging piping materials and coatings thereon.
- C. Storage and Protection:
 - 1. Store piping materials in a manner that will reduce risk of interior and exterior damage.
 - 2. Block piping materials to prevent rolling.
 - 3. Protect materials from weather and sun as recommended by the manufacturer.
 - 4. Provide factory-applied plastic end-caps on each length of pipe and tube, except for concrete, corrugated metal, hub-and-spigot, and clay pipe. Maintain end-caps through shipping, storage and handling to prevent pipe-end damage and prevent entrance of dirt, debris, and moisture.
 - 5. Protect stored pipes and tubes. Elevate above grade and enclose with durable, waterproof wrapping. When stored inside, do not exceed structural capacity of the floor.
 - 6. Protect flanges, fittings, and specialties from moisture and dirt by inside storage and enclosure, or by packaging with durable, waterproof wrapping. Attach protectors over entire gasketed surface of flanges.

7. Flexible piping shall be stored in shaded area prior to installation.

1.8 PROJECT CONDITIONS

- A. Field Measurements: Verify actual dimensions of openings, construction contiguous with work, and related items by field measurements before fabrication.
- B. Flange Coordination: Coordinate the dimensions, hole drillings and type of flange face (flat or raised) of the flanges furnished with companion flanges of valves, pumps, and equipment to be connected to or installed in the piping.
- C. NSF Certified: All surfaces and materials in contact with water or sludge shall comply with the requirements of the Safe Drinking Water Act and shall conform to NSF-61. Product shall bear the mark or seal of an accredited testing laboratory.

1.9 COORDINATION

- A. Coordinate installation of required supporting devices and set sleeves in cast-in-place concrete and other structural components as they are constructed.
- B. Coordinate installation of identifying devices after completing covering and painting if devices are applied to surfaces.
- C. Coordinate size and location of concrete bases. Formwork, reinforcement, and concrete requirements are specified in Division 03.
- D. Coordinate installation of piping systems with other trades; such as electrical, instrumentation, fire protection, and HVAC plumbing and ducts.

PART 2 - PRODUCTS

2.1 PIPING

- A. As specified in Section 40 06 00, and as shown on the Drawings.
- B. Diameters Shown:
 1. Standardized Products: Nominal Size.
 2. Fabricated Steel Piping (Except Cement-Lined): Outside diameter, ASME B36.10M.

2.2 PIPE JOINING MATERIALS

- A. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents and piping material.
 1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch maximum thickness, unless otherwise indicated.
 - a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
 - b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.
 2. AWWA C111, rubber, flat face, 1/8-inch thick, unless otherwise indicated; and full-face or ring type, unless otherwise indicated.
- B. Flange Bolts and Nuts:
 1. ASME B18.2.1, carbon steel, unless otherwise indicated.

2. Exposed: ASTM A307, Grade B, hex head bolts; ASTM A563, Grade A or B, hex head nut; and ASTM F436 hardened steel washers. Corten acceptable for mechanical joints.
 3. Buried: Corten or Type 316 stainless steel hex head nuts and washers of the same material as bolts.
 4. Submerged: Type 316 stainless steel bolts; Type 316, hex head nuts and washers of the same material as bolts.
- C. Segmented Mechanical Couplings: Provide when designated on the Drawings.
1. Housing: Ductile iron conforming to ASTM A-536, grade 65-45-12, with orange enamel coating.
 2. Coupling Gasket: Grade "E" EDPM.
 3. Bolts and Nuts: Stainless steel oval neck track bolts meeting the mechanical property requirements of ASTM F593, Group 2 (316 stainless steel), condition CW. Stainless steel heavy hex nuts meeting the mechanical property requirements of ASTM F594, Group 2 (316 stainless steel), condition CW, with galling reducing coating.
 4. Victaulic Style 77 standard flexible couplings or equivalent.
- D. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.
- E. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.
- F. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing, unless otherwise indicated; and AWS A5.8, BAg1, silver alloy for refrigerant piping, unless otherwise indicated.
- G. Welding Filler Metals: Comply with AWS D10.12/D10.12M for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.
- H. Solvent Cements for Joining Plastic Piping:
1. All solvent cements shall be NSF/ANSI 61 certified.
 2. Solvent cement shall be suitable for the intended application.
 - a. For chemical applications:
 - 1) Refer to Section 40 05 31.11 "Piping System, Chemical Feed".
 3. CPVC Piping: ASTM F 493.
 4. PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.
- I. Fiberglass Pipe Adhesive: As furnished or recommended by pipe manufacturer.

2.3 TRANSITION FITTINGS

- A. Transition Fittings, General: Same size as, and with pressure rating at least equal to and with ends compatible with, piping to be joined.
- B. Transition Couplings NPS 1-1/2 and Smaller:
1. Underground Piping: Manufactured piping coupling or specified piping system fitting.
 2. Aboveground Piping: Specified piping system fitting.
- C. AWWA Transition Couplings NPS 2 and Larger:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Cascade Waterworks Mfg. Co.
 - b. Dresser, Inc.; DMD Div.
 - c. Ford Meter Box Company, Inc. (The); Pipe Products Div.
 - d. JCM Industries.
 - e. Smith-Blair, Inc.
 - f. Viking Johnson.
 - g. ROMAC Industries, Inc.
 2. Description: AWWA C219, metal sleeve-type coupling for underground pressure piping.
- D. Plastic-to-Metal Transition Fittings:
1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Spears Manufacturing Co.
 2. Description: CPVC and PVC one-piece fitting with manufacturer's Schedule 80 equivalent dimensions; one end with threaded brass insert, and one solvent-cement-joint or threaded end.
- E. Plastic-to-Metal Transition Unions:
1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Colonial Engineering, Inc.
 - b. NIBCO INC.
 - c. Spears Manufacturing Co.
 2. Description: CPVC and PVC four-part union. Include brass or stainless-steel threaded end, solvent-cement-joint or threaded plastic end, rubber O-ring, and union nut.
- F. Flexible Transition Couplings for Underground Nonpressure Drainage Piping:
1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Cascade Waterworks Mfg. Co.
 - b. Fernco, Inc.
 - c. Mission Rubber Company.
 - d. Plastic Oddities.
 2. Description: ASTM C 1173 with elastomeric sleeve ends same size as piping to be joined, and corrosion-resistant metal band on each end.

2.4 INSULATING FLANGES, COUPLINGS AND UNIONS

- A. Dielectric Fittings, General: Assembly of copper alloy and ferrous materials or ferrous material body with separating nonconductive insulating material suitable for system fluid, pressure, and temperature.
- B. Dielectric Unions:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Capitol Manufacturing Co.
 - b. Central Plastics Company.
 - c. Epco Sales, Inc.
 - d. Hart Industries, International, Inc.
 - e. Watts Water Technologies, Inc.
 - f. Zurn Plumbing Products Group; Wilkins Div.
 2. Description: Factory fabricated, union, NPS 2 and smaller.
 - a. Pressure Rating: 150 psig minimum at 180 deg F unless otherwise specified.
 - b. End Connections: Solder-joint copper alloy and threaded ferrous; threaded ferrous.
- C. Dielectric Flanges:
1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Capitol Manufacturing Co.
 - b. Central Plastics Company.
 - c. Epco Sales, Inc.
 - d. Watts Water Technologies, Inc.
 2. Description: Factory-fabricated, bolted, companion-flange assembly, NPS 2-1/2 to NPS 4 and larger.
 - a. Pressure Rating: 150 psig minimum unless otherwise specified.
 - b. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.
- D. Dielectric-Flange Kits:
1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Advance Products & Systems, Inc.
 - b. Calpico, Inc.
 - c. Central Plastics Company.
 - d. Pipeline Seal and Insulator, Inc.
 2. Description: Non-conducting materials for field assembly of companion flanges, NPS 2-1/2 and larger.
 - a. Pressure Rating: 150 psig minimum unless otherwise specified.
 - b. Gasket: Neoprene or phenolic.
 - c. Bolt Sleeves: Phenolic or polyethylene.
 - d. Washers: Phenolic with steel backing washers.
- E. Dielectric Couplings:
1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Calpico, Inc.
 - b. Lochinvar Corporation.

2. Description: Galvanized-steel coupling with inert and noncorrosive, thermoplastic lining, NPS 3 and smaller.
 - a. Pressure Rating: 300 psig at 225 deg F unless otherwise specified.
 - b. End Connections: Threaded.
- F. Dielectric Nipples:
 1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Perfection Corporation.
 - b. Precision Plumbing Products, Inc.
 - c. Victaulic Company.
 2. Description: Electroplated steel nipple with inert and noncorrosive, thermoplastic lining.
 - a. Pressure Rating: 300 psig at 225 deg F unless otherwise specified.
 - b. End Connections: Threaded or grooved.

2.5 CONNECTORS AND COUPLINGS

- A. General: Unless otherwise specified;
 1. Carbon steel, Type 304 stainless steel bolts, fasteners, tie rods and accessories are required for connectors intended for buried service and Type 316 stainless steel for wetted or submerged service.
 2. Carbon steel bolts, fasteners, tie rods and accessories are required in exposed atmospheric service. Coat items in accordance with Division 9 Section 09 90 00 "Painting and Protective Coatings."
 3. Submerged couplings shall be stainless steel Type 316.
 4. Buried couplings may be epoxy coated steel or stainless steel Type 304 Depend-O-Lok.
- B. Elastomer Bellows Connector:
 1. Type: Fabricated spool, with single filled arch.
 2. Materials: Nitrile tube and neoprene cover.
 3. End Connections: Flange, 125-lb ANSI B16.1 standard, with elastomeric face and steel retaining rings.
 4. Working Pressure: 190 psig minimum, size 12-inch and smaller.
 5. Thrust Restraint: Manufacturer designed control rods, fasteners, and accessories to limit travel of elongation and compression.
 6. Manufacturers and Products:
 - a. Garlock; Style 204
 - b. Goodall rubber Co.
 - c. General Rubber Corp.
- C. Flexible Type Couplings (Steel and Stainless Steel Pipe):
 1. Design: Provide thrust ties across flexible couplings.
 2. Body and Middle ring: Carbon, Type 304, or Type 316.
 3. Followers: Ductile iron, malleable iron, Type 304, or Type 316.
 4. Bolts: Carbon steel, Type 304 or 316 stainless steel.
 5. Gaskets: EDPM

6. Materials of construction of coupling, closure plates, end rings, and fasteners to match piping materials on which coupling is employed, as well as whether it is exposed, wetted or submerged service. Carbon steel components to have factory-applied fusion bonded epoxy coating (7MDFT).
 7. Manufacturer and Product:
 - a. Dresser; Style 128
 - b. Smith-Blair; Style 912
- D. Split Sleeve Couplings (Steel and Stainless Steel Pipe):
1. Design: Double arch, with built-in thickened shoulders. Full joint restraint achieved for two times test pressure by weld-on end rings. Closure plates and sealing pad integral with coupling.
 2. Gaskets: EDPM O-ring style.
 3. Joint Deflection: Up to 2 degrees.
 4. Carbon steel metal components to have factory-applied fusion bonded epoxy coating (7 MDFT).
 5. Materials of construction of coupling, closure plates, end rings, and fasteners to match piping materials on which coupling is employed, as well as whether it is exposed, wetted or submerged service.
 6. Manufacturer and Product: Victaulic, Inc., Depend-O-Lok Model FxF, Type 2 Coupling, or equal.
- E. Flanged Coupling Adapters (FCA) (Ductile Iron and Steel Pipe):
1. Design: Provide thrust across flexible coupling adapters.
 2. Body: Carbon steel conforming to AWWA C207.
 3. Flange: AWWA C207 or ANSI Standards.
 4. Bolts: 316 stainless steel.
 5. Gaskets: EPDM.
 6. Carbon steel metal components to have factory-applied fusion bonded epoxy coating (7 MDFT).
 7. Materials of construction of coupling, closure plates, end rings, and fasteners to match piping materials on which coupling is employed, as well as whether it is exposed, wetted or submerged service.
 8. Manufacturer and Product:
 - a. Dresser; Style 128
 - b. Smith-Blair; Style 912
- F. Wedge Action Restraints (Ductile Iron and PVC Pipe):
1. Design: Wedges and wedge actuating components are incorporated into the design of the follower gland.
 2. Material: Ductile iron, ASTM A536, Grade 65-45-12; wedges BHN 370 minimum.
 3. Nuts: Designed with torque-limiting twist-off nuts, exposing a bolt head sized to permit adjustment and removal of joint restraint.
 4. Chemical and nodularity test shall be performed as recommended by Ductile Iron Society on a per ladle basis.
 5. Traceability: Provide material traceability records.
 6. Coating:
 - a. Wedge Assembly: Two coats of liquid Xylan fluoropolymer, heat cured.

- b. Casting Body: Polyester based powder, electrostatically applied and heat cured, providing corrosion, impact and UV protection.
 - 7. Approvals:
 - a. Ductile Iron Pipe Restraints:
 - 1) Underwriters Laboratories: Size 3-inch through 24-inch.
 - 2) Factory Mutual: Size 3-inch through 12-inch.
 - b. PVC Pipe Restraints:
 - 1) Underwriters Laboratories: Size 4-inch through 12-inch.
 - 2) Factory Mutual: Size 4-inch through 12-inch.
 - 3) Size 4-inch through 24-inch comply with ASTM F1674.
 - 8. Manufacturer and Product:
 - a. Ductile Iron Pipe:
 - 1) EBAA Iron Megalug 1100 series.
 - 2) ROMAC Industries, Inc RFCA.
 - b. PVC Pipe:
 - 1) EBAA Iron Megalug 2000 PVC series.
 - 2) ROMAC Industries, Inc RFCA-PVC.
- G. Dismantling Joint (Steel Pipe):
 - 1. Design: Double ended flange adapter, allowing longitudinal adjustment in piping alignment.
 - 2. Body: ASTM A36.
 - 3. Flange: ends compatible with piping to be joined.
 - 4. Bolts: 316 stainless steel.
 - 5. Tie rods: 316 stainless steel.
 - 6. Gaskets: EPDM, NBR.
 - 7. Manufacturer and Product:
 - a. Romac.
 - b. Approved equal.

2.6 PIPE SLEEVES

- A. Mechanical sleeve seals for pipe penetrations:
 - 1. Pipe to wall/casing penetration closures shall be modular mechanical type, consisting of interlocking synthetic rubber links shaped to continuously fill the annular space between pipe or conduit and wall/casing opening. Once expanded, the mechanical seal shall provide a watertight seal.
 - 2. Elastomeric element size and material shall be selected per manufacturer recommendations. Assemble with ASTM A276, Type 316 stainless steel bolts and nuts.
 - 3. Pressure end plates shall be either Type 316 stainless steel or manufactured of glass reinforced plastic, with a minimum tensile strength of 27,000 psi.
 - 4. Sized: According to manufacturer's recommendations for the size of pipe shown; to provide a watertight seal between pipe and wall sleeve opening.
 - 5. Available Manufacturers:
 - a. Pipeline Seal & Insulator, Inc. (Link-Seal)
- B. Galvanized-Steel Sheet Sleeves: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.
- C. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized, plain ends.

- D. Cast-Iron Sleeves: Cast or fabricated "wall pipe" equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.
- E. Molded PVC Sleeves: Permanent, with nailing flange for attaching to wooden forms.
- F. PVC Pipe Sleeves: ASTM D 1785, Schedule 40.
- G. Molded PE Sleeves: Reusable, PE, tapered-cup shaped and smooth outer surface with nailing flange for attaching to wooden forms.
- H. Insulated and Encased Pipe Sleeve: Conforming to Pipe Shields, Inc.; Models WFB, WFB-CS and –CW Series, as applicable.
- I. Seepage Ring: Provide a seepage ring in middle of wall sleeve as follows:
 - 1. 1/4-inch minimum thickness, centered between sleeve ends for water stoppage on sleeves located in exterior or water bearing walls.
 - 2. Outside Diameter: 2 inches greater than pipe sleeve outside diameter.
 - 3. Continuously fillet weld on each side all around.

2.7 EXPANSION JOINTS

- A. Elastomer Bellows:
 - 1. Type: Reinforced, molded wide-arch.
 - 2. End connections: Flanged, 125-lb ANSI B1.1 standard, with Type 304 stainless steel retaining rings.
 - 3. Washers: Over the retaining rings to provide a leak proof joint under test pressure.
 - 4. Thrust Protection: Manufacturer designed and supplied control rods, fasteners, and accessories to protect bellows from overextension at test pressures.
 - 5. Tube and Bellows Arch Lining: EDPM.
 - 6. Rated Temperature: 250°F.
 - 7. Rated Deflection and Pressure:
 - a. Lateral Deflection: 3/4-inch minimum.
 - b. Burst Pressure: four times rated pressure.
 - c. Compression Deflection at Minimum Pressure: 1/2-inch at 250 psig.
 - 8. Manufacturer and Product:
 - a. Holz Rubber Company, Inc.
 - b. Mercer Rubber Co.; Series 500
 - c. General Rubber Corp.
 - d. Goodall.

2.8 LININGS AND COATINGS

- A. Interior Pipe Linings: Prepare, prime, and finish pipe interior in accordance the applicable piping system Division 40 Sections and Division 09 Section 09 90 00 "Painting and Protective Coatings."
- B. Exterior coatings: Prepare, prime, and finish pipe exterior in accordance the applicable piping system Divisions 40 Sections and Division 09 Section 09 90 00 "Painting and Protective Coatings."

2.9 IDENTIFICATION

- A. Provide piping, valve, equipment, and related product identification devices in accordance with Division 10 Section 10 90 00 "Identification, Stenciling, and Tagging."

2.10 HANGERS AND SUPPORTS

- A. Provide hangers and supports as shown on the drawings and in accordance with Division 40 Section 40 05 07 "Hangers and Supports for Process Piping."

2.11 FIRESTOPPING

- A. Voids between sleeves or core-drilled openings and pipe or conduit passing through fire rated assemblies shall be fire stopped to comply with requirements of ASTM E 814.

PART 3 - EXECUTION

3.1 PIPED UTILITY DEMOLITION

- A. Refer to Division 01 Section 01 73 29 "Cutting and Patching" and Division 2 Sections 02 41 00 "Demolition" and Section 02 41 13 "Selective Demolition" for general demolition requirements and procedures.
- B. Disconnect, demolish, and remove piped utility systems, equipment, and components indicated to be removed.
 - 1. Piping to Be Removed: Remove portion of piping indicated to be removed and cap or plug remaining piping with same or compatible piping material (unless otherwise shown on Drawings).
 - 2. Piping to Be Abandoned in Place: Drain piping. Fill abandoned piping with flowable fill, and cap or plug piping with same or compatible piping material (unless otherwise shown on Drawings).
 - 3. Equipment to Be Removed: Disconnect and cap services and remove equipment.
 - 4. Equipment to Be Removed and Reinstalled: Disconnect and cap services and remove, clean, and store equipment; when appropriate, reinstall, reconnect, and make operational.
 - 5. Equipment to Be Removed and Salvaged: Disconnect and cap services and remove equipment and deliver to the Owner.
- C. If pipe, insulation, or equipment to remain is damaged in appearance or is unserviceable, remove damaged or unserviceable portions and replace with new products of equal capacity and quality.

3.2 GENERAL INSTALLATION REQUIREMENTS

- A. Contractor shall be responsible for, develop, and comply with the trench safety plan and a confined space entry plan in accordance with Division 31.
- B. Contractor shall provide a dewatering system of sufficient scope, size, and capacity to control hydrostatic pressures and to lower, control, remove, and dispose of ground water and permit excavation and construction to proceed on dry, stable subgrades complying with the requirements of Section 31 23 19 "Dewatering."

- C. Excavation, trenching and backfilling of trenches for buried utilities shall comply with the requirements of Section 31 23 00 "Excavation, Trenching, and Backfilling for Utilities."
- D. Install all piping systems in accordance with the Drawings, Specifications, reviewed shop drawings and manufacturer's installation instructions. Pipe and fitting materials shall comply with the individual Division 40 piping system sections.
- E. Examine all piping materials prior to installation and replace items that are damaged or otherwise defective.
- F. Thoroughly clean inside of all piping, valves, and accessories, and outside of all materials which will be exposed. Clean before installation and maintain in that condition until accepted by the Owner.
- G. Provide secure temporary caps or plugs over all pipe openings at the end of each day to prevent foreign material from entering the piping systems. Brace pipe to prevent it from floating.
- H. Do not modify structures, equipment, or piping for the purpose of installing piping unless specifically authorized by the Engineer.
- I. All piping systems shall be cleaned and tested prior to making connections at structures and to existing pipe systems. Small diameter pipes shall be flushed, and large diameter pipes shall have mandrels pulled or other acceptable verification furnished that pipes are clean and no construction debris remains. Temporary blocking and forms used to grout inverts and blockouts shall be removed and manholes and pipes shall be tested before payment will be approved for the last 10 percent of the respective pipe pay estimate items.

3.3 PIPING FLEXIBILITY PROVISIONS

- A. General: Install flexible couplings to facilitate installation of piping, connections to equipment and pumping units, and to permit disassembly of valve, instrumentation components in accordance with approved Shop Drawings.
- B. Flexible Joints at Concrete Backfill or Encasement: Install within 18 inches from the termination of any concrete backfill or encasement.
- C. Flexible Joints at Concrete Structures:
 - 1. Install 18 inches or less from the face of structure; joint may be flush with face.
 - 2. Install a second flexible joint, whether shown or not:
 - a. Pipe Diameter 18 Inches and Smaller: Within 18 inches of the first flexible joint.
 - b. Pipe Diameter Larger than 18 Inches: Within one pipe diameter of the first flexible joint.

3.4 DIELECTRIC FITTING APPLICATIONS

- A. Dry Piping Systems: Connect piping of dissimilar metals with the following:
 - 1. NPS 2 and Smaller: Dielectric unions.
 - 2. NPS 2-1/2 to NPS 12: Dielectric flanges or dielectric flange kits.
- B. Wet Piping Systems: Connect piping of dissimilar metals with the following:
 - 1. NPS 2 and Smaller: Dielectric couplings.
 - 2. NPS 2-1/2 to NPS 4: Dielectric nipples.
 - 3. NPS 2-1/2 to NPS 8: Dielectric nipples or dielectric flange kits.

4. NPS 10 and NPS 12: Dielectric flange kits.

3.5 PIPING INSTALLATION

- A. Install piping according to the following requirements and Division 40 Sections specifying piping systems.
- B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on the Coordination Drawings.
- C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise in the Drawings.
- D. Install piping to permit valve servicing.
- E. Install piping at indicated slopes.
- F. Install piping free of sags and bends.
- G. Install fittings for changes in direction and branch connections.
- H. Select system components with pressure rating equal to or greater than system operating pressure.
- I. Sleeves are not required for core-drilled holes.
- J. Permanent sleeves are not required for holes formed by removable PE sleeves.
- K. Penetrations: Install sleeves for pipes passing through concrete and masonry walls and concrete floor and roof slabs.
 - 1. Cut sleeves to length for mounting flush with both surfaces.
 - a. Exception: Extend sleeves installed in floors of equipment areas or other wet areas 2 inches above finished floor level.
 - 2. Install sleeves in new walls and slabs as new walls and slabs are constructed.
 - a. Steel Pipe Sleeves: For pipes smaller than NPS 6.
 - b. Steel Sheet Sleeves: For pipes NPS 6 and larger, penetrating gypsum-board partitions.
 - 3. Watertight Penetrations:
 - a. Provide wall pipes with thrust collars.
 - b. Provide taps for stud bolts in flanges set flush with wall face.
 - 4. Non-Watertight Penetrations:
 - a. Pipe sleeves with seep ring or modular mechanical seal.
 - b. Sleeves are not required for core-drilled openings.
 - 5. Existing Walls: Core-drilled openings and use modular mechanical seal.
 - 6. Caulk all sleeves water and air tight. Seal annular space between pipe and sleeve with fire stopping compound.
- L. Verify final equipment locations for roughing-in.
- M. Refer to equipment specifications in other Sections for roughing-in requirements.

- N. Isolation Valves: Provide piping systems with line size shutoff valves located at risers, at main branch connections to mains for all equipment, and at other locations as indicated and required.
- O. Vent and Drain Valves:
 - 1. Pipe 2-1/2-Inch Diameter and Larger: 3/4-inch vent, 1-inch drain, unless otherwise shown in the Drawings.
 - 2. Pipe 2-inch and Smaller: 1/2-inch vent. 3/4-inch drain, unless otherwise shown.
 - 3. Install vent and drain valves at low points (drains) and high point (vents) of piping systems so that these systems can be entirely drained and vented. Provide line size ball valves for all vents and drains.
- P. Gravity drain systems beneath slabs shall be ductile iron, except for chemical drains, unless shown specifically on Plans. Encase all piping beneath slabs.
- Q. Install cleanouts on sludge piping so that all runs between bends may be accessed and at intervals not exceeding 250 feet on straight runs.
- R. All bolts and fasteners on buried fittings and valves shall be Corten, carbon steel, or Type 304 stainless steel. All bolts and fasteners on submerged fittings and valves shall be Type 316 stainless steel.
- S. Provide taps and connections for flushing, testing, and disinfecting pipeline systems.
- T. Provide taps or weld-o-lets with stainless steel ball valves and piping at all high points in the piping systems for addition of air valves.

3.6 PIPING JOINT CONSTRUCTION

- A. General:
 - 1. Join pipe and fittings according to the following requirements and Division 40 Sections specifying piping systems.
 - 2. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
 - 3. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- B. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
 - 1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
 - 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
- C. Welded Joints: Construct joints according to AWS D10.12, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.
- D. Push-on Joints:
 - 1. Comply with the recommendations of the pipe manufacturer relative to gasket installation and other jointing operations.
 - 2. Prepare pipe ends by removing from bell and spigot ends all lumps, blisters, excess coal-tar coatings, oil and grease, then wire brush and wipe clean and dry before laying pipe.

3. Install ring gasket and, when seated, apply thin film of lubricant to inside surface of gasket.
 4. Set spigot, applying lubricant as necessary, aligning with bell and contacting gasket.
 5. Pipe 6 inches and smaller may be driven with a bar lever on end of pipe.
 6. For larger pipe, use only approved ratchet-type jacking tool to pull pipe "home."
- E. Flanged Joints:
1. Prior to installation of bolts, accurately center and align flanged joints to prevent mechanical prestressing of flanges, pipe, and equipment. Align bolt holes to straddle the vertical, horizontal, or north-south center line. Do not exceed 3/64-inch per foot of inclination of the flange face from true alignment.
 2. Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned.
 3. Use bolts, nuts, and washers of the designated material for service conditions. Tighten bolts progressively to prevent unbalance stress. Draw bolts tight to ensure proper seating of gaskets. Use suitable lubricants on bolt threads.
- F. Mechanical Joints:
1. Assemble in accordance with manufacturer's instructions. Remove all foreign matter from pipe ends, gaskets, and fittings before installation.
 2. Wash ends of pipe, gaskets, and fittings with soapy water before assembly.
 3. If effective sealing is not obtained, disassemble joint and clean and reassemble. Over tightening bolts to compensate for poor installation practice will not be permitted.
 4. Mechanical joints shall be suitably restrained to prevent movement.
- G. Mechanical Couplings, Rigid:
1. Install per manufacturer's instructions. Pipe ends shall be clean and smooth.
 2. Space between pipe ends shall be at least 1/4-inch, but not more than 1-inch.
- H. Flexible Couplings and Flanged Coupling Adapters:
1. Install per Drawings and in accordance with manufacturer's instructions at locations to facilitate removal of equipment, valves, and other elements.
 2. All flexible couplings and flanged couplings shall be restrained.
- I. Grooved Joints: Assemble joints with grooved-end pipe coupling with coupling housing, gasket, lubricant, and bolts according to coupling and fitting manufacturer's written instructions.
- J. Soldered Joints: Apply ASTM B 813 water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy (0.20 percent maximum lead content) complying with ASTM B 32.
- K. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.
- L. Pressure-Sealed Joints: Assemble joints for plain-end copper tube and mechanical pressure seal fitting with proprietary crimping tool according to fitting manufacturer's written instructions.
- M. Plastic Piping Solvent-Cemented Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:

1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
 2. CPVC Piping: Join according to ASTM D 2846.
 3. PVC Pressure Piping: Join schedule number ASTM D 1785, PVC pipe and PVC socket fittings according to ASTM D 2672. Join other-than-schedule-number PVC pipe and socket fittings according to ASTM D 2855.
 4. PVC Nonpressure Piping: Join according to ASTM D 2855.
- N. Plastic Pressure Piping Gasketed Joints: Join according to ASTM D 3139.
- O. Plastic Nonpressure Piping Gasketed Joints: Join according to ASTM D 3212.
- P. Plastic Piping Heat-Fusion Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join according to ASTM D 2657.
1. Plain-End PE Pipe and Fittings: Use butt fusion.
 2. Plain-End PE Pipe and Socket Fittings: Use socket fusion.
- Q. Bonded Joints: Prepare pipe ends and fittings, apply adhesive, and join according to pipe manufacturer's written instructions.

3.7 VALVES AND VALVE BOXES

- A. Prior to installing valves, remove foreign matter from within the valve. Inspect valves in the open and closed position to verify that all parts are in satisfactory working condition.
- B. Install valves, setting valves plumb, with operators aligned as shown on the Drawings. For buried valves, center valve boxes on valves. Carefully tamp earth around each valve box for a minimum of four feet or to the trench face if less than four feet.

3.8 SECURING AND SUPPORTING

- A. Exposed Piping Systems:
1. Engineered Hanger and Support System: The Contractor shall provide an engineered hanger and support system for the various piping systems in accordance with Division 40 Section 40 05 07 "Hangers and Supports for Process Piping"; as shown on the Drawings; and as specified herein to maintain the line and grade and prevent the transfer of stress to pumps, equipment and other related work.
 - a. This includes the design of multiple piping supports and trapeze hangers and the selection of appropriate hangers and anchors to the structures, buildings, and facilities. This design shall be accomplished by a professional engineer licensed in the state of Colorado.
 2. Reaction Anchorage and Blocking: Install suitable reaction blocking, struts, anchors, clamps, joint harness, or other adequate means for preventing movement of pipe caused by unbalanced internal liquid pressure. Pressure can be expected at tees, elbows, Y-branches, and other bends, which are installed in piping subjected to internal hydrostatic heads in excess of 15-feet in exposed piping.
- B. Buried Piping Systems:
1. Reaction Anchorage and Blocking: Install suitable reaction blocking, struts, anchors, clamps, joint harness, or other adequate means for preventing movement of pipe caused by unbalanced internal liquid pressure. Pressure can be expected at unplugged

tees, Y-branches and bends deflecting 11-1/4 degrees or more, which are installed in piping subjected to internal hydrostatic heads in excess of 30-feet in buried piping.

2. Restrained Joints:

- a. Unless otherwise indicated on the Drawings, all joints and fittings shall be mechanically restrained.
- b. All fittings shall be restrained using restrained joint pipe and fittings for a sufficient length to resist the internal hydrostatic pressures.
- c. Restrained push-on pipe and fittings shall be capable of being deflected after assembly.
- d. The design for restrained joints, including the length necessary to resist the design thrust and the approval of the fill material and compaction method, shall be performed and sealed by a professional engineer licensed in the state of Colorado.
- e. The above applies to unsaturated soil conditions. In locations where ground water is encountered, the soil density shall be reduced to its buoyant weight for all backfill below the water table and the coefficient of friction shall be reduced to 0.25.
- f. Bends and Appurtenances:
 - 1) Provide restraints at all bends.
 - 2) Horizontal changes in pipe direction may be accomplished without the use of direction-changing fittings. Controlled horizontal longitudinal bending using deflected joints may be used and shall not exceed 50 percent of the manufacturer's written recommendations.
 - 3) Vertical changes in pipe direction may be accomplished without the use of directional-changing fittings which require vertical thrust blocking and/or joint restraint. Controlled vertical longitudinal bending shall be accomplished using deflected joints, resulting in a circular pipe arc where joints do not require restraint. Joint deflections shall not exceed 50 percent of the manufacturer's written recommendations.
 - 4) Valves, hydrants, and fittings shall be supported by a concrete block or concrete cradle. The weight of these items shall not be supported by the pipe.

3. Concrete Thrust Blocking:

- a. Concrete thrust blocking is not acceptable unless shown on Drawings.

3.9 CORROSION PROTECTION

- A. Xylan Coating: not used.

3.10 PIPING CONNECTIONS

- A. Make connections according to the following, unless otherwise indicated:
 1. Install unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment.
 2. Install flanges, in piping NPS 2-1/2 and larger, adjacent to flanged valves and at final connection to each piece of equipment.
 3. Install dielectric fittings at connections of dissimilar metal pipes.

- B. Connections with Existing Piping:
 - 1. Field verify all dimensions, sizes, configuration and related items on all existing piping to which connections are to be made.
 - 2. Connections between new work and existing piping shall utilize suitable fittings for the conditions encountered.
 - 3. Each connection with an existing pipe shall be made one at a time under conditions which will least interfere with service to the Owner or to customers, and as authorized by the Owner. Provide notification 48 hours in advance prior to making connections.
- C. Pipe Connections:
 - 1. Piping connections shall be of the type indicated on the Drawings or in the Piping Schedule.
 - 2. Field-welded joints will be permitted only when indicated on the Drawings and will require approval by the Engineer.
 - 3. Field-welded joints will only be permitted at locations where the interior coatings can be repaired and inspected.
 - 4. Additional flanged, compression sleeve or grooved end couplings may be added by the Contractor to facilitate fabrication, handling, transportation, and field assembly at no additional cost.

3.11 EQUIPMENT INSTALLATION

- A. Install equipment level and plumb, unless otherwise indicated.
- B. Install equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference with other installations. Extend grease fittings to an accessible location.
- C. Install equipment to allow right of way to piping systems installed at required slope.

3.12 PAINTING

- A. Painting of piped systems, valves, specials, hangers and supports, equipment, and components shall be as specified in Section 09 90 00 "Painting and Protective Coatings."
- B. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

3.13 IDENTIFICATION

- A. Piping Systems: Install pipe and valve markers, including arrows showing normal direction of flow in accordance with Section 10 90 00 "Identification, Stenciling, and Tagging."
 - 1. Plastic markers, with application systems. Install on insulation segment if required for hot non-insulated piping.
 - 2. Locate pipe markers on exposed piping according to the following:
 - a. Near each valve and control device.
 - b. Near each branch, excluding short takeoffs for equipment and terminal units. Mark each pipe at branch if flow pattern is not obvious.
 - c. Near locations where pipes pass through walls or floors or enter inaccessible enclosures.
 - d. At manholes and similar access points that permit view of concealed piping.
 - e. Near major equipment items and other points of origination and termination.

- B. Buried Piping System Identification:
 - 1. Buried water piping systems shall have marking tape installed approximately 12 inches above the pipe in accordance with Division 31 Section 31 23 00 "Excavation, Trenching, and Backfilling for Utilities."
 - 2. Install detectable warning tape above non-metallic pipelines.

3.14 ERECTION OF METAL SUPPORTS AND ANCHORAGES

- A. Refer to Section 40 05 07 "Hangers and Supports for Process Piping" for information on the installation of the engineered hangers and supports for piping systems.

3.15 CONNECTIONS TO EQUIPMENT FURNISHED BY OTHERS

- A. Provide service connections to equipment furnished by others, utilizing equipment shop drawings furnished for indicating type, number, and location of connecting points. As part of the work, field adjustments as to the type, number, and location may be required. This is considered part of the Work.
 - 1. Roughing-In: Extend service connections to various items of equipment. Temporarily terminate at proper points as indicated on the shop drawings furnished or as directed.
 - 2. Final Connections: Provide items, such as pipe, fittings, adapters, valves, insulation, and other materials, required to connect equipment from the rough-in locations.
 - 3. Valves: Provide cut-off valve for each service at rough-in locations, except drains.

3.16 CLEANING OF PIPING SYSTEMS

- A. Clean piping systems thoroughly. Purge pipe of construction debris and contamination before placing the system in service. Provide temporary connections required for cleaning, purging and circulation.
- B. Install temporary strainers in front of pumps, tanks, solenoid valves, control valves, and other equipment where permanent strainers are not indicated. Keep these strainers in service until the equipment has been tested, then remove either entire strainer or straining element only. Fit strainers with line size blow off valve.

3.17 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Tests and Inspections:
 - 1. Lined carbon steel pipe and fittings shall be inspected by the Contractor after installation to ensure linings are intact in accordance with the piping system section and shall certify to that effect.
 - a. Pipe 24 Inches and Smaller: Engage an inspection organization to video inspect pipe and report findings.
 - b. Pipe 24 Inches and Larger: Engage an inspection organization to video inspect pipe and report findings.
 - 2. Pressure test piping systems in accordance with Division 40 Section 40 08 00 "Field Testing of Process Interconnections."
 - 3. Additional field-testing shall be as described in the individual piping systems sections of Division 40.

- C. The piping system component(s) will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.

3.18 PIPE SCHEDULE

- A. Refer to Section 40 06 00.

END OF SECTION

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SECTION 40 05 06
COUPLINGS, ADAPTERS, AND SPECIALS FOR PROCESS PIPING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Wall and Floor Pipe Sleeves.
 - 2. Flanged Coupling Adapters.
 - 3. Restrained Flanged Coupling Adapters (RFCA).
 - 4. Dismantling Joints.
 - 5. Expansion Joints (Rubber and PTFE).
 - 6. Service Saddles.
 - 7. Dielectric Connections.
 - 8. Dielectric Hardware Kits.
- B. Related Sections:
 - 1. Section 09 96 56 - Epoxy Coatings.
 - 2. Section 33 01 10.58 - Disinfection of Potable Water Piping and Tanks.
 - 3. Section 40 05 07 - Hangers and Supports for Process Piping.
 - 4. Section 40 05 19 - Ductile Iron Process Pipe.
 - 5. Section 40 05 23 - Stainless Steel Process Pipe and Tubing.
 - 6. Section 40 05 24 - Steel Process Pipe.
 - 7. Section 40 05 31 - Thermoplastic Process Pipe.

1.2 DEFINITIONS

- A. Process Piping Systems: Includes all piping, fittings, valves, specials, hangers and supports, and related items required for a complete process piping system.
- B. Ferrous Metal: Iron, steel, stainless steel, and alloys with iron as principal component.
- C. Nonferrous Metals: Copper.
- D. Nonmetallic: PVC, CPVC, PE, HDPE, and FRP.
- E. Wetted or Submerged Piping Systems:
 - 1. Submerged, or less than 1 foot above the maximum liquid surface of water holding structures.
 - 2. Below top of channels, under cover of slabs of channels or tanks.
 - 3. In other damp or covered locations (e.g., vaults, wetwells, utility corridors, etc.)
- F. Exposed or Atmospherically Exposed Piping Systems: All piping systems exposed to the atmosphere (not buried, submerged, wetted, or embedded). This designation includes insulated piping inside chases or piping hidden from view.

1.3 REFERENCES

- A. American National Standards Institute (ANSI):
 - 1. ANSI B16.5 - Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24, Metric/Inch Standard.
 - 2. ANSI B16.39 - Malleable Iron Threaded Pipe Unions.
 - 3. ANSI B31 - Standards of Pressure Piping.
- B. American Society of Testing and Materials (ASTM):
 - 1. ASTM A53/A53M - Specification for Pipe, Steel, Black and Hot-dipped, Zinc-Coated, Welded and Seamless.
 - 2. ASTM A105/A105M - Specification for Carbon Steel Forgings and Piping Applications.
 - 3. ASTM B169/B169M - Specification for Aluminum Bronze Sheet, Strip, and Rolled Bar.
 - 4. ASTM B650 - Specification for Electro-Deposited Engineering Chromium Coatings of Ferrous Substrates.
 - 5. ASTM C1173 - Standard Specification for Flexible Transition Couplings for Underground Piping Systems.
 - 6. ASTM D5926 - Standard Specifications for Poly (Vinyl Chloride) (PVC) Gaskets for Drain, Waste, and Vent (DWV), Sewer, Sanitary, and Storm Plumbing Systems.
 - 7. ASTM F593, Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
- C. National Sanitary Foundation (NSF):
 - 1. NSF 61 - Drinking Water System Components, Health Effects.

1.4 COORDINATION

- A. Coordinate Work of this Section with installation of process piping.
- B. Coordinate installation of required supporting appurtenances including pipe sleeves in concrete penetration applications and other structural components as they are constructed.
- C. Coordinate installation of piping systems with other trades including but not limited to Plumbing, Fire Protection, HVAC, Electrical, and Controls.
- D. Coordinate installation of identifying devices after completing covering and painting if devices are applied to surfaces.

1.5 SUBMITTALS

- A. Per Section 01 33 00 - Submittal Procedures.
- B. Product Data:
 - 1. Submit manufacturer's descriptive literature and product specifications for each product provided. At minimum product data to Indicate:
 - a. Pressure ratings, movements, spring rates, bolt patterns, flange types, and gasket material selection.
 - b. Provide manufacturer's catalog information with dimensions, material, and assembled weight.

- C. Manufacturer's Certificates:
 - 1. Certify that products meet or exceed specified requirements.
 - 2. Submit manufacturer's certificate of NSF 61 compliance for all components in direct contact with potable water.
- D. Delegated Design Submittals:
 - 1. Submit Shop Drawings and design calculations for Owner/Engineer approval.
 - 2. Shop Drawings to Indicate general arrangement including dimensions, special fittings and bends, weights, and all other pertinent fabrication information.
- E. Manufacturer's Instructions: Submit product installation instructions including bolting torque specs assembly patterns.
- F. Source Quality-Control Submittals: Indicate results of factory inspections and tests.
- G. Field Quality-Control Submittals: Indicate results of Contractor furnished inspections and tests.

1.6 CLOSEOUT SUBMITTALS

- A. Per Section 01 70 00 - Execution and Closeout Requirements.
- B. Provide final executed warranty information including terms and conditions with warranty period and start date clearly indicated.
- C. Project Record Documents:
 - 1. Maintain accurate and up-to-date record documents showing Contract and Shop Drawing modifications. Record documents shall show actual location of all piping and appurtenances on a copy of the Contract Drawings.
 - 2. Record documents shall show piping with elevations referenced to the project datum and dimensions from permanent structures. For straight runs of pipe provide offset dimensions as required to document pipe location.

1.7 QUALITY ASSURANCE

- A. Materials in Contact with Potable Water: Certified according to NSF 61.
- B. Same Manufacturer to provide all like components including pipe, fittings, and flanges.

1.8 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing products specified in this Section with minimum three years' documented experience.

1.9 DELIVERY, STORAGE, AND HANDLING

- A. Per Section 01 60 00 - Product Requirements.
- B. Inspection: Accept materials on Site in manufacturer's original packaging and inspect for damage.
- C. Store materials according to manufacturer instructions.
- D. Protection:
 - 1. Protect materials from moisture and dust by storing in clean, dry location remote

from construction operations areas.

2. Furnish temporary end caps and closures on piping and fittings and maintain in place until installation.
3. Provide additional protection according to manufacturer instructions.

1.10 EXISTING CONDITIONS

A. Field Measurements:

1. Contractor shall verify actual dimensions of openings, adjacent facilities and equipment, utilities, and related items by field measurements before fabrication, as applicable.
2. Indicate field measurements on Shop Drawings.

1.11 WARRANTY

- ##### A.
- All products furnished and installed under this section shall be warranted in accordance with the requirements of Section 01 78 36 - Warranties.

PART 2 - PRODUCTS

2.1 PIPE PENETRATION SLEEVES:

- ##### A.
- Unless otherwise specified, provide wall penetration sleeves designed for use with modular mechanical seals to provide a corrosion-resistant sealing surface for pipes penetrating floors, walls, foundation, or any other concrete barrier as indicated on the Contract Drawings.
- ##### B. Material:
1. Type 304L stainless steel.
 2. Type 316L stainless steel.
 3. Textured HDPE.
- ##### C. Seepage Ring: Provide a seepage ring in middle of pipe sleeve as follows:
1. Continuously fillet welded on each side all around or integrally molded.
 2. Size Seepage Ring as follows:
 - a. Sleeve nominal diameter 12 inch and smaller:
 - 1) Pipe outside diameter plus 4 inches.
 - 2) Collar thickness: 1/2 inch.
 - b. Sleeve nominal diameter 14 inch through 18 inch:
 - 1) Pipe outside diameter plus 4 inches.
 - 2) Collar thickness: 3/4 inch.
 - c. Sleeve nominal diameter 20 inch and 24 inch:
 - 1) Pipe outside diameter plus 6 inches.
 - 2) Collar thickness: 3/4 inch.
 - d. Sleeve nominal diameter 26 inch through 42 inch:
 - 1) Pipe outside diameter plus 8 inches.
 - 2) Collar thickness: 1 inch.

2.2 MECHANICAL SLEEVE SEALS:

- A. Provide modular, mechanical type seal for use with all pipe penetration sleeves. Seal to consist of interlocking synthetic rubber links shaped to continuously fill the annular space between pipe or conduit and sleeve. Once expanded, the mechanical seal shall provide a watertight seal.
- B. Manufacturers:
 - 1. Flexicraft Industries.
 - 2. GPT by EnPro Industries.
- C. Sized: According to manufacturer's recommendations for the size of pipe shown; to provide a watertight seal between pipe and wall sleeve opening.
- D. Elastomeric element size and material shall be selected per manufacturer recommendations based on individual service conditions. Assemble with ASTM A276, Type 316 stainless steel bolts and nuts.
- E. Pressure end plates shall be either Type 316 stainless steel or glass reinforced plastic, with a minimum tensile strength of 27,000 psi.

2.3 FLANGE COUPLING ADAPTER - SLEEVE TYPE:

- A. Application: Connecting plain end ductile iron, carbon steel, or stainless-steel pipe to flanged pipe fitting, valve, instrument, or equipment item where misalignment, future maintenance, or constructability constraints exist, and restraint is not required.
- B. Manufacturers:
 - 1. Dresser Piping Specialties, Dresser Inc.
 - 2. Romac.
 - 3. Smith Blair, Inc.
- C. Pressure and service: Equal to or greater than connected equipment and piping.
- D. Material: Ductile Iron per A536.
- E. Flange Drilling: Per ANSI B16.5, Class 150.
- F. Gaskets: EPDM.
- G. Bolts and Nuts:
 - 1. ASME B18.2.1, carbon steel, unless otherwise indicated.
 - 2. ASTM A307, Grade B, hex head bolts; ASTM A563, Grade A or B, hex head nut; and ASTM F436 hardened steel washers. Corten is acceptable for mechanical joints.
 - 3. Submerged applications: Type 316 stainless steel bolts; Type 316, hex head nuts and washers of the same material as bolts.
- H. Harnessing:
 - 1. Harness couplings to restrain pressure piping. For pipelines that will be under pressure, test pressures are specified in piping schedules in Section 40 06 00.
 - 2. Tie adjacent flanges with bolts of corrosion-resistant alloy steel. Provide flange-mounted stretcher bolt plates to be designed by manufacturer, unless otherwise approved. For buried or submerged applications, provide external bolting and other

hardware of Type 316 stainless steel, including tie bolts, bolt plates, lugs, nuts, and washers.

3. Conform to dimensions, size, spacing, and materials for lugs, bolts, washers, and nuts as recommended by manufacturer and approved by Engineer for pipe size, wall thickness, and test pressure required. Provide minimum 5/8-inch diameter bolts.

2.4 FLANGE COUPLING ADAPTER - SET SCREW TYPE:

- A. Application: Connecting plain end ductile iron to flanged pipe fitting, valve, instrument, or equipment item where prefabricated pipe spool is not available or practical.
- B. Obtain Engineer approval prior to use.
- C. Manufacturers:
 1. EBAA Iron Inc.
 2. Or Engineer approved equal.
- D. Pressure and service: Equal to or greater than connected equipment and piping.
- E. Material: Ductile Iron per A536.
- F. Flange: ANSI B16.1, Class 125.
- G. Set Screws: Rockwell hardness of C40-45 converted from Brinnell.

2.5 RESTRAINED FLANGE COUPLING ADAPTER:

- A. Application: Connecting plain end ductile iron, carbon steel, or stainless-steel pipe to flanged pipe fitting, valve, instrument, or equipment item where misalignment, future maintenance or constructability requires, and restraint is required.
- B. Manufacturers:
 1. Romac Industries, Inc.
 2. Or Engineer approved equal.
- C. Pressure and service: Equal to or greater than connected equipment and piping.
- D. Material: Ductile Iron per A536.
- E. Flange Drilling: Per ANSI B16.5, Class 150.
- F. Gasket: EPDM.
- G. Bolts and nuts:
 1. ASME B18.2.1, carbon steel, unless otherwise indicated.
 2. ASTM A307, Grade B, hex head bolts; ASTM A563, Grade A or B, hex head nut; and ASTM F436 hardened steel washers. Corten is acceptable for mechanical joints.
 3. Submerged applications: Type 316 stainless steel bolts; Type 316, hex head nuts and washers of the same material as bolts.
- H. Harnessing:
 1. Harness adapters to restrain pressure piping.
 2. For flanged adapters 12-inch diameter and smaller, provide 1/2-inch diameter (minimum) Type 316 stainless steel anchor studs installed in pressure-tight anchor

boss. For buried or submerged applications, provide external bolting and other hardware of Type 316 stainless steel, including tie bolts, bolt plates, lugs, nuts, and washers. Provide number of studs required to restrain test pressure and service conditions. Harness shall be as designed and recommended by flanged adapter manufacturer. Provide the following minimum anchor studs unless otherwise approved by Engineer.

- a. Six-inch Diameter and Smaller: 2.
 - b. Eight-inch Diameter and Smaller: 4.
 - c. Ten-inch Diameter and Smaller: 6.
 - d. Twelve-inch Diameter and Smaller: 8.
3. For adapters larger than 12-inch diameter, provide split-ring harness clamps with minimum of four corrosion-resistant alloy steel bolts. For buried or submerged applications, provide external bolting and other hardware of Type 316 stainless steel, including tie bolts, bolt plates, lugs, nuts, and washers. Harness assembly shall be as designed and recommended by flanged adapter manufacturer. Dimensions, sizes, spacing and materials shall be suitable for service and conditions encountered and shall be approved by Engineer.
 4. Harness couplings to restrain pressure piping. For pressure pipelines, test pressures are included in piping schedules in Section 40 06 00.

2.6 DISMANTLING JOINTS:

- A. Application: Connecting flanged ductile iron, carbon steel, or stainless-steel pipe to flanged pipe fitting, valve, instrument, or equipment item where misalignment, future maintenance, or constructability constraints exist.
- B. Manufacturers:
 1. Romac Industries, Inc.
 2. Or Engineer approved equal.
- C. Pressure and service: Equal to or greater than as connected equipment and piping.
- D. Material: Ductile Iron per A536.
- E. Flange Drilling: Per ANSI B16.5, Class 150.
- F. Gaskets: EPDM.
- G. Bolts and Nuts:
 1. ASME B18.2.1, carbon steel, unless otherwise indicated.
 2. ASTM A307, Grade B, hex head bolts; ASTM A563, Grade A or B, hex head nut; and ASTM F436 hardened steel washers. Corten is acceptable for mechanical joints.
 3. Submerged applications: Type 316 stainless steel bolts; Type 316, hex head nuts and washers of the same material as bolts.
- H. Harnessing:
 1. Harness couplings to restrain pressure piping. For pipelines that will be under pressure, test pressures are specified in piping schedules in Section 40 06 00.
 2. Tie adjacent flanges with bolts of corrosion-resistant alloy steel. Provide flange-mounted stretcher bolt plates to be designed by manufacturer, unless otherwise

approved. For buried or submerged applications, provide external bolting and other hardware of Type 316 stainless steel, including tie bolts, bolt plates, lugs, nuts, and washers.

3. Conform to dimensions, size, spacing, and materials for lugs, bolts, washers, and nuts as recommended by manufacturer and approved by Engineer for pipe size, wall thickness, and test pressure required. Provide minimum 5/8-inch diameter bolts.

2.7 EXPANSIONS JOINTS

A. Manufacturers:

1. Flexicraft Industries.
2. Garlock.
3. Mercer.
4. Proco.

~~B.~~ All expansion joints shall be provided with stainless steel limit/control rods in the quantity recommend by the manufacturer for the joint size and application.

C. Type I Expansion Joints:

1. Unless otherwise indicated Type I expansion joints shall be provided for lower 1/3 sidewall connections to polyethylene storage tanks.
2. Pressure and service: Equal to or greater than connected equipment and piping.
3. All wetted parts shall be PTFE.
4. Expansion joint to have a minimum of 3 convolutions and stainless-steel flanges. Galvanized parts will not be accepted.
5. Joint flanges shall be van-stone type with a drilling pattern per ASME B16.5 for Class 150 flat faced flanges.

D. Type II Expansion Joints:

1. Unless otherwise indicated Type II expansion joints shall be provided for all connections to centrifugal pumps.
2. Pressure and service: Equal to or greater than connected equipment and piping.
3. All wetted parts shall be EPDM.
4. Single wide-arch type with stainless steel flange retaining rings.
5. Flange Drilling: Per ANSI B16.5 for Class 150 flanges.

2.8 SERVICE SADDLES:

- A. Application: For the installation of tapped outlet connections in ductile iron or PVC process piping.
- B. Per AWWA C800.
- C. Manufacturers:
 1. Dresser Piping Specialties, Dresser Inc.
 2. Romac.
 3. Smith Blair, Inc.

- D. Pressure and service: Equal to or greater than as connected equipment and piping.
- E. Body:
 - 1. Ductile Iron per A536.
 - 2. Fusion bonded epoxy or nylon finish, minimum thickness 12 mils.
- F. Gaskets:
 - 1. EPDM.
 - 2. Gasket shall be securely glued or imbedded in the body of the clamp to ensure a positive seal against the pipe.
- G. Hardware:
 - 1. Stainless Steel, Type 316 per ASTM A276.
 - 2. Provide single strap design unless otherwise required by pipe diameter.
 - 3. Straps shall have a curvature accurately formed to meet the diameter of the pipe.
 - 4. Lubricant treated nuts to prevent galling.

2.9 DIELECTRIC CONNECTIONS:

- A. Application: Where conveying a conductive fluid and two dissimilar metal pipes are joined including, copper pipe, carbon steel pipe, stainless steel pipe, cast-iron pipe, or ductile iron pipe, provide:
 - 1. Dielectric union.
 - 2. Dielectric flange fitting.
 - 3. Or flange dielectric kit.
- B. Manufacturers:
 - 1. Capitol Manufacturing Co.
 - 2. Central Plastics Company.
 - 3. Georg Fischer Central Plastics LLC.
 - 4. Epco Sales, Inc.
 - 5. Watts Water Technologies, Inc.
- C. Flange Dielectric Fittings and Kits:
 - 1. Insulating gaskets:
 - a. Glass reinforced epoxy.
 - b. 1/8-inch minimum thickness.
 - c. Buna-N sealing element.
 - 2. Insulating bolt sleeve:
 - a. Mylar.
 - b. 1/32-inch minimum thickness.
 - 3. Insulating washers:
 - a. Phenolic laminate.
 - b. 1/8-inch minimum thickness.
 - c. One washer per flange bolt.

4. Backing washers:
 - a. Steel.
 - b. 1/8-inch minimum thickness.
 - c. Two washers per flange bolt.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verification of Conditions:
 1. Inspect materials for defects in material and workmanship. Verify compatibility of products with pipe, fittings, valves, and appurtenances.
- B. Preinstallation Testing:
 1. Examine all piping materials prior to installation and replace items that are damaged or otherwise defective.
- C. Evaluation and Assessment:
 1. Flange Coordination: Coordinate the dimensions, hole drillings and type of flange face (flat or raised) of the flanges furnished with companion flanges of valves, pumps, and equipment to be connected to or installed in the piping.

3.2 PREPARATION

- A. Surface Preparation:
 1. Thoroughly clean inside of all piping, valves, and accessories, and outside of all materials which will be exposed. Clean before installation.

3.3 INSTALLATION

- A. Install all pipe coupling, adapters, and specials in accordance with the approved Shop Drawings, Contract Drawings, specifications, and manufacturer's installation instructions. Pipe and fitting materials shall comply with the individual Division 40 piping system sections.
- B. Dielectric Fitting Application:
 1. Dry Piping Systems: Connect piping of dissimilar metals with the following:
 - a. NPS 2 and Smaller: Dielectric unions.
 - b. NPS 2-1/2 to NPS 12: Dielectric flanges or dielectric flange kits.
 2. Wet Piping Systems: Connect piping of dissimilar metals with the following:
 - a. NPS 2 and Smaller: Dielectric couplings.
 - b. NPS 2-1/2 to NPS 4: Dielectric nipples.
 - c. NPS 2-1/2 to NPS 8: Dielectric nipples or dielectric flange kits.
 3. NPS 10 and NPS 12: Dielectric flange kits.
- C. Tolerances:
 1. Install products plumb, level, square and free from warp or twist while maintaining dimensional tolerances and alignment with surrounding construction and/or adjacent surfaces.

3.4 ADJUSTMENT

- A. Adjust expansion joints as required to ensure that expansion joints will be fully extended when ambient temperature is at minimum operating temperature, and fully compressed at maximum operating temperature for the system in which expansion joints are installed.

3.5 CLEANING

- A. Clean as recommended by manufacturer. Do not use materials or methods which may damage finish/surface or surrounding construction.

END OF SECTION

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SECTION 40 05 07
HANGERS AND SUPPORTS FOR PROCESS PIPING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Hanging pipe supports.
 - 2. Wall mounted pipe supports.
 - 3. Floor mounted pipe supports.
- B. Related Sections:
 - 1. Section 03 11 00 - Concrete Forming.
 - 2. Section 03 15 00 - Concrete Accessories.
 - 3. Section 03 30 00 - Cast-in-Place Concrete.
 - 4. Section 05 50 00 - Metal Fabrications.
 - 5. Section 09 96 56 - Epoxy Coatings.
 - 6. Section 40 05 19 - Ductile Iron Process Pipe.
 - 7. Section 40 05 23 - Stainless Steel Process Pipe and Tubing.
 - 8. Section 40 05 24 - Steel Process Pipe.
 - 9. Section 40 05 31 - Thermoplastic Process Pipe.
 - 10. Section 40 05 36.13 - Fiberglass-Reinforced Plastic Pipe for Process Air Service.

1.2 REFERENCES

- A. American Welding Society (AWS):
 - 1. AWS D1.1 - Structural Welding Code - Steel.
 - 2. AWS D1.6 - Structural Welding Code - Stainless Steel.
- B. American Society of Mechanical Engineers (ASME):
 - 1. ASME B31.9 - Building Services Piping.
 - 2. Section IX, Boiler and Pressure Vessel Code: Welding and Brazing Qualifications.
- C. American Society of Testing and Materials (ASTM):
 - 1. ASTM A36/A36M - Standard Specification for Carbon Structural Steel.
 - 2. ASTM A47/A47M - Standard Specification for Ferritic Malleable Iron Castings.
 - 3. ASTM A123 - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
 - 4. ASTM A181/A181M - Standard Specification for Carbon Steel Forgings, for General-Purpose Piping.
 - 5. ASTM A576 - Standard Specification for Steel Bars, Carbon, Hot-Wrought, Special Quality.
- D. Manufacturer's Standardization Society (MSS):
 - 1. MSS SP-58 - Pipe Hangers and Supports-Materials, Design, and Maintenance.

2. MSS SP-69 - Pipe Hangers and Supports-Selection and Application.
3. MSS SP-89 - Pipe Hangers and Supports-Fabrication and Installation Practices.

1.3 DEFINITIONS:

- A. Submerged:
 1. Less than one foot above the maximum liquid surface of water holding structures.
 2. Below top of channels, under cover of slabs of channels or tanks.
 3. In other damp or covered locations (e.g., vaults, wetwells, utility corridors, etc.)
- B. Exposed:
 1. Exposed to the atmosphere (not buried, submerged, wetted, or embedded).
 2. Piping inside chases, or piping hidden from view.

1.4 COORDINATION

- A. Coordinate Work of this Section with installation of process piping.

1.5 SUBMITTALS

- A. Per Section 01 33 00 - Submittal Procedures: Requirements for submittals.
- B. All submitted information shall include Contractor certification that the submittal describes exactly the equipment to be provided.
- C. Product Data: Submit manufacturer's descriptive literature, including load capacity.
- D. Shop Drawings: Indicate system layout with location, including critical dimensions, sizes, hanger and support locations, and details of trapeze hangers, anchors, and guides.
- E. Manufacturer's Instructions: Submit special procedures and assembly of components.
- F. Manufacturer's Certificate: Certify that products meet or exceed specified requirements.
- G. Welder Certificates: Certify welders and welding procedures employed on Work, verifying AWS qualification within previous 12 months.
- H. Delegated Design Submittals:
 1. Submit signed and sealed Shop Drawings with design calculations and assumptions for load carrying capacity of trapeze, multiple pipe, and riser support hangers.
 2. Indicate sizing methods and calculations used to determine load carrying capacity of trapeze, multiple pipe, and riser support hangers.
- I. Field Quality-Control Submittals: Indicate results of Contractor -furnished tests and inspections.

1.6 CLOSEOUT SUBMITTALS

- A. Per Section 01 70 00 - Execution and Closeout Requirements: Requirements for submittals.
- B. Project Record Documents: Submit all tank As-built drawings and record actual locations and final orientation of tank and accessories.

1.7 QUALITY ASSURANCE

- A. Per Section 01 43 00 - Quality Assurance.

- B. Welding:
 - 1. Qualify welding processes and welding operators according to the following codes depending on the material welded.
 - a. AWS D1.1 - Structural Welding Code, Steel.
 - b. AWS D1.6 - Structural Welding Code, Stainless Steel.
 - 2. Certify that each welder has satisfactorily passed AWS qualification tests for welding processes involved and, if pertinent, has undergone recertification.
 - 3. Qualify welding processes and welding operators according to ASME "Boiler and Pressure Vessel Code," Section IX, "Welding and Brazing Qualifications."

1.8 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing products specified in this Section with minimum 5-years' documented experience.
- B. Fabricator: Company specializing in fabricating work specified in this Section with minimum 5-years' documented experience.
- C. Licensed Professional: Professional Engineer experienced in design of specified Work and licensed in State of Colorado.

1.9 DELIVERY, STORAGE AND HANDLING

- A. Per Section 01 60 00 - Product Requirements.
- B. Inspection:
 - 1. Accept materials on Site in manufacturer's original packaging and inspect for damage.
 - 2. Obtain bill of lading for each material and/or product.
 - 3. Ensure shop coatings were not compromised during delivery and handling.
 - 4. Reject damaged materials.
- C. Store materials according to manufacturer instructions.
- D. Protection:
 - 1. At no time shall bare carbon steel come into contact with stainless steel products specified herein. This includes but not limited to bare cables or chains, hooks, metal bars or skids.
 - 2. Do not store products in direct contact with the ground surface or materials that might absorb water.
 - 3. Store material indoors or otherwise isolated from the moisture, dust, and general construction operation.

1.10 EXISTING CONDITIONS

- A. Field Measurements:
 - 1. Contractor shall verify actual dimensions of openings, adjacent facilities and equipment, utilities, and related items by field measurements before fabrication, as applicable.
 - 2. Indicate field measurements on Shop Drawings.

- B. Project/Site Environmental Conditions:
 - 1. Equipment location: Indoor, damp environment.
 - 2. Ambient air temperature range: 10 to 40 degrees C.
 - 3. Ambient air relative humidity range: 5 to 95 percent.

1.11 WARRANTY

- A. All products furnished and installed under this section shall be warranted in accordance with the requirements of Section 01 78 36 - Warranties.

PART 2 - PRODUCTS

2.1 PIPE HANGARS AND SUPPORTS

- A. Manufacturers:
 - 1. ASC Engineered Solutions, Anvil.
 - 2. Atkore, Unistrut.
 - 3. Carpenter & Paterson, Inc.
 - 4. Eaton, B-line.
 - 5. Empire Industries, Inc.
 - 6. Haydon Corporation.
 - 7. Piping Technologies & Products, Inc.
 - 8. PHD Manufacturing, Inc.
 - 9. PHS Industries, Inc.
 - 10. Or Engineer approved equivalent.
- B. General Requirements:
 - 1. It shall be the Contractor's responsibility to provide a complete system of pipe supports including:
 - a. Number, location, and size of supports.
 - b. Restraints and other process pipe anchoring means.
 - 2. Additional pipe supports may be required adjacent to in-line instruments, valves, expansion joints, couplings, and flanged connections. Piping shall be supported so that strain imposed on attached equipment is prevented.
 - 3. Piping Smaller than 30-inches: Supports are shown only where specific types and locations are required; provide additional supports as required.
 - 4. Piping 30-inches and Larger: Support systems have been designed for piping and shall be placed at the designated locations as shown on the Contract Drawings.
 - 5. Maximum Support Spacing:
 - a. Ductile Iron Process Pipe: 15 feet.
 - b. Carbon and Stainless Steel Process Pipe:
 - 1) Pipe nominal diameter 1-1/2 inch and smaller: 5 feet
 - 2) Pipe nominal diameter 2 thru 4 inch: 10 feet.
 - 3) Pipe nominal diameter 5 thru 8 inch: 15 feet.

- 4) Pipe nominal diameter 10 inches and larger: 20 feet.
 - c. Thermoplastic Process Pipe:
 - 1) Pipe nominal diameter 1-1/4 inch and smaller: 3 feet
 - 2) Pipe nominal diameter 1-1/2 thru 3 inch: 4 feet.
 - 3) Pipe nominal diameter 4 inches and larger: 7 feet.
 - d. All Other Pipe Materials: 5 feet.
6. Contractor shall provide neoprene gasket, or other means of isolation, between dissimilar metals.
- C. Description:
- 1. Comply with ASME B31.9 and MSS SP-58.
 - 2. Provide means of vertical adjustment after erection.
 - 3. Materials of Construction, unless otherwise specified:
 - a. Submerged: Stainless steel, Type 316.
 - b. Exposed: Carbon steel, hot dip galvanized per ASTM A123.
 - 4. Single Pipe Hanger:
 - a. Pipe Sizes 1/2 to 1-1/2 Inches:
 - 1) Configuration: Split ring, MSS SP-58 Type 6 or 12.
 - 2) Swivel: Adjustable.
 - b. Pipe Sizes 2 Inches and Larger:
 - 1) Configuration: Clevis, MSS SP-58 Type 1.
 - 2) Swivel: Adjustable.
 - c. Pipes subject to axial movement:
 - 1) Configuration: Adjustable roller hanger with swivel, MSS SP-58 Type 43.
 - 2) Use pipe protection shield or saddles on FRP and insulated lines.
 - 5. Multiple Pipe or Trapeze Hangers:
 - a. Channel: 1-5/8-inch x 1-5/8-inch minimum cross-sectional dimensions.
 - b. Pipe support: Two-piece pipe clip or U-bolt type, MSS SP-58 Type-59.
 - c. Pipes subject to axial movement:
 - 1) Use channel mounted roller supports; use pipe protection shield or saddles on FRP and insulated lines.
 - 2) Use channel mounted pipe guide as required.
 - 6. Horizontal Wall Support for Pipe Sizes 3 Inches and Smaller: Offset or straight J-hook.
 - 7. Horizontal Wall Support for Pipe Sizes 4 Inches and Larger:
 - a. Configuration: Welded steel bracket, MSS SP-58 Type-31, Type-32, Type-33.
 - b. Pipe Attachment:
 - 1) U-Bolts: MSS Type 24.
 - 2) Straps: MSS Type 26.
 - 8. Vertical Wall Support:
 - a. Configuration: Riser Clamp, MSS SP-58, Type 4.

- b. For insulated pipes: MSS SP-58, Type 3.
 - c. Extension Pipe or Riser Clamp: MSS-58 Type 8 or Type 42.
- 9. Floor Mounted Pipe Supports:
 - a. May be used in conjunction with structural concrete support pier.
 - b. Anchor bolt holes 1/16-inch larger than the anchor bolt diameter.
 - c. Fill the space between the baseplate and the floor with non-shrink grout.
 - d. Stanchion Type, Adjustable:
 - 1) Saddle: MSS SP-58, Type 38.
 - 2) Stanchion: Base cut and threaded for use with MSS SP-58, Type 38.
 - e. Fabricated Pipe Rack:
 - 1) Custom support structures to be designed and fabricated in instances where piping and appurtenance layout is not suited to standard catalog items or standard catalog items are not available.
 - 2) Material: Carbon Steel.
 - 3) Finish: Per 09 96 56 - Epoxy Coatings.
 - f. Pipe Attachment:
 - 1) U-Bolts: MSS Type 24.
 - 2) Straps: MSS Type 26.
- D. Performance and Design Criteria:
 - 1. Design for pipe movement without disengagement of supported pipe.
 - 2. Allow for expansion and contraction of piping while eliminating undue stress on piping appurtenances and equipment.
 - 3. Provide expansion joints to permit lateral or axial movement where anticipated.
 - 4. Point Loads:
 - a. Support plastic piping containing valves, instruments, and all other inline point loads on both sides of load.
 - b. Avoid point loads on plastic and fiberglass piping by providing extra-wide pipe saddles, clamps, or shields.

2.2 HANGER RODS

- A. Materials of Construction, unless otherwise specified:
 - 1. Submerged: Stainless steel, Type 316.
 - 2. Exposed: Carbon steel, hot dip galvanized per ASTM A123.
- B. End Connections: All thread.
- C. Size: Comply with ASME B31.1 and as indicated on Contract Drawings.
- D. Load limits:
 - 1. Nominal Rod Diameter:
 - a. 3/8 inch: 610 pounds.
 - b. 1/2 inch: 1,130 pounds.
 - c. 5/8 inch: 1,810 pounds.

- d. 3/4 inch: 2,710 pounds.
- e. 7/8 inch: 3,770 pounds.
- f. 1 inch: 4,960 pounds.

2.3 STRUCTURAL ATTACHMENTS

- A. I-Beam Clamp: Concentric loading type, MSS SP-58, Type 21, 28, 29, or 30, which engage both sides of beam flange.
- B. Concrete Insert: MSS SP-58, Type 18, continuous slot along one side with in turned clamping ridges.

2.4 FORMED STEEL CHANNEL

- A. Materials of Construction, unless otherwise specified:
 - 1. Submerged: Stainless steel, Type 316.
 - 2. Exposed: Carbon steel, hot dip galvanized per ASTM A123.
- B. Thickness: 12 gauge.
- C. Mounting Pattern: 1-1/2 on center.

2.5 MISCELLANEOUS MATERIALS

- A. Support Anchor Bolts: Per Section 05 50 00 - Metal Fabrications.
- B. Grout: Per Section 03 60 00 - Grouting.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Per Section 01 70 00 - Execution and Closeout Requirements:
- B. Verify that field dimensions as indicated on Shop Drawings.

3.2 PREPARATION

- A. Examine areas and conditions under which the hanger and support system will be installed. Do not proceed with work until satisfactorily conditions have been corrected in manner acceptable to installer.
- B. Proceed with installation of the hanger and support system only after required structural work has been completed in areas where work is to be installed. Correct inadequacies including, but not limited to. Proper placement of inserts, anchors, and other structural attachments. Review Drawings to obtain structural support limitations.

3.3 INSTALLATION

- A. Comply with ASME 31.9, MSS SP 69 and MSS SP 89.
- B. Install hangers, supports, clamps, and attachments as required to properly support piping from building structure.
- C. Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers, and other accessories.

- D. Install building attachments within concrete or to structural steel. Space attachments within maximum piping span length indicated in MSS SP 69. Install additional attachments at concentrated loads, including valves, flanges, guides, strainers, expansion joints, and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten insert to forms. Install reinforcing bars through openings at top of inserts. For concrete slabs forming finished ceiling locate inserts flush with slab surface.
- E. Obtain permission from Engineer before using powder-actuated anchors.
- F. Obtain permission from Engineer before drilling or cutting structural members.
- G. Install hangers and supports to allow controlled movement of piping systems, permit freedom of movement between pipe anchors, and facilitate action of expansion joints, expansion loops, expansion bends, and similar units.
- H. Install hangers and supports so that piping live and dead loading and stresses from movement will not be transmitted to connected equipment.
- I. Locate a minimum of 1 support or hanger within 2-feet from a pipe change in direction.
- J. Ensure supports and hangers are placed in such a manner that when equipment is removed for maintenance, temporary supports will not be required.
- K. Use concrete pipe cradles for piping larger than 3-inch nominal diameter along floor and in trenches at piping elevations lower than can be accommodated using stanchion type.

3.4 METAL FABRICATION

- A. Cut, drill, and fit miscellaneous metal fabrications for pipe and equipment supports.
- B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.
- C. Field Welding: Comply with AWS D1.1 procedures for manual shielded metal arc welding, appearance and quality of welds, methods used in correcting welding work, and the following:
 - 1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
 - 2. Obtain fusion without undercut or overlap.
 - 3. Remove welding flux immediately.
 - 4. Finish welds at exposed connections so that no roughness shows after finishing, and so that contours of welded surfaces match adjacent contours.

3.5 ADJUSTING

- A. Hanger Adjustment: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.
- B. Vibration of the piping system during operation is not acceptable. Contractor shall provide additional lateral supports as required to eliminate piping vibration at no addition cost to Owner.

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SECTION 40 05 19
PIPING SYSTEM, DUCTILE IRON PIPE

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section provides requirements for ductile iron piping system for exposed and buried applications and includes:
 - 1. Mechanical joint, push-on and flanged ductile iron pipe, sizes 4-inch through 24-inch.
 - 2. Mechanical joint and flanged ductile iron and cast-iron fittings, sizes 4-inch through 24-inch.
 - 3. Gaskets and fasteners.
 - 4. Protective coatings, linings, and encasements.
- B. Related Sections:
 - 1. Refer to Section 40 05 01 "Piping Systems, Basic Materials and Methods" for information regarding submittals; coordination; material delivery, handling, and storage; project conditions; design requirements; other materials; installation of piping systems; field testing; and related work.
 - 2. This Section contains material requirements for pipe, fittings, specials, and appurtenances for the ductile iron piping systems, as well as Part 1- General and Part 3 - Execution additional requirements not specified in the above-referenced Section.

1.3 REFERENCES

- A. American Water Works Association (AWWA):
 - 1. C104/A21.4 - Cement-Mortar Lining for Ductile-Iron Pipe and Fittings for Water.
 - 2. C105/21.5 - Polyethylene Encasement for Gray and Ductile Cast-Iron Piping for Water and Other Liquids.
 - 3. C110/A21.10 - American National Standard for Gray-Iron and Ductile-Iron Fittings, 3-inch through 48-inch for Water and Other Liquids.
 - 4. C111/A21.11 - American National Standard for Rubber Gasket Joints for Ductile-Iron and Gray-Iron Pressure Pipe and Fittings.
 - 5. C115/A21.15 - American National Standard for Flanged Ductile-Iron Pipe with Ductile-Iron or Gray-Iron Threaded Flanges.
 - 6. C150/A21.50 - American National Standard for the Thickness Design of Ductile Iron Pipe.
 - 7. C151/A21.51 - American National Standard for Ductile-Iron Pipe, Centrifugally Cast.
 - 8. C153/A21.53 - Ductile-Iron Compact Fittings.
 - 9. C600 - Installation of Ductile Iron Water Mains and Their Appurtenances.
 - 10. C606 - Grooved and Shouldered Joints.
 - 11. M41 - Manual Ductile Iron Pipe and Fittings.
- B. ASTM International, Inc. (ASTM):
 - 1. A48 - Specification for Gray Iron Castings.

2. A193 - Specification for Alloy-Steel and Stainless Steel bolting Materials for High Temperature or High Pressure Service and Other Special Purpose Applications.
 3. A194 - Specification for Carbon and Alloy Steel Nuts for Bolts for High-Pressure or High-Temperature Service, of Both.
 4. A307 - Specification for Carbon Steel Bolts and Studs, 60000 PSI Tensile Strength.
 5. A320 - Specification for Alloy-Steel and Stainless Steel Bolting Materials for Low Temperature Service.
 6. A536 - Specification for Ductile Iron Castings.
 7. A563 - Specification for Carbon and Alloy Steel Nuts.
 8. D1330 - Specification for Rubber Sheet Gaskets.
- C. National Sanitation Foundation (NSF):
1. NSF/ANSI 61 - Drinking Water Components – Health Effects.

1.4 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings:
1. Pipe layout drawings shall include plan, elevations, sections, details, and attachments to other work.
 2. Pipe layout schedule/drawings including pipeline stationing, elevation, and restrained joint locations.
 3. Schedule of materials furnished.
 4. Pipe layout drawings and data shall clearly indicate where pipe requiring special provisions are to be located, connections to equipment, valves, and related items.
- C. Material Certificates:
1. Certificate of Compliance with all applicable and appropriate reference standards certifying that all pipe, fittings, and specials, and other products and materials furnished, comply with the applicable provision of the Specification.
 2. Certification of Adequacy of Design: the Certificate of Adequacy of Design shall show the necessary provisions required in the design of the pipe to comply with applicable sections of this Specification.
- D. Field quality-control test reports.

1.5 PROJECT REQUIREMENTS

- A. Restrained Pipe and Fitting Joints, Buried Piping:
1. Restrained joints shall be used for a sufficient distance from each bend, tee, elbow, plug, or other fitting to resist thrust that will develop at the design pressure.
 2. Contractor shall provide restraint length calculations in accordance with AWWA M41 based on the laying conditions, soil conditions, depth of cover, and pressures to determine the number of restrained joints that will be required.
 3. For the purposes of thrust restraint, design pressures shall be the working pressure shown, plus the additional surge allowance for potable water, service water, and pump discharge piping, unless indicated otherwise on the Drawings. The design pressure shall be 1.5 times the design test pressure indicated for all other piping, unless indicated otherwise on the Drawings.

- B. Hangers and Supports, Exposed Piping: Refer to Section 40 05 07 "Hangers and Supports for Process Piping" for requirements for engineered hangers and supports for piping systems to be provided by Contractor.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Comply with the Manufacturer's handling and storage recommendations.
- B. All pipe ends shall be covered with a weather resistant cap, plug, or blind flange prior to shipment, which shall remain in place until installation of the pipe.
- C. All pipe and fittings shall be stored on blocking, at least 4 inches off the ground and shall be kept free of debris and dirt until installation.

PART 2 - PRODUCTS

2.1 PIPE AND FITTINGS

- A. General: Ductile iron with a thickness design for the pressures and laying conditions complying with the requirements of AWWA C150 and the manufacturer in accordance with AWWA C151.
 - 1. Comply with the following minimum thickness class, unless otherwise indicated in Section 40 06 00.
 - a. Class 52 for pipe.
 - b. Class 53 for threaded flanged joints.
 - c. Class 53 for grooved end pipe, grooved in accordance with AWWA C606.
 - 2. Acceptable Pipe Manufacturers:
 - a. American
 - b. US Pipe
 - c. McWane
 - 3. Acceptable Fitting Manufacturers
 - a. Star Pipe Products
 - b. Tyler Union
 - c. Sigma
- B. Mechanical-Joint, Ductile-Iron Pipe: AWWA C151, with AWWA C153 mechanical-joint bell and plain spigot end unless grooved or flanged ends are indicated.
 - 1. Mechanical-Joint, Ductile-Iron Fittings: AWWA C110, ductile-iron or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern.
 - 2. Glands, Gaskets, and Bolts: AWWA C111, ductile-iron or gray-iron glands, vulcanized styrene butadiene rubber (SBR) gaskets conforming to NSF 61, and stainless-steel bolts. Provide an anti-seizing compound for 316 stainless steel nuts and bolts.
- C. Push-on-Joint, Ductile-Iron Pipe: AWWA C151, with push-on-joint bell and plain spigot end unless grooved or flanged ends are indicated.
 - 1. Push-on-Joint, Ductile-Iron Fittings: AWWA C110, ductile-iron or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern.
 - 2. Gaskets: AWWA C111, vulcanized SBR gaskets conforming to NSF 61.
- D. Grooved-Joint, Ductile-Iron Pipe: AWWA C151, with cut, rounded-grooved ends, conforms to AWWA C606, 250 psi minimum working pressure fittings.
 - 1. Grooved-End, Ductile-Iron Pipe Appurtenances:
 - a. May be used as an alternate to flanged joints for exposed locations.

- b. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1) Anvil International, Inc.
 - 2) Victaulic Company of America.
- E. Flanged-Joint, Ductile-Iron Pipe: AWWA C151, flanged ends.
 - 1. Flange Joints: Comply with the requirements of AWWA C115.
 - a. Class 150 or Class 250 as designated on Drawings or Section 40 06 00.
 - 2. Bolting:
 - a. Exposed or Atmospherically Exposed: ASTM A307, carbon steel, Grade A hex head bolts; ASTM A563, Grade A hex head nuts; ASTM F436 hardened steel washers; and ASTM A240, Type 304 SS.
 - b. Wetted, Submerged or Buried: ASTM A193 or ASTM A320, Type 316 stainless steel bolts; ASTM A194, Type 316, nuts; and washers of the same material as the bolts. Provide an anti-seizing compound for 316 stainless steel nuts and bolts.
 - c. Gaskets:
 - 1) Flange, Flat Face: Full-faced, AWWA C111, 1/8-inch thick rubber, factory cut.
 - 2) Flange, Raised Face: Use flat ring gasket.

2.2 SPECIAL PIPE FITTINGS

- A. Ductile-Iron, Flexible Expansion Joints: Compound fitting with combination of flanged and mechanical-joint ends complying with AWWA C110 or AWWA C153. Include 2 gasketed ball-joint sections and 1 or more gasketed sleeve sections, rated for 250-psi and for offset and expansion indicated.
 - 1. Available Manufacturers:
 - a. EBAA Iron Sales, Inc.
 - b. Romac Industries, Inc.
 - c. Star Pipe Products.
- B. Ductile-Iron Deflection Fittings: Compound coupling fitting with ball joint, flexing section, gaskets, and restrained-joint ends complying with AWWA C110 or AWWA C153. Include rating for 250-psig minimum working pressure and for up to 15 degrees of deflection.
 - 1. Available Manufacturers:
 - a. EBAA Iron Sales, Inc.
- C. Ductile-Iron Expansion Joints: Three-piece assembly of telescoping sleeve with gaskets and restrained-type, ductile-iron bell-and-spigot end sections complying with AWWA C110 or AWWA C153. Include rating for 250-psig minimum working pressures and for expansion indicated.
 - 1. Available Manufacturers:
 - a. Dresser, Inc.; DMD Div.
 - b. EBAA Iron Sales, Inc.
 - c. JCM Industries.
- D. Flange adapter: For joining steel pipe to cast iron, provide Dresser Style 127 or equal. Gasket to be Buna-S, Grade 27.
- E. Dismantling Joint: Double-ended flange adapter, allowing longitudinal adjustment in piping system, similar to Dresser Style 131 or equal.

- F. Reducing and Transition Coupling: Required for making reduction in sizes of piping; changing classes of piping; or joining steel and cast iron pipe, provide Dresser Style 62 or equal.

2.3 PROTECTIVE COATINGS, LININGS, AND ENCASEMENT

- A. Pipe and Fittings Interior:
1. Mortar: Unless otherwise specified in the Section 40 06 00, all ductile iron pipe and fittings shall be provided with a cement-mortar lining in accordance with AWWA C104.
 2. Epoxy: When specified in the Section 40 06 00, apply a high build, fusion bonded epoxy lining per AWWA C116, minimum 16 mils dry film thickness, per AWWA C116. When pipe and fittings are used for potable water service, epoxy lining shall be NSF 61 certified.
 - a. Available Manufacturer: Induron Ceramapure PL90 or approved equal.
 3. Glass Lining:
 - a. Consist of glass completely fused above 1,450 degrees F, with a thickness of 6 to 10 mils and defects, which exposed base metal not greater than 0.1 percent of total lined surface.
 - b. Hardness shall be greater than 5 on the Mohs scale and lining bonded sufficiently to withstand a metal strain of 0.001-inch/inch without damage to the glass lining.
 - c. Finished lined pipe shall not deviate more than 0.0125-inch per foot of length from a centerline perpendicular to the flange face or square end of the pipe.
 - d. Available Manufacturers: Water Works Supply Co., Ferrock MEH-32; Ceramic Coating Co., SL-31; or Ervite Corp., SG-14.
- B. Pipe and Fittings Exterior:
1. Refer to coating type listed in the Section 40 06 00.
 2. Painted: Provide shop coat primer required for the coating system specified in Section 09 90 00 "Painting and Protective Coatings."
 3. Bituminous: Provide shop applied 1-mil bituminous coating system per AWWA C151 for pipe and AWWA C110 for fittings.
- C. Encasement for Underground Metal Piping: ASTM A 674 or AWWA C105.
1. Form: Sheet or tube.
 2. Material: LLDPE film of 0.008-inch minimum thickness or high-density, cross-laminated PE film of 0.004-inch minimum thickness.
 3. Color: Black.

2.4 VENT AND DRAIN VALVES

- A. Pipelines 2-1/2-Inch Diameter and Larger: 3/4-inch vent, 1-inch drain, unless indicated otherwise on the Drawings.
- B. Pipelines 2-Inch Diameter and Smaller: 1/2-inch vent, 1-inch drain, unless indicated otherwise on the Drawings.
- C. Install vents and drains at piping system high points (vents) and low points (drains) as required by final installation configuration. Provide line size ball valves for all vents and drains.

2.5 INSULATED CONNECTIONS

- A. Provide dielectric insulation kits, including gaskets, insulating sleeves and washers for each bolt and nuts, where flanges are to be cathodically insulated. Metal hardware such as backup washers shall be Type 316 stainless steel. Refer to Section 40 05 01 "Piping Systems, Basic Materials and Methods" for description and additional information.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Comply with the requirements of Section 40 05 01 "Piping Systems, Basic Materials and Methods". Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Laying Buried Pipe:
 - 1. Install pipe to the lines, grades and elevations shown on the Drawings, complying with the requirements of AWWA C600.
 - 2. Unless otherwise shown on the Drawings, within the plant site, bury piping with a minimum cover of 3-feet. Off-site, bury lines 12 inches and smaller with a minimum cover of 4-feet and lines 14 inches and larger with a minimum cover of 5-feet.
 - 3. Do not lay pipe in water, or when the trench or weather is unsuitable for work. Keep water out of trench until jointing is complete. When work is not in progress, close ends of pipe and fittings securely so no trench water, earth or other substances will enter pipes or fittings.
 - 4. Keep the inside of the pipe free from foreign matter during operations by plugging or other approved method.
 - 5. Provide pipe bedding in accordance with the Drawings and Division 31. Place pipe so that the full length of each section rests solidly upon the pipe bed, with recesses excavated to accommodate bells and joints. Take up and relay pipe when the grade or joint is disturbed after laying.
 - 6. Lay pipe with bells facing the direction of the laying except when making enclosures.
 - 7. Provide a restrained push-on joint or mechanical joint ten feet from outside face of structures.
- C. Restrained Joints: Unless otherwise indicated on the Drawings, the Contractor shall use mechanically restrained pipe joints and fittings (no thrust blocks). The length of pipe requiring thrust restraint shall be calculated as described in Chapter 8 of AWWA M-41.
 - 1. All joints requiring thrust restraint shall be wedge-action type (buried) or restrained with mechanical systems (exposed).
 - 2. Contractor shall design restrained joints based on the specified pressures as shown in the Section 40 06 00 or Drawings and in accordance with AWWA M-41.
 - 3. The design for restrained joints, including the length necessary to resist the design thrust, for the embedded conditions, shall be performed and sealed by a Professional Engineer in the state where the Project is being constructed.
 - 4. Contractor shall bear all costs for the design and will not receive reimbursement from the Owner.

3.2 CLEANING

- A. All piping systems shall be thoroughly cleaned and flushed and all construction debris or foreign material removed. The Contractor shall provide all temporary connections, equipment, and the like for cleaning.

3.3 FIELD QUALITY CONTROL

- A. Sterilization: Clean and sterilize potable water lines in accordance with Section 40 08 00 "Field Testing of Process Interconnections".
- B. Piping Tests: Conduct piping tests before joints are covered and after concrete thrust blocks have hardened sufficiently.
- C. Hydrostatic Tests: Conduct testing in accordance with Section 40 08 00 "Field Testing of Process Interconnections".
- D. Prepare reports of testing activities.

3.4 PIPING SCHEDULE

- A. Refer to Section 40 06 00.

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SECTION 40 05 24
PIPING SYSTEM, STEEL PIPE

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Fabricated, lined and coated steel pipe, sizes 6-inch through 144-inch.
- B. Related Sections:
 - 1. Refer to Section 40 05 01 "Piping Systems, Basic Materials and Methods" for information regarding submittals; coordination; material delivery, handling, and storage; project conditions; design requirements; other materials; installation of piping systems; field testing; and related work.
 - 2. This Section contains material requirements for pipe, fittings, specials, and appurtenances for the steel piping systems, as well as Part 1- General and Part 3- Execution additional requirements not specified in the above referenced Section.

1.3 REFERENCES

- A. American National Standards Institute (ANSI):
 - 1. B16.1 – Cast Iron Pipe Flanges, Class 25, 125, 250, and 800
 - 2. B16.3 – Malleable Iron Threaded Fittings: Classes 150 and 300
 - 3. B16.5 – Pipe Flanges and Flanged Fittings: NPS 1/2 through 24
 - 4. B16.9 – Factory-Made Wrought Steel Buttwelding Fittings
 - 5. B16.11 – Forged Fittings Socket-Welding and Threaded
 - 6. B16.21 – Nonmetallic Gaskets for Pipe Flanges
- B. American International (ASTM):
 - 1. A123 – Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
 - 2. A234 – Specification for Pipe fittings of Wrought Iron Carbon Steel and Alloy Steel for Moderate and Elevated Temperature Service
 - 3. A307 – Specification for Carbon Steel Bolts and Studs, 60 000 PSI Tensile Strength
 - 4. A384 – Practice for Safeguarding Against Warpage and Distortion During Hot-Dip Galvanizing of Steel Assemblies
 - 5. A385 – Practice for Providing High Quality Zinc Coatings (Hot-Dip)
 - 6. A563 – Specification for Carbon and alloy Steel Nuts
 - 7. D1330 – Specification for Rubber Sheet Gaskets
 - 8. D6386 – Practice for Preparation of Zinc (Hot-Dip Galvanized) Coated Iron and Steel Products and Hardware Surfaces for Painting
 - 9. F436 – Specification for Hardened Steel Washers
- C. American Society of Mechanical Engineers (ASME):
 - 1. B31.3 – Process Piping Code
 - 2. ASME Boiler and Pressure Vessel Code—Sec. IX, Welding and Brazing Qualifications
- D. American Water Works Association (AWWA):
 - 1. C200 – Standard for Steel Water Pipe-6 In. (150 mm) and Larger
 - 2. C203 – Standard for Coal-Tar Protective Coatings and Linings for Steel Water Pipe

3. C205 – Standard for Cement-Mortar Protective Lining and Coating for Steel Water Pipe-4 In. (100 mm) and Larger-Shop Applied
 4. C206 – Standard for Field Welding of Steel Water Pipe
 5. C207 – Standard for Steel Pipe Flange for Waterworks Service. 4 In. Through 144 In.
 6. C208 – Standard for Dimensions for Fabricated Steel Water Pipe Fittings
 7. C210 – Liquid-Epoxy Coatings and Linings for Steel Water Pipe and Fittings
 8. C213 – Standard for Fusion-Bonded Epoxy Coatings and Linings for Steel Water Pipe and Fittings
 9. C219 – Standard for Bolted, Sleeve-Type Couplings for Plain End Pipe
 10. C221 – Standard for Fabricated Steel Mechanical Slip-Type Expansion Joints.
 11. C606 – Grooved and Shouldered Joints
- E. American Welding Society (AWS):
1. D1.1—Structural Welding Code - Steel
- F. National Sanitation Foundation (NSF):
1. NSF/ANSI 61 – Drinking Water Components – Health Effects

1.4 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings:
1. Pipe layout drawings shall include plan, elevations, sections, details, and attachments to other work.
 2. Pipe layout schedule/drawings including pipeline stationing, elevation, and flange and restrained joint locations.
 3. Schedule of materials furnished.
 4. Pipe layout drawings and data shall clearly indicate where pipe requiring special provisions are to be located, connections to equipment, valves, and related items.
 5. Welder certifications.
- C. Material Certificates:
1. Certificate of Compliance with all applicable and appropriate reference standards certifying that all pipe, fittings, and specials, and other products and materials furnished, comply with the applicable provision of the Specification.
 2. Certification of Adequacy of Design: The Certificate of Adequacy of Design shall show the necessary provisions required in the design of the pipe to comply with applicable sections of this Specification.
- D. Field quality-control test reports.

1.5 PROJECT REQUIREMENTS

- A. Quality Assurance:
1. Piping system manufacturer or fabricator shall have at least five (5) years' experience in producing products similar to those indicated for this Project and with a record of successful in-service performance, as well as sufficient production capacity to produce required units.
 2. Welding Procedures:
 - a. Requirements for Welding Operations: In accordance with AWWA C200, qualify welding processes and welding operators according to one of the following codes:
 - 1) Sec. IX of the ASME Boiler and Pressure Vessel Welding Code, or
 - 2) ASME B31.3 "Process Piping Code".

- b. Certify that each welder has satisfactorily passed AWS qualification tests for welding processes involved and, if pertinent, has undergone recertification.
 - c. Welder's current certification shall be less than one year old.
 - d. All shop welds shall be visually inspected by the fabricator's quality control division. Each weld shall be marked with an inspection stamp, certifying that the weld is acceptable.
 - e. Field Welding: When approved by Engineer, shall comply with the requirements of AWWA C206.
 - B. Design Pressures:
 - 1. Operating Pressure: Refer to Section 40 06 00.
 - 2. Surge Allowance: 40% of operating pressure.
 - 3. Water Temperature: 95°F maximum
 - C. Hangers and Supports, Exposed Piping: Refer to Section 40 05 07 "Hangers and Supports for Process Piping" for requirements for engineered hangers and supports for piping systems to be provided by Contractor.
- 1.6 DELIVERY, STORAGE, AND HANDLING
- A. Comply with the Manufacturer's handling and storage recommendations.
 - B. All pipe ends shall be covered with a weather resistant cap, plug, or blind flange prior to shipment, which shall remain in place until installation of the pipe.
 - C. All pipe and fittings shall be stored on blocking, at least 4 inches off the ground and shall be kept free of debris and dirt until installation.

PART 2 - PRODUCTS

2.1 PIPE AND FITTINGS

- A. Pipe:
 - 1. Pipe and fittings shall be manufactured or fabricated, coated, and lined (if applicable) at a single location.
 - 2. Referenced Standard: AWWA C200 or API Spec. 5L, Grade B.
 - 3. Type:
 - a. 6-Inch through 20-Inch: Mill or fabricated pipe, OD controlled.
 - b. 24-Inch and Larger: Fabricated pipe, ID controlled.
 - 4. Fabrication:
 - a. Except for seamless mill-type pipe, all piping shall be made from steel plates rolled into cylinders or sections thereof with longitudinal butt welded seams as indicated below, or shall be spirally formed and butt welded.
 - 1) 20-Inch and Smaller: One seam.
 - 2) 22-Inch to 54-Inch: Two seams.
 - 3) 56-Inch and Larger: Three seams.
 - b. Girth seams shall be butt-welded and shall not be closer than six feet nor more than 20 feet apart, except in specials and fittings.
 - c. Spiral lap welded steel pipe is not acceptable.
 - d. Circumferential deflection of all pipe in-place shall not exceed 2.0 percent of pipe diameter.
 - 5. Diameter:
 - a. Nominal pipe diameter shall be as shown on the Drawings. Unless otherwise designated, nominal diameter shall be as follows:
 - 1) Steel Pipe, Mortar Lining: Diameter shall be inside diameter of lining.

- 2) Steel Pipe, Coal-Tar or Epoxy Lining: Diameter shall be inside diameter of pipe for 12-inch and smaller. Outside diameter of pipe for 14-inch and larger.
- b. Outside diameter of pipe shall be compatible with flanges, couplings, specials and related work.
6. Wall Thickness:
 - a. General: In accordance with AWWA Design Manual M-11 for the internal and external loads specified either on the Drawings or listed in Section 40 06 00. Air Piping shall be Schedule 10 minimum.
 - b. Minimum Wall Thickness: As given in Table 40 05 24-1.

TABLE 40 05 24-1 MINIMUM WALL THICKNESS	
Diameter Range (Inches)	Wall Thickness (Inches)
24 and under	3/16
26 – 36	1/4
38 – 45	5/16
48 – 54	3/8
57 – 60	7/16
63 and larger	1/2

7. Type Ends: As follows unless otherwise shown on the Drawings or specified.
 - a. Buried: Welded joints provided internal joints can be adequately coated after welding.
 - b. Exposed or Submerged, Waste or Water Service: Flanged or plain ends with couplings.
 - c. Plain: When flexible couplings of flanged coupling adapters are shown on Drawings.
 - d. Exposed, Air Service: Do not use welded connections. Flanges or restrained, flexible couplings shall be used. Gaskets shall be suitable for 240°F with lubrication oil present.
 - e. Coupling Coating: Fusion bonded epoxy interior and exterior or galvanized if pipe is specified to be galvanized.
 - f. Field Welding: Not allowed unless approved by the Engineer.

B. Fittings:

1. Welded:
 - a. Socket welded, forged steel per ANSI B16.11.
 - b. Butt-welded, steel per ANSI B16.9.
2. 6-Inch to 24-Inch: Wrought carbon steel fittings of smooth, seamless construction per ASTM A234.
3. Larger than 24-Inches: Fabricated steel fittings of same material as pipe per AWWA C208 and AWWA M-11. Fabricated steel fittings shall comply with the dimensions listed in Table 1 and the configuration as shown in Figures 1 through 6 of AWWA C208.

2.2 CONNECTIONS

A. Flanges:

1. Comply with requirements of ANSI B16.1, Class 125; AWWA C207, Class D, Class E, or Class F; or ANSI B16.5, Class 150 or Class 300, with class based on operating conditions and mating flanges of valves, pumps and equipment.

2. Unless otherwise specified, provide slip-on type, flat face having a serrated finish.
 3. Attached flanges to pipe with bolt holes straddling the vertical and centerlines of the pipe.
- B. Bolting Materials:
1. Bolting:
 - a. Exposed: ASTM A307, Grade B, hex head bolts; ASTM A563, Grade C, D, or DH, hex head nuts; and ASTM F436 hardened steel washers.
 - b. Submerged or Buried: ASTM A193 or ASTM A320, Type 316 stainless steel bolts; ASTM A194, Type 316, nuts; and washers of the same material as the bolts.
 - c. Gaskets:
 - 1) Standard: ANSI B16.1
 - 2) Flange, Flat Face: Full-faced, 1/8-inch thick Neoprene, 80 Durometer minimum, factory cut.
 - 3) Flange, Raised Face: Use flat ring gasket.
 - 4) Air Service: Buna-N.
 - 5) Blind Flange Gasket: Cover entire inside surface, cementing to blind flange surface.
- C. Bolted, Sleeve-Type Couplings, Plain End Pipe: Comply with AWWA C219.
- D. Expansion Joints, Mechanical Slip-Type: Comply with AWWA C221.
1. Expansion joints used on the hot-dip galvanized steel, low-pressure air piping shall be Victaulic Style 231, Type 2 or approved equal, with silicone gaskets, and stainless steel cladding and fasteners.

2.3 LININGS AND COATINGS

- A. Pipe and Fittings Interior:
1. Cement-Mortar: Applied in accordance with AWWA C205.
 2. Hot Dip Galvanized
 - a. Preparation
 - 1) Steel pipes and fittings shall be prepared before being galvanized per ASTM D6386
 - 2) Zinc metal used to galvanize the steel pipes and fittings shall be furnished per ASTM B6
 - b. Coating
 - 1) Steel pipes and fittings shall be hot-dipped galvanized per ASTM A123
 - 2) Follow the recommended practice for safeguarding against warpage and distortion during hot-dip galvanizing of steel pipes and fitting shall be per ASTM A384.
 - 3) Hot dipped galvanized zinc coating shall be a minimum of 2.0 oz/sf of pipe surface interior and exterior.
 - c. Finishing
 - 1) Finish of the hot-dip galvanized pipe shall be tested per ASTM
- B. Pipe and Fittings Exterior:
1. Exposed and submerged piping and fittings: One shop coat of primer compatible with finish paint system as specified in painting specifications. Provide field primer and finish coatings on piping and fittings in accordance with Section 09 90 00.
 2. Buried steel piping shall be polyurethane coated. Polyurethane coating shall meet the requirements of AWWA C222. Use a coating that conforms to an ASTM D 16 Type V system (2-package polyisocyanate, polyol-cured urethane coating). The components are mixed in 1:1 ratio at time of application. The components shall have balanced

viscosities in their liquid state and shall not require agitation during use. The plant-applied coating shall be CORROPIPE II OMNI as manufactured by Madison Chemical Industries Inc., or equal Futura Coatings. The cured coating shall have the following properties:

- a. Conversion to Solids by Volume: 97% plus or minus 3%.
- b. Temperature Resistance: Minus 40°F and plus 130°F.
- c. Minimum Adhesion: 1500 psi, when applied to steel pipe which has been blasted to comply with SSPC-SP10.
- d. Cure Time: For handling in 1 minute at 120°F, and full cure within 7 days at 70°F.
- e. Maximum Specific Gravities: Polyisocyanate resin, 1.20. Polyol resin, 1.15.
- f. Minimum Impact Resistance: 80 inch-pounds using 1-inch diameter steel ball.
- g. Minimum Tensile Strength: 2000 psi.
- h. Hardness: 55 plus or minus 5 Shore D at 70°F.
- i. Flexibility Resistance: ASTM D 522 using 1-inch mandrel. Allow coating to cure for 7 days. Perform testing on test coupons held for 15 minutes at temperature extremes specified above.
- j. Dry Film Thickness: 35 mils

2.4 WALL PIPES AND SLEEVES

- A. General: Laying lengths and end connections to be as shown on Drawings.
- B. Wall Thickness:
 1. Wall pipes: Equal to or greater than that of adjoining pipe.
 2. Wall sleeves: Standard weight.
- C. Wall Collars:
 1. Provide for all wall pipes to serve as a water stop and prevent axial movement of all pipes.
 2. Size Collars are as follows:

Pipe Size (Inches)	Collard O.D. (Inches)	Collar Thickness (Inches)
6 - 12	Pipe O.D. Plus 4	1/2
14 - 18	Pipe O.D. Plus 4	3/4
20 - 24	Pipe O.D. Plus 6	3/4
26 - 42	Pipe O.D. Plus 8	1
48 and larger	Pipe O.D. Plus 10	1-1/4

2.5 PIPE DESIGN CLASSES

- A. Pipe fittings and joints:
 1. Designed for a minimum working pressure of 50 psi (which includes surges and thrusts), unless otherwise shown, as well as soil loads and stresses from thermal expansion and contraction.
 2. Fittings, specials, and connections shall be same class as the associated pipe unless otherwise indicated.
 3. All pipe and fittings shall be clearly marked with the pressure class and piece number to permit easy identification in the field.
- B. Buried Pipe Design:
 1. Based on internal and external loads imposed on the piping system. Refer to Section 31 23 00 "Excavation, Trenching, and Backfilling for Utilities" and the Drawings for information on trench embedment and backfill requirements.

2. Pipe shall be designed for the trench depths indicated using a Soil Modulus 23 E' of 1000, and a maximum pipe deflection of 2 percent of D for mortar lined and coated pipe (3% for mortar lined and flex coated; 5% for flexible lined and coated), where D = Diameter.

PART 3 - EXECUTION

3.1 INSTALLATION, CLEANING, AND TESTING

- A. Comply with the requirements of Section 40 05 01 "Piping Systems, Basic Materials and Methods".
- B. Protective Coating System for Welded Joints
 1. General:
 - a. Application of protective coating at the pipe joints will be as follows: apply a two layer field applied coating system (the factory applied 35 mil polyurethane coating shall be held back on the bell and spigot of the welded joint), a field applied 60 mil by 6-inch wide strip of CANUSA HCO Wrapid Tape heat resistant tape at the location of the welding, and a field applied 110 mil (full recovered thickness) by 18-inch wide CANUSA AquaWrap high shrink heat shrinkable joint sleeve. After the heat shrinkable joint sleeve is installed, the Contractor may backfill the trench, and then weld the joint.
 - b. The Contractor is responsible for their operations so that they do not damage the factory applied coating system.
 - c. When applying the two layer joint coating system for post welding the joints, the Contractor must show that their operation will not damage the joint coating system to the Engineer's satisfaction. The Contractor will be required to fully uncover a maximum of 10 joints, selected at random by the Engineer or Owner to visually inspect and test the joint after welding. Any damage must be repaired. If the Contractor's welding procedure damages the joint coating system, the Contractor, at the direction of the Engineer, will be required to modify their welding procedure.
 2. Joint Coating (3 layer):
 - a. Apply a three-layer joint coating system before welding the joints except cutback area.
 - b. Pipe Manufacturing and Heat Tape
 - 1) A 35 mil thickness polyurethane coating shall be applied over entire length of pipe. The Contractor shall field apply 60 mil thick by 6-inch wide strip of CANUSA HCO Wrapid Tape heat resistant tape to the exterior bell end of the pipe, centered on the location of the welding, over a 35 mil factory applied polyurethane coating.
 - c. Surface Preparation and Installation for Heat Shrinkable Joint Sleeve:
 - 1) Clean pipe surface and adjacent coating of all mud, oil, grease, rust, and other foreign contaminants with a wire brush in accordance with SSPC-SP2, Hand Tool Cleaning, or SSPC-SP3, Power Tool Cleaning. Remove oil or grease contamination by solvent wiping the pipe and adjacent coating in accordance with SSPC-SP1, Solvent cleaning. Clean the full circumference of the pipe and a minimum of 6 inches onto the existing coating.
 - 2) Remove all loose or damaged pipe coating at joint and either repair the coating as specified herein or increase the length of the joint coating, where reasonable and practical.
 - 3) Complete joint bonding of pipe joints before application of joint coating.

- 4) Joint bonds shall be low profile bonds and all gaps and crevices around the bonds shall be filled with mastic sealant.
 - 5) Store sleeves in shipping box until use is required. Keep dry and sheltered from exposure to direct sunlight. Store off the ground or concrete floors and maintain at a temperature between 60°F and 100°F as recommended by the sleeve manufacturer.
 - 6) Metal surface shall be free of all dirt, dust, and flash rusting prior to sleeve application.
 - 7) Preheat pipe uniformly to 140°F to 160°F or as recommended by the sleeve manufacturer. Monitor pipe temperature using a surface temperature gauge, infrared thermometer, or color changing crayons. Protect preheated pipe from rain, snow, frost, or moisture with tenting or shields and do not permit the joint to cool.
 - 8) Prime joint with specified primer and fill all cracks, crevices, and gaps with mastic filler in accordance with the manufacturer's recommendations for the full circumference of the pipe.
 - 9) Apply heat shrink sleeve when it is at a minimum temperature of 60°F and while maintaining the pipe temperature above the preheat temperature specified. Apply sleeve in accordance with the manufacturer's instructions and center the sleeve over the joint to provide a minimum of 3 inches overlay onto the existing pipe coating.
 - 10) Apply heat to the sleeve using either propane fire infrared heaters or wrap around heaters. Hold flame a minimum of 6 inches from the sleeve surface. Periodically roll the coating on the pipe surface. Heat from the center of the sleeve to the outer edge until properly seated, then begin in the opposite direction. Monitor sleeve for color change, where appropriate, or with appropriate temperature gauges.
 - 11) Completed joint sleeve shall be fully bonded to the pipe and existing coating surface, without voids, mastic beading shall be visible along the full circumference of the sleeve, and there shall be no wrinkling or excessive burns on the sleeves. Sleeves which do not meet these requirements shall be removed and the joint recoated as directed by the Engineer. Minor repairs may be repaired using heat shrink sleeve repair kits.
 - 12) Allow the sleeve to cool before moving, handling, or backfilling. In hot climates, provide shading from direct sunlight. Water quenching will be allowed only when permitted by the sleeve manufacturer.
- d. Inspection, Testing, and Repairs
- 1) Holiday testing shall be performed using a wet sponge holiday tester at each joint after field application of heat shrinkable joint sleeve. If any holidays or cuts are detected, the sleeve shall be repaired using CANUSA Repair Patch Kit (CRPK) or approved equal. The damaged area shall be covered with a minimum of 50 mm overlap around the damaged area.

C. Restrained Joints: Unless otherwise indicated on the drawings, the Contractor shall use mechanically restrained pipe joints and fittings (no thrust blocks). The length of pipe requiring thrust restraint shall be calculated as described in Chapter 13 of AWWA M11.

1. All joints requiring thrust restraint shall be welded (buried) in accordance with AWWA C206 or restrained with mechanical systems (exposed).
2. Contractor shall design restrained joints based on the specified pressures as shown in Section 40 06 00 or Drawings and in accordance with AWWA M11.

3. The design for restrained joints, including the length necessary to resist the design thrust, for the embedded conditions, shall be performed and sealed by a Professional Engineer in the state where the Project is being constructed.
 4. Contractor shall bear all costs for the design and will not receive reimbursement from the Owner.
- D. Field Testing: Comply with the requirements of Section 40 08 00 "Field Testing of Process Interconnections".
1. Minimum test pressure shall be as indicated on the pipe schedule.
- 3.2 PIPING SCHEDULE
- A. Refer to Section 40 06 00.

END OF SECTION

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SECTION 40 05 31
THERMOPLASTIC PROCESS PIPE

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Polyvinyl Chloride (PVC) pipe and fittings.
2. Chlorinated Polyvinyl Chloride (CPVC) pipe and fittings.
3. Acrylonitrile-butadiene-styrene (ABS) pipe and fittings.
4. Polyvinylidene fluoride (PVDF) pipe, fittings, and tubing.
5. Polyethylene (PE) tubing.

B. Related Sections:

1. Section 40 90 00 - Identification, Stenciling, and Tagging.
2. Section 33 01 10.58 - Disinfection of Water Utility Piping Systems.
3. Section 40 05 06 - Couplings, Adapters, and Specials for Process Piping.
4. Section 40 05 07 - Hangers and Supports for Process Piping.

1.2 REFERENCES

A. American Society of Testing and Materials (ASTM):

1. ASTM A193/A193M - Standard Specification for Alloy-Steel and Stainless-Steel Bolting for High Temperature or High-Pressure Service and Other Special Purpose Applications.
2. ASTM A194/A194M - Standard Specification for Carbon Steel, Alloy Steel, and Stainless-Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.
3. ASTM D1784 - Standard Specification for Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds.
4. ASTM D1785 - Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120.
5. ASTM D2467 - Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80.
6. ASTM D2564 - Standard Specification for Solvent Cements for Poly (Vinyl Chloride) (PVC) Plastic Piping Systems.
7. ASTM D2737 - Standard Specification for Polyethylene (PE) Plastic Tubing.
8. ASTM D2837 - Standard Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials or Pressure Design Basis for Thermoplastic Pipe Products.
9. ASTM D2855 - Standard Practice for Making Solvent-Cemented Joints with Poly (Vinyl Chloride) (PVC) Pipe and Fittings.
10. ASTM D3261 - Standard Specification for Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing.
11. ASTM F402 - Standard Practice for Safe Handling of Solvent Cements, Primers, and Cleaners Used for Joining Thermoplastic Pipe and Fittings.
12. ASTM F437 - Standard Specification for Threaded Chlorinated Poly (Vinyl Chloride)

(CPVC) Plastic Pipe Fittings, Schedule 80.

13. ASTM F439 - Standard Specification for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80.
 14. ASTM F441/F441M - Standard Specification for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40 and 80.
 15. ASTM F442/F442M - Standard Specification for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe (SDR-PR).
 16. ASTM F477 - Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe.
 17. ASTM F493 - Standard Specification for Solvent Cements for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe and Fittings.
 18. ASTM F656 - Standard Specification for Primers for Use in Solvent Cement Joints of Poly (Vinyl Chloride) (PVC) Plastic Pipe and Fittings.
- B. American National Standards Institute (ANSI):
1. ANSI B16.5 - Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24, Metric/Inch Standard.
- C. National Sanitary Foundation (NSF):
1. NSF 61 - Drinking Water System Components, Health Effects.

1.3 COORDINATION

- A. Coordinate installation of required supporting appurtenances including pipe sleeves in concrete penetration applications and other structural components as they are constructed.
- B. Coordinate installation of piping systems with other trades including but not limited to, HVAC, electrical, instrumentation, and fire protection.
- C. Coordinate flange dimensions, mounting pattern, and type of flange provided with companion flanges of valves, pumps, and equipment to be connected to or installed in the piping system.

1.4 SUBMITTALS

- A. Per Section 01 33 00 - Submittal Procedures: Requirements for submittals.
- B. Product Data:
1. Submit manufacturer's descriptive literature and product specifications for each product provided. At minimum product data to indicate:
 - a. Pressure ratings, bolt patterns, flange types, and gasket material selection.
 - b. Data on pipe materials, pipe fittings, and accessories.
 - c. Provide manufacturer's catalog information with dimensions, material, and assembled weight.
- C. Manufacturer's Certificates:
1. Certify that products meet or exceed specified requirements.
 2. Submit manufacturer's certificate of NSF 61 compliance for all components in direct contact with potable water.
- D. Delegated Design Submittals:

1. Submit Shop Drawings and design calculations for Owner/Engineer approval.
 2. Shop Drawings to Indicate general arrangement including dimensions, special fittings and bends, weights, and all other pertinent fabrication information.
- E. Manufacturer's Instructions: Submit pipe installation instructions including welding preparation.
- F. Source Quality-Control Submittals: Indicate results of shop tests and inspections.
- G. Field Quality-Control Submittals:
1. Submit pressure testing plan for Owner/Engineer approval. Plan shall Include at minimum:
 - a. Testing date(s).
 - b. Piping systems and specific sections to be tested.
 - c. Test type.
 - d. Method of isolation.
 2. Certifications of calibration: Testing equipment.
 3. Certified test results report.
- H. Qualifications Statements: Submit qualifications for Manufacturer.

1.5 CLOSEOUT SUBMITTALS

- A. Per Section 01 70 00 - Execution and Closeout Requirements: Requirements for submittals.
- B. Provide final executed warranty information including terms and conditions with warranty period and start date clearly indicated.
- C. Project Record Documents:
1. Maintain accurate and up-to-date record documents showing Contract and Shop Drawing modifications. Record documents shall show the actual location of all piping and appurtenances on a copy of the Contract Drawings.
 2. Record documents shall show piping with elevations referenced to the project datum and dimensions from permanent structures. For straight runs of pipe provide offset dimensions as required to document pipe location.

1.6 QUALITY ASSURANCE

- A. Materials in Contact with Potable Water: Certified according to NSF 61.
- B. Same Manufacturer to provide all like components including pipe, fittings, and flanges.
- C. Permanently mark each length of pipe with manufacturer's name or trademark and indicate conformance to standards.
- D. Maintain electronic copy of each standard affecting Work of this section on Site.

1.7 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing products specified in this Section with minimum five years' documented experience.

1.8 DELIVERY, STORAGE AND HANDLING

- A. Per Section 01 60 00 - Product Requirements.

- B. Inspection:
 - 1. Accept materials on Site in manufacturer's original packaging and inspect for damage.
 - 2. Obtain bill of lading for each material and/or product.
 - 3. Reject damaged materials.
- C. Storage and Protection:
 - 1. Provide temporary end caps and closures on piping and fittings; maintain in place until installation.
 - 2. UV Protection: Cover or otherwise shield all material stored outdoors.
 - 3. Store all material on wood pallets or timbers.

1.9 EXISTING CONDITIONS

- A. Field Measurements:
 - 1. Contractor shall verify actual dimensions of openings, adjacent facilities and equipment, utilities, and related items by field measurements before fabrication, as applicable.
 - 2. Indicate field measurements on Shop Drawings.
- B. Project/Site Environmental Conditions:
 - 1. Equipment location: Indoor, damp environment.
 - 2. Ambient air temperature range: 10 to 40 degrees C.
 - 3. Ambient air relative humidity range: 5 to 95 percent.

1.10 WARRANTY

- A. All products furnished and installed under this section shall be warranted in accordance with the requirements of Section 01 78 36 - Warranties.

PART 2 - PRODUCTS

2.1 PVC PIPE AND FITTINGS

- A. General:
 - 1. Locations per Contract Drawings and as indicated in Section 40 06 00 or as necessary for exposed potable and non-potable water service, drain, foul air, and chemical feed tubing carrier pipe service.
 - 2. Material properties per ASTM D1784.
- B. Pipe and fittings:
 - 1. Schedule 80 per ASTM D1785.
 - 2. Manufactured with titanium dioxide for UV protection.
- C. Joints:
 - 1. Socket and solvent welded.
 - 2. Provide flanged joints where connected equipment may require future disassembly.
 - 3. Solvent Cement:
 - a. Non-chemical service: Comply with ASTM D2564.
 - b. Chemical service:

- 1) Comply with ASTM F 493.
 - 2) Manufacturer certified for chemical compatibility.
4. Primers:
 - a. Comply with ASTM F656.
 - b. Chemical service: Manufacturer certified for chemical compatibility.
5. Flanges:
 - a. Drilling per ASME B16.5 Class 150.
 - b. Two-piece, flat face, van stone design.
 - c. Flange Bolting:
 - 1) Hex-Head Bolts: Stainless steel; ASTM A193/A193M; Grade B8M Class 1.
 - 2) Hex-Head Nuts: Stainless steel; ASTM A194/A194M; Grade 8M.
 - d. Flange Gaskets:
 - 1) Type: Full faced per ASME B16.21.
 - 2) Material: EPDM

2.2 CVPC PIPE AND FITTINGS

- A. General:
 1. Locations per Contract Drawings and as indicated in Section 40 06 00 or as necessary for exposed chemical conveyance service including clean-In-place process streams.
 2. Materials properties per ASTM D1784.
- B. Pipe and fittings:
 1. Schedule 80 per ASTM F441 and F439.
 2. Manufactured with titanium dioxide for UV protection.
- C. Joints:
 1. Socket and solvent welded.
 2. Provide flanged joints where connected equipment may require future disassembly.
 3. Solvent Cement:
 - a. Chemical service:
 - 1) Comply with ASTM F 493.
 - 2) Manufacturer certified for chemical compatibility.
 4. Primers:
 - a. Comply with ASTM F656.
 - b. Chemical service: Manufacturer certified for chemical compatibility.
 5. Flanges:
 - a. Drilling per ASME B16.5 Class 150.
 - b. Two-piece, flat face, van stone design.
 - c. Flange Bolting:
 - 1) Hex-Head Bolts: Stainless steel; ASTM A193/A193M; Grade B8M Class 1.
 - 2) Hex-Head Nuts: Stainless steel; ASTM A194/A194M; Grade 8M.
 - d. Flange Gaskets:

- 1) Type: Full faced per ASME B16.21.
- 2) Material: EPDM

2.3 PVDF TUBE AND FITTINGS

- A. General:
 1. Locations per Contract Drawings and as indicated in Section 40 06 00 or as necessary for exposed highly corrosive chemical feed service.
- B. Tube:
 1. Size and Wall thickness: As indicated in Section 40 06 00.
 2. Minimum working pressure: 100 psig.
 3. Color: White or clear.
- C. Joints:
 1. Type: Barblock compression type inserts with external closure collar.
 2. Material: Polypropylene or as required for chemical compatibility.

2.4 PE TUBE AND FITTINGS

- A. General:
 1. Locations per Contract Drawings and as indicated in Section 40 06 00 or as necessary for exposed chemical feed service.
- B. Tube:
 1. Size and Wall thickness: As indicated in Section 40 06 00.
 2. Minimum tensile elongation at break shall be at least 700 percent, in accordance with ASTM D 638.
 3. Environmental-stress-cracking resistance F50 in accordance with ASTM D 1693: 1,000 hours.
 4. Minimum working pressure: 100 psig.
 5. Color: White or clear.
- C. Joints:
 1. Type: Barblock compression type inserts with external closure collar.
 2. Material: Polypropylene or as required for chemical compatibility.

2.5 SOURCE QUALITY CONTROL

- A. Shop Tests and Inspections:
 1. Pipe manufacturer shall maintain continuous quality control program.
 2. Where applicable and when requested by Engineer, submit results of source quality control tests specified in reference standards.
- B. Stamp, mark, or otherwise indicate on product:
 1. Name or trademark of manufacturer.
 2. Weight, class, or nominal thickness.
 3. Country where manufactured.
 4. Year the pipe was produced.

5. Nominal Size.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Inspect pipe materials for defects in material and workmanship.
- B. Verify that field dimensions are as indicated on Shop Drawings.
- C. Location of Existing Piping:
 - 1. Locations of existing piping shown on Contract Drawings are approximate.
 - 2. Determine the true location of existing piping to which connections are to be made, crossed, and that could be disturbed.
- D. Inspect existing flanges for nonstandard bolt hole configurations or design and verify that new pipe and flange mate properly.
- E. Verify compatibility of new pipe and fittings.
- F. Stop Work and Request for Interpretation to Engineer upon conflicting horizontal locations and vertical elevations.

3.2 INSTALLATION

- A. Per ASME B31.3.
- B. Piping runs:
 - 1. Straight along alignment as indicated on Shop Drawings, with minimum number of joints.
 - 2. Install vertical pipe plumb in all directions unless otherwise shown on Contract Documents.
 - 3. Install piping parallel or perpendicular to walls of structures. Piping at angles and 45 degree runs across corners of structures will not be accepted unless specifically shown on the Contract Documents or approved by the Engineer.
 - 4. Piping upstream and downstream of flow measuring devices shall provide straight lengths as required for accurate flow measurement.
- C. Group piping wherever practical at common elevations; install to conserve building space and not interfere with the use of space and other Work.
- D. Install piping to permit valve servicing.
- E. Install small diameter piping generally as shown when specific locations and elevations are not indicated. Locate such piping as required to avoid ducts, equipment, beams, and other obstructions.
- F. If there is a conflict between manufacturer's recommendations and the Contract Documents, request in writing instructions from Engineer before proceeding.
- G. Install piping to leave all corridors, walkways, work areas, and similar spaces unobstructed. Unless otherwise approved by Engineer provide a minimum headroom clearance under piping and pipe supports of 7.5 feet. Clearances beneath piping shall be measured from the outermost edge of piping, flanges or other type of joint that extends beyond the nominal outside diameter of piping.

- H. Field Cuts: According to pipe manufacturer instructions.
- I. Joining:
 - 1. Primers and Cleaners: Comply with ASTM F402.
 - 2. PVC Solvent-Cemented Joints: Comply with ASTM D2855.
- J. Insulation: As indicated on Contract Drawings and/or in Section 40 06 00.

3.3 FIELD QUALITY CONTROL

- A. Per Section 01 70 00 - Execution and Closeout Requirements.
- B. Inspection:
 - 1. Inspect for piping defects that may be detrimental as determined by the Engineer.
 - 2. Repair damaged piping, or provide new, undamaged pipe.
 - 3. After installation, inspect for proper supports and interferences.
- C. Pressure Pipe Testing:
 - 1. Notify the Engineer in writing 5 days in advance of testing. Perform testing in the presence of the Engineer.
 - 2. Per ASME B31.3, Appendix H.
 - 3. Conduct hydrostatic test for minimum ten minutes.
 - 4. Water used for testing purposes shall be potable water only.
 - 5. Test Pressure:
 - a. 125 percent of maximum anticipated piping system working pressure or as indicated on Section 40 06 00.
 - b. Not greater than the working pressure of the lowest rated component in the piping system.
 - 6. Filling:
 - a. Fill section to be tested with water slowly and expel air from piping at high points.
 - b. Maximum Fill Velocity: 1.0 foot per second.
 - c. Ensure that all air has been expelled through air and vacuum release valves, taps, or connections shown on Contract Drawings for permanent piping, valves, or accessories. Do not make additional taps solely for air expulsion purposes unless approved by Engineer.
 - d. Close air vents and corporation cocks after air is expelled.
 - e. Raise pressure to specified test pressure in 25 psi increments resting a minimum of 2 minutes between increments.
 - 7. Examination shall be made of all joints and flanges. There shall be no visible evidence of leakage. Joints previously tested need not be examined for leaks.
 - 8. If test indicates leakage, locate source of leakage, make corrections, and retest until zero leakage is achieved.
 - 9. Pressure testing of neat polymer lines shall be performed with food grade mineral oil. Lines shall be air-dried to eliminate moisture following the cleaning and pressure testing.
- D. Vacuum Testing for Chlorine Gas Vacuum Piping:

1. Establish vacuum in the test pipe section as verified with a calibrated vacuum gauge, isolate the pipe section, and continue to measure the vacuum in the pipe section over a 60-minute period. The maximum allowable vacuum reduction in the pipe section after 60 minutes shall be 5 percent of the specified test vacuum (e.g., if the test vacuum is specified as 20-inch Hg, the vacuum reading at the end of the test shall be at least 19-inch Hg vacuum).
 2. Defective pipe sections shall be corrected and retested.
- E. Test Report:
1. Shall include at minimum:
 - a. Test date and time.
 - b. Description and identification of piping test boundaries.
 - c. Test fluid.
 - d. Test pressure.
 - e. Test duration.
 - f. Remarks, including the type and location of leaks and the repair or replacement performed to remedy excessive leakage.
 - g. Certification by signature of the Contractor and Engineer that the test(s) was satisfactorily completed.

3.4 CLEANING

- A. Following assembly and testing and prior to disinfection and final acceptance, flush pipelines, except as specified in this Section, with potable water at 2 1/2 fps minimum flushing velocity until foreign matter is removed.
- B. Blow clean of loose debris plant process air, carbon dioxide, natural gas, and instrument air lines with compressed air at 4,000 fpm; do not flush with water.
- C. Disinfection: Disinfect potable-water piping as specified in Section 33 01 10.58 - Disinfection of Water Utility Piping Systems.
- D. Chlorine Gas Vacuum Piping and Tubing: Blow pipe clean of loose debris with instrument-grade clean and dry compressed air. Ensure the pipe is open, not valved off, at the end of the section to be cleaned so the pipe does not become pressurized. Do not pressurize PVC with compressed air. Do not flush chlorine gas vacuum piping with water. After cleaning, purge the air with nitrogen gas.

3.5 IDENTIFICATION

- A. Per Section 40 90 00 "Identification, Stenciling, and Tagging."

3.6 SCHEDULE

- A. Refer to Section 40 06 00.

END OF SECTION

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SECTION 40 05 51
COMMON REQUIREMENTS FOR PROCESS VALVES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. This Section includes the following general-duty valves:
 - 1. Ball Valves, Bronze, 2-1/2 inches and smaller.
 - 2. Ball Valves, Ferrous-Alloy, 2-1/2 inches and smaller.
 - 3. Ball Valves, PVC, 6 inches and smaller.
 - 4. Ball Valves, Stainless Steel, 12 inches and smaller.
 - 5. Check Valves, Bronze 3-inch and smaller.
 - 6. Check Valves, PVC, 4 inches and smaller.
 - 7. Check Valve, Iron Body, 3-inch and smaller.
 - 8. Diaphragm Valves, 1/2-inch and larger.
 - 9. Backflow Preventer, Reduce Pressure.
 - 10. Instrument Air Shutoff Valve.
 - 11. Combination Balancing and Shutoff Valve.
 - 12. Sampling valve.
 - 13. Pressure Relief Valves.
 - 14. Pressure Reducing Valves.
 - 15. Solenoid Valves.
 - 16. Valve appurtenances.
- B. Related Sections:
 - 1. Refer to Section 40 05 01 "Piping Systems, Basic Materials and Methods" for information regarding correlation with piping system submittals; coordination; material delivery, handling, and storage; project conditions; design requirements; other materials; installation of piping systems; field testing; and related work.
- C. Valve and Related Lists: Lists are included for the convenience of the Engineer and Contractor and are not complete listings of all valves, devices and material to be provided under this Contract. The Contractor agrees to prepare his own material and valve takeoff lists as necessary to meet the requirements of the Project.

1.3 DEFINITIONS

- A. Following are standard abbreviations used for valves:
 - 1. CWP: Cold working pressure.
 - 2. EPDM: Ethylene-propylene-diene terpolymer rubber.
 - 3. NRS: Nonrising stem.
 - 4. OS&Y: Outside screw and yoke.
 - 5. PTFE: Polytetrafluoroethylene plastic.
 - 6. SWP: Steam working pressure.
 - 7. WOG: Water, oil and gas (Cold working pressure)
 - 8. TFE: Tetrafluoroethylene plastic.

1.4 SUBMITTALS

- A. Product Data: For each type of valve indicated. Include body, seating, and trim materials; valve design; pressure and temperature classifications; end connections; arrangement; dimensions; and required clearances. Include list indicating valve and its application. Include rated capacities; shipping, installed, and operating weights; furnished specialties; and accessories.
- B. Provide a detailed list of any exceptions taken to these specifications. Include specification reference and proposed alternative with reason stated for exception. If Manufacturer and/or Contractor fails to describe such exceptions, the responsible entity will not be relieved of the responsibility for executing the work as described herein, even though such shop drawings have been reviewed by the Engineer.
- C. Product Certificates: For each type of valve, from manufacturer.
 - 1. Compliance with AWWA, ASTM, and ANSI standards including hydrostatic tests, operational tests and other testing required by the standards.
- D. Operation and Maintenance Data: Provide in accordance with Division 1 Section 01 78 23 "Operation and Maintenance Data."
- E. Field Quality Control: Provide field testing and performance reports.

1.5 QUALITY ASSURANCE

- A. Obtain all valves of the same style and type, along with the associated manual operators, from a single manufacturer.
- B. NSF Compliance: NSF 61, "Drinking Water Systems Components – Health Effects" for valve materials for potable-water service.
- C. Valve manufacturer shall demonstrate a minimum of five years of experience in similar applications for size of valves furnished. References shall be provided upon request.
- D. Valve supplier shall maintain a complete stock of parts in the state where the Project is constructed or shall indicate that parts will be delivered upon 48-hour after receipt of request.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Prepare valves for shipping as follows:
 - 1. Protect internal parts against rust and corrosion.
 - 2. Protect threads, flange faces, grooves, and weld ends.
 - 3. Set angle, gate, and globe valves closed to prevent rattling.
 - 4. Set ball and plug valves open to minimize exposure of functional surfaces.
 - 5. Set butterfly valves closed or slightly open.
 - 6. Block valves in either closed or open position.
- B. Use the following precautions during storage:
 - 1. Maintain valve end protection.
 - 2. Store valves indoors and maintain at higher than ambient dew-point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.
 - 3. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use handwheels or stems as lifting or rigging points.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, those listed in the valve descriptions.
- B. Naming of a manufacturer does not indicate approval nor eliminate their responsibility of providing equipment in compliance with the component features as specified herein. All manufacturers are required to comply fully with these specifications. Any deviations without sufficient evidence proving equal or superior quality shall be rejected without further review.

2.2 GENERAL

- A. Valve to include operator, actuator, handwheel, chain wheel, extension stem, floor stand, worm and gear operator, operating nut, chain, wrench, valve boxes, and all accessories and related equipment for a complete operating system. Refer to P&ID Drawings for valves requiring limit switches, electric or pneumatic operators, and related controls.
- B. Comply with the following:
 - 1. Service: Suitable for intended service, with valve pressure and temperature ratings not less than indicated and as required for the system pressures and temperatures.
 - 2. Valve Sizes: Same size as connection to upstream piping, unless otherwise indicated.
 - 3. Valve Ends (Unless otherwise specified):
 - a. Compatible with adjacent piping or equipment connections.
 - b. Bronze Valves: 2-inch and Smaller; threaded or soldered ends depending on application.
 - c. Ferrous valves, 3-inch and Smaller: Threaded ends.
 - d. Ferrous Valves, 3-inch and Larger:
 - 1) Exposed Valves: Flanged ends.
 - 2) Buried Valves: Mechanical joint ends.
- C. Valve Actuators:
 - 1. Operator sized to operate valve for full range of pressures and velocities.
 - 2. Open by turning counterclockwise, close by turning clockwise, unless otherwise specified.
 - 3. Chainwheel: For attachment to valves, of size and mounting height, as indicated in the "Valve Installation" Article in Part 3.
 - 4. Gear Drive Operator: For quarter-turn valves 8-inch and larger.
 - 5. Handwheel: For valves other than quarter-turn types.
 - 6. Lever Handle: For quarter-turn valves 6-inch and smaller.
 - 7. Wrench: For valves with square heads. Furnish Owner with one wrench for every 10 valves, for each size square plug head.
- D. Valves in Insulated Piping: Valves shall have 2-inch stem extensions and the following features:
 - 1. Gate Valves: Shall be rising-stem type.
 - 2. Ball Valves: Shall have extended operating handle of non-thermal-conductive material, protective sleeve that allows operation of valve without breaking the vapor seal or disturbing insulation, and memory stops that are fully adjustable after insulation is applied.
 - 3. Butterfly Valves: Shall have extended necks.
- E. Valve Flanges: ASME B16.1 for cast-iron valves, ASME B16.5 for steel valves and ASME B16.24 for bronze valves.

- F. Valve Grooved Ends: AWWA C606.
- G. Solder Joint: With sockets according to ASME B16.18.
 - 1. Caution: Use solder with melting point below 840 deg F for angle, check, gate, and globe valves; below 421 deg F for ball valves.
- H. Threaded: With threads according to ASME B1.20.1.
- I. Valve Bypass and Drain Connections: MSS SP-45.
- J. Factory assemble valve with operator, actuator and accessories.
- K. Fasteners for flanged valves shall be as follows: Comply with pipe joining material requirements of Division 40 Section 40 05 01, "Piping Systems, Basic Materials and Methods."
- L. Obtain all valves of the same type and materials of construction with associated manual operators from a single manufacturer.

2.3 MATERIALS

- A. Brass and bronze valve components and accessories shall be made with dezincification-resistant materials. Bronze valves made with copper alloy (brass) containing more than 15 percent zinc are not permitted.
- B. Approved alloys are of the following ASTM designations:
 - 1. B61, B62, B98 (Alloy No. C65100, C65500, or C66100), B127, B139 (Alloy No. C51000), B584 (Alloy UNS No. C90300 or C94700), B164, and B194.
 - 2. Stainless steel, ANSI Type 316 may be substituted for bronze.

2.4 FACTORY FINISHING

- A. Interior Lining and Coating:
 - 1. Interior ferrous metal surfaces of valve body, stem, actuator and related components shall be epoxy coated in accordance with AWWA C550 "Protective Interior Coatings for Valves and Hydrants", unless otherwise specified.
 - 2. Epoxy coating material shall be NSF approved for use in potable water.
 - 3. Either two-part liquid material or heat-activated (fusion) material except only heat-activated material if specified as "fusion" or "fusion bonded" epoxy.
 - 4. Minimum 12-mil dry film thickness except where limited by valve operating tolerances. Epoxy coating shall be spark tested at the valve manufacturer's factory in accordance with AWWA C550 to verify uniform thickness. A certified test report on valve manufacturer's letterhead shall be supplied for each valve furnished.
 - 5. Color to match adjacent piping. Coating application to be accomplished in accordance with Division 9.
 - 6. Safety isolation and lockout valves with handles, handwheels, or chain wheels "Safety Yellow."
 - 7. Exposed valves, other than above, paint handles, handwheels, or chain wheels "Red."
 - 8. Material in contact with water shall conform to NSF/ANSI 61.

2.5 BALL VALVE

- A. Bronze Ball Valves, General: MSS SP-110 and have bronze body complying with ASTM B 584, except for Class 250 which shall comply with ASTM B 61, full-depth ASME B1.20.1 threaded or solder ends, and blowout-proof stems.
 - 1. Two-Piece, Full-Port, Bronze Ball Valves with Bronze Trim: Chrome-plated bronze ball and bronze stem and; reinforced TFE seats; threaded body packnut design (no

threaded stem designs allowed) with adjustable stem packing, solder or threaded ends; and 150 psig SWP 600 psig CWP rating.

a. Manufacturers:

- 1) Crane ChemPharma Energy.
- 2) NIBCO.
- 3) Conbraco Apollo.
- 4) Milwaukee Valve.

2. Two-Piece, Full-Port, Bronze Ball Valves with Stainless-Steel Trim: Type 316 stainless-steel vented ball and stem, reinforced TFE seats, threaded body packnut design (no threaded stem designs allowed) with adjustable stem packing, soldered or threaded ends; 150 psig SWP and 600-psig CWP ratings.

a. Manufacturers:

- 1) Crane ChemPharma Energy.
- 2) NIBCO.
- 3) Milwaukee Valve.

B. Ferrous-Alloy Ball Valve, 3-inch and Smaller:

1. Split-body construction, ASTM A-216 Type WCB, carbon-steel body; ASTM A-351, Type CF8M vented stainless-steel ball; and ASTM A-276, Type 316 stainless-steel stem; carbon-filled TFE seats; 285 psig CWP rating.
2. Fire rated according to API 607 (4th edition); and having flanged ends and blowout-proof stem.
3. Conforms to MSS SP-72.
4. Manufactures:
 - a. Crane ChemPharma Energy.
 - b. NIBCO.
 - c. Milwaukee Valve.

C. PVC/CPVC Ball Valve, 2 inches and Smaller:

1. True union type manufactured to ASTM F 1970 and constructed from PVC Type 1, ASTM D 1784 Cell Classification 12454 or CPVC Type IV, ASTM D 1784 Cell Classification 23447; O-rings shall be EPDM or Viton®; ball seats of PTFE, EPDM, or EPDM backed PTFE; handles of polypropylene; supplied with solvent-welded or threaded ends; approved for potable water service; rated at 150 psi at 73°F; and shall be full port and block flow in both directions.
2. Manufacturer:
 - a. ASAHI-America.
 - b. Hayward.
 - c. Teflon.
 - d. NIBCO.
 - e. Spears.

D. PVC/CPVC Ball Valve, 3 inches through 6 inches:

1. True union type manufactured to ASTM F 1970 and constructed from PVC Type 1, ASTM D 1784 Cell Classification 12454 or CPVC Type IV, ASTM D 1784 Cell Classification 23447; O-rings shall be EPDM; ball seats of PTFE; handles of polypropylene; supplied with solvent-welded connections or flanged ends drilled to ASME B16.4; approved for potable water service; provide a pressure relief hole drilled on the low pressure side of ball; rated at 150 psi at 73 degrees F; and shall be full port and block flow in both directions.
2. Manufacturers:
 - a. ASAHI-America.
 - b. NIBCO.

- c. Spears.
- E. Stainless Steel Ball Valve, ½-inch to 2 inches:
 - 1. Three-piece body, full port, vented ball, block-out proof stem, Type 316 stainless steel trim, reinforced TFE seat and seal, threaded ends, lever operator, rated 1000-psi CWP. Conforms to MSS SP-110.
 - 2. Manufacturers:
 - a. KF Valves Contromatics.
 - b. Crane ChemPharma Energy.
 - c. NIBCO.
- F. Stainless Steel Ball Valve, 3 inches to 12 inches:
 - 1. Unibody design, blowout-proof stem, Type 316 stainless steel trim, mounting pad, fire safe, vented ball, flanged ends, rated 275-psi CWP. Conforms to MSS SP-72 and MSS SP-25.
 - 2. Manufacturers:
 - a. NIBCO.

2.6 CHECK VALVES

- A. PVC/CPVC Check Valve, 4 inches and Smaller:
 - 1. True union type manufactured to ATSM F 1970 and constructed from PVC Type 1, ASTM D 1784 Cell Classification 12454 or CPVC Type IV, ASTM D 1784 Cell Classification 23447; O-rings and seals shall be EPDM or Viton®; ball seats of PTFE or standard O-ring type; approved for potable water service; having replaceable valve components; and rated 150-psi at 70 degrees F.
 - 2. Manufacturers:
 - a. ASAHI-America.
 - b. NIBCO.
 - c. Spears.
- B. Class 125 Bronze Check Valve, 3-inch and Smaller:
 - 1. Bronze, horizontal swing, regrinding type, Y-pattern, renewable seat and disc, 2-inch and smaller rated 125-psi SWP and 200-pound CWP, size 2-1/2-inch and 3-inch rated 150-psi SWP and 300-CWP, Conforms to MSS SP-80.
 - 2. Manufacturers:
 - a. Crane ChemPharma Energy.
 - b. NIBCO.
 - c. Powell Valves.
- C. Class 125 Iron Body Check Valve, 3-inch and Smaller:
 - 1. Class 125, iron body, horizontal swing, regrinding type, Y-pattern, renewable seat and disc, 2-inch and smaller rated 125-psi SWP and 200-pound CWP, size 2-1/2-inch and 3-inch rated 150-psi SWP and 300-CWP, Conforms to MSS SP-70.
 - 2. Manufacturers:
 - a. Crane ChemPharma Energy.
 - b. NIBCO.
 - c. Powell Valves.

2.7 DIAPHRAGM VALVES

- A. Diaphragm Valves, 1/2-Inch and Larger:
 - 1. Type: Weir type, polypropylene-lined cast iron body, ANSI B16.1 flanged ends, manual operator indicating rising stem type with handwheel, diaphragm neoprene, in accordance with MSS-SP-88, Category B.

2. Manufactures:
 - a. ITT Engineered Valves.
 - b. Saunders Valve, Inc.
- B. Diaphragm Valves, 1/2-Inch and Larger:
 1. Type: Straight-through type, polypropylene-lined cast iron body, ANSI B16.1 flanged ends, manual operator indicating rising stem type with handwheel, diaphragm neoprene, in accordance with MSS-SP-88, Category B.
 2. Manufacturers:
 - a. ITT Engineered Valves.
 - b. Saunders Valve, Inc.
- C. Diaphragm Valve, Plastic Body, 1/2-Inch and Larger:
 1. Type: Weir Type, constructed from CPVC Type IV, ASTM D 1784 Cell Classification 23447; multiple layers of EPDM, PTFE, PVDF, or Viton®; flanged end connections; built-in position indicator with polypropylene handwheel; reinforced polypropylene bonnet, stainless steel hardware.
 2. Pressure Rating:
 - a. 1/2-inch through 4-inch: 150-psi at 73 degrees F.
 - b. 6-inch: 100-psi at 73 degrees F.
 - c. 8-inch: 75-psi at 73 degrees F
 3. Manufacturer:
 - a. ASAHI America.
 - b. Spears.

2.8 MISCELLANEOUS VALVES AND RELATED ITEMS

- A. Reduced Pressure backflow Preventer:
 - a. Refer to Division 22.
- B. Instrument Air Shutoff Valve:
 1. Stainless steel body and ball, nylon handle.
 2. Manufacturer and Product:
 - a. Swagelok; Series 40.
 - b. Imperial Eastman; Series 200.
- C. Sampling Valve:
 1. Description: Insertion type, Type 304 stainless steel bonnet, Type 316 stainless steel piston and stem, threaded end connections, hand crank, rated 600-psig CWP.
 2. Manufactures and Products:
 - a. Strahman; SV700.
- D. Pressure Relief Valves (NOT USED):

2.9 SELF-CONTAINED AUTOMATIC VALVES

- A. Pressure-Reducing Valve, 2-1/2 Inches and Smaller.
 1. Type: Direct diaphragm operated, spring controlled, bronze body.
 2. Size(s) and Rating(s): As shown in Section 40 06 00.
 3. Manufacturers and Products:
 - a. Fisher; Type 75A.
 - b. Mueller.
- B. Pressure-Reducing Valve, 3 inches and Larger:
 1. Function:

- a. Automatically reduces a higher inlet pressure to a steady lower downstream pressure, regardless of changing flow rate and/or varying inlet pressure.
 - b. Pilot-operated regulator capable of holding downstream pressure to a pre-determined limit. When downstream pressure exceeds the pressure setting of the control pilot, the main valve and pilot valve close bubble-tight.
 - 2. Main Valve: Hydraulically operated, single diaphragm-actuated, pilot controlled, globe valve, consisting of:
 - a. Ductile iron, ASTM A536, or cast steel, ASTM A216-WCB, body and bolted cover. All working parts shall be accessible without removal of the valve from the line.
 - b. Disc Retainer and Diaphragm Washer: Cast Iron.
 - c. Trim: Disc guide, seat and cover bearing, bronze or stainless steel.
 - d. Disc: Buna-N rubber.
 - e. Stem, Nut and Spring: Stainless steel.
 - f. End Connections: Flange, 150 ANSI.
 - g. Flows: See Section 40 06 00.
 - 3. Pilot Control System: Direct-acting, adjustable, spring-loaded, normally open, diaphragm valve, designed to permit flow when pressure is less than the spring setting.
 - a. Pilot Control: Bronze, ASTM B62.
 - b. Trim: Type 303 stainless steel.
 - c. Disc: Buna-N rubber.
 - d. Adjustment Ranges: See Section 40 06 00.
 - 4. Manufacturers and Products:
 - a. CLA-VAL; Model 90.
 - b. Bermad; Model 720.
 - c. GA Industries.
- C. Solenoid Valve, 2-Inch and Smaller:
- 1. Type: Two-way internal pilot operated diaphragm type, brass body, resilient seat suitable for air or water, solenoid coil molded epoxy, NEMA Class A, 120 volts ac, 60-Hz, unless otherwise indicated. Solenoid enclosure NEMA 250, Type 4, unless otherwise indicated.
 - 2. Sizes and normal position (OPEN or CLOSED) as indicated.
 - 3. Minimum operating pressure differential no greater than 5-psig, maximum operating pressure differential not less than 125-psig.
 - 4. Manufacturers:
 - a. ASCO.
 - b. Skinner.
- D. Ball Valves, Electric Operated, 2-Inch and Smaller:
- 1. Type: Continuous duty rated true union ball valve with manual override and NEMA 4X nonmetallic housing over actuator, closure time 6 seconds for 90° cycle.
 - 2. Materials.
 - a. Body: PVC or CPVC to match piping, minimum pressure rating 230-psi.
 - b. Seals: EPDM or Vitron as applicable for intended service.
 - c. Motor: Heavy duty gear train, reversible motor with thermal overload switch, 120-volt, 60-Hz, with position indicator.
 - 3. Manufactures and Products:
 - a. GF Model 346 ball valve with Type EA20 actuator and Type 126 bracket.

2.10 APPURTENANCES

A. Manual Operators:

1. Provide manual operators on valves.
 - a. Operator force not to exceed 40 pounds under any operating conditions, including initial breakaway. Gear reduction operator when force exceeds 40 pounds.
 - b. Operator self-locking or equipped with self-locking devices.
 - c. Position indicator on quarter-turn valves
 - d. Worm and gear operators one-piece design worm-gears of gear bronze material. Worm hardened alloy steel with thread ground and polished. Traveling nut type operators threaded steel reach rods with internally bronze or ductile iron nut.
 2. Exposed Operator:
 - a. Galvanized and painted handwheels.
 - b. Lever operators allowed on valves 6 inches and smaller.
 - c. Cranks on gear operators.
 - d. Chain wheel operator with tie backs, extension stem, floor stands, and other accessories to permit operation from normal operation level.
 - e. Valve handles to take a padlock and handwheels a chain and padlock.
 - f. Handwheels to comply with requirements of AWWA C500, Section 4.4.13 "Wrench Nuts and Handwheels."
 3. Buried Valves: Wrench Nuts:
 - a. Buried Valves: 2-1/2-Inch and Smaller: Provide cross handle for operation by a forked key.
 - b. Buried Valves, 3-Inch and Larger: Provide wrench nuts on buried valves, on valves which are to be operated through floor boxes and where shown on Drawings.
 - 1) Comply with requirements of AWWA C500, Section 4.4.13 "Wrench Nuts and Handwheels."
 - 2) Furnish no less than two operating keys for operation of wrench nut operating valves.
 - c. Provide concrete pad around valve box at ground surface as shown on the Drawing details.
 4. Design buried service valves for quarter-turn valves to withstand 450 foot-pounds of input torque at the fully open or FULLY CLOSED positions, grease packed and gasketed to withstand a submersion in water to 10-psi.
 5. Buried valves shall have a valve box. Valve box and bonnet shall be cast iron. All components of shaft extensions shall be Type 316 stainless steel including nut shaft, shaft housing and guides.
 6. Extension stem diameter shall be 1-inch or diameter of valve shaft, whichever is greater.
 7. Stem guides made of cast iron with bronze bushings with adjustable offset. Provide stem guides at 5-foot intervals.
- B. Chain Wheel and Guide: Handwheel direct mounted, with galvanized or cadmium-plated chain.
- C. Operating Stands:
1. Provide fabricated steel or cast iron operating stands in locations shown on the Drawings.
 2. Support handwheel or operator approximately 36 inches above finish floor.
 3. Handwheel diameter will not be less than 8 inches.
 4. Provide sleeve made for opening in floor beneath each operating stand.
 5. Provide suitable thrust bearing in each operating stand to carry weight of extension stem.

D. Valve Boxes:

1. Cast iron, extension sleeve type, suitable for depth of cover required by Drawings.
2. Not less than 5 inches in diameter and minimum thickness at any point of 3/16-inch; provide valve boxes with suitable cast iron bonnets, bases and covers.
3. Provide covers; cast thereon an appropriate name designating service for which valve is used.
4. When located in traffic areas, designed for H-20 loadings.
5. Set valves and valve boxes plumb; place each valve box directly over valve it serves, with top of box flush with finished grade.
6. As shown on Drawings, provide concrete pad around valve surface box at ground surface.

E. Extension Stem:

1. Provide extension stem when depth of valve is more than 3-feet below finish grade.
2. Provide extension stem with wrench nut locating the wrench nut 6 inches below ground surface and/or box cover.
3. Extension stem shall locate wrench nut in floor box.

F. Floor Box and Stem: Plain type for support of non-rising type stem, complete with stem, operating nut, and stem guide brackets. Provide stainless steel guides with adjustable offset. Spaced such that stem L/R ratio does not exceed 200. Anchor bolts to be Type 316 stainless steel.

G. Torque Tube: Where operator for quarter-turn valve is located on floor stand, furnish extension stem torque tube of a type properly sized for maximum torque capacity of valve.

H. Identification: Provide valve identification tags in accordance with Division 10 Section 10 90 00 "Identification, Stenciling, and Tagging" and as specified in the various Valve Schedules and as shown on the Drawings.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine piping system for compliance with requirements for installation tolerances and other conditions affecting performance.
 1. Proceed with installation only after unsatisfactory conditions have been corrected.
- B. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.
- C. Operate valves in positions from fully open to fully close. Examine guides and seats made accessible by such operations.
- D. Examine threads on valve and mating pipe for form and cleanliness.
- E. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.
- F. Do not attempt to repair defective valves; replace with new valves.

3.2 INSTALLATION

A. General:

1. Install valves, floorstands, valve boxes, and appurtenances in accordance with the Drawings and manufacturer's instructions.
 2. Install valves and operators or actuators to provide for ease of access and operation.
 3. Install buried valve.
- B. Flanged Ends:
1. Bolt holes shall straddle vertical centerline of pipe.
 2. Clean flange faces insert gasket and bolts, and tighten nuts progressively and uniformly.
- C. Threaded Ends:
1. Clean threads by wire brushing or swabbing.
 2. Apply joint compound.
- D. Valve Installation:
1. Piping installation requirements are specified in other Division 40 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
 2. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.
 3. Locate valves for easy access and provide separate support where necessary. Provide access doors in finished walls and plaster ceilings for valve access.
 4. Install valves in horizontal piping with stem at or above center of pipe.
 - a. Butterfly valves will be installed with stem horizontal to allow support for the disc and the cleaning action of the disc.
 - b. Unless otherwise noted, install operating stem vertical in horizontal runs of pipe having centerline elevations 4 feet 6 inches or less above finished floor.
 - c. Unless otherwise noted, install operating stem horizontal in horizontal runs of pipe having centerline elevation between 4 feet 6 inches and 7 feet above finish floor.
 5. Install valves in position to allow full stem movement.
 6. Install check valves for proper direction of flow and as follows:
 - a. Swing Check Valves: In horizontal position with hinge pin level.
 - b. Dual-Plate Check Valves: In horizontal or vertical position, between flanges.
 - c. Lift Check Valves: With stem upright and plumb.
 7. Butterfly valves shall be installed with stems horizontal.
 8. If a plug valve seat position is not shown, locate as follows:
 - a. Horizontal Flow: The flow shall produce an "unseating" pressure; the plug shall open into the top half of valve.
 - b. Vertical Flow: Install seat in the highest portion of the valve.
 9. Install line size ball valve and union upstream of each solenoid valve, in-line flow switch, or other in-line electrical device, excluding magnetic flowmeters, for isolation during maintenance.
 10. Provide union or flanged connection within two feet of each threaded end valve unless valve can be otherwise easily removed from piping.
 11. Install safety isolation valves on compressed air lines which have stored energy in accordance with latest OSHA requirements.
- E. Valve Operators:
1. Manual Operators:
 - a. Provide manual operators on valves, including those which are equipped with power or pneumatic actuated operators or designed for automatic operation.
 - b. Unless otherwise specified in the various valve sections, provide handwheel or lever operators for valves, 6-inch and smaller, and gear operators for valves, 8-inch and larger.

2. Buried Service:
 - a. 2-1/2-inch and smaller:
 - b. 3-inch and Larger (not installed in Valve Vault):
 - 1) Provide stainless steel shaft extension and wrench nut. Minimum extension stem diameter shall be 1-inch or diameter of valve shaft, whichever is larger.
 - 2) Provide valve box, bonnet and cover.
 - c. Wrench nut, handwheel and gear operator shall comply with the requirements of applicable AWWA Standards.
 - d. As shown on the Drawings, buried Valves, 8-inch and larger, shall rest on concrete pad. Pad shall extend full width of trench, from back-to-back of hub or flange.
3. Above Ground Service:
 - a. 3-inch and Larger: gear operators all valves 8-inch and larger, unless otherwise noted.
 - b. Chain Wheel Operators: Install chain wheel operators on valves 4-inch and larger and more than 84 inches above floor, unless otherwise noted. Extend chains to 60 inches above finished floor elevation. Where chains hang in normally travel areas, use appropriate "L" type tie-back anchors.
4. Electric and pneumatic operators and actuators shall comply with the requirements of the applicable Division 40 operator section.

3.3 FIELD QUALITY CONTROL

A. Perform Tests and Inspections:

1. Valve may be either tested while testing pipelines, or as a separate step.
2. Test that valve opens and closes smoothly with operating pressure on one side and atmospheric pressure on the other, in both directions for two-way valve and applications.
3. Count and record the number of turns to open and close valve; account for any discrepancies with manufacturer's data.
4. Set, verify, and record set pressures for all relief and regulating valves.
5. Automatic valves to be tested in conjunction with control system testing and as specified under Manufacturer's services.

B. Prepare test and inspection reports.

3.4 MANUFACTURERS' SERVICES

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and valve installations, including connections, and to assist in testing. Provide in accordance with Division 1.
- B. For every **five** pneumatic or electrically operated valves or gates, or less, provided on the Project, a qualified manufacturers' representative shall be present at the Project site for the minimum person-days, travel excluded, as indicated:

Person-Days	Activity Description
1/2	Inspection of valve installation, functional testing, and certification valve assembly has been installed and tested in accordance with manufacturer's instructions and these specifications.
1/2	Plant startup.
1/2	Training of Owner's personnel in operation and maintenance.

- C. Startup Services; Comply with the requirements of Section 01 75 00 "Starting and Adjusting".
- D. Training of Owner's Personnel: Comply with the requirements of Division 1 requirements.

3.5 VALVE SCHEDULE

- A. Section 40 06 00

END OF SECTION

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SECTION 40 05 61
GATE VALVES

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes the following gate valves:
 - 1. AWWA Ductile-Iron Resilient-Seated Gate Valves, 3-inch and larger.

B.

1.2 RELATED SECTIONS:

- 1. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.
- 2. Refer to Section 40 05 51 "Common Requirements for Process Valves;"
 - a. For information regarding submittals; quality assurance; coordination; material delivery, handling, and storage; projection conditions; design requirements; coating requirements; other materials; installation of piping systems; field testing; and related work.
- 3. Refer to Section 40 05 57.23 "Electric Motor Actuators."
- 4. Refer to Section 09 90 00 "Painting and Protective Coatings."

1.3 REFERENCES

- A. ANSI/NSF- 61- Drinking Water System Components.
- B. ANSI B16.1- Cast Iron Pipe Flanges and Flanged Fittings
- C. ANSI/AWWA C111/A21.11- Rubber -Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
- D. AWWA Standard C509 or C515- Resilient-Seated Gate Valves for Water Supply Service.
- E. AWWA C-500- Metal Seated Gate Valves for Water Service.
- F. ASTM A-479 – Standard Specification for Stainless steel Bars and Shapes

1.4 SUBMITTALS

- A. Product Data: For each type of valve indicated, include body, seating, and trim materials; valve design; pressure and temperature classifications; end connections; arrangement; dimensions; and required clearances. Include list indicating valve and its application. Include rated capacities; shipping, installed, and operating weights; furnished specialties; and accessories.
- B. Provide a detailed list of any exceptions taken to these specifications. Include specification reference and proposed alternative with reason stated for exception. If MANUFACTURER and/or CONTRACTOR fails to describe such exceptions, the responsible entity will not be relieved of the responsibility for executing the work as described herein, even though such shop drawings have been reviewed by the ENGINEER.
- C. Product Certificates: For each type of valve, from MANUFACTURER.
 - 1. Compliance with AWWA, ANSI/NSF 61 , and ASTM standards including hydrostatic tests, operational tests and other testing required by the standards.
 - 2. Valve manufacturer shall provide certification from an independent testing laboratory

that its valve can operate through 1000 cycles at unbalanced closing pressure (working pressure) and flow to open discharge without causing damage to any of the epoxy coating on the body or rubber coating on the gate.

- D. Operation and Maintenance Data: Provide in accordance with Section 01 78 23 "Operation and Maintenance Data."
- E. Field Quality Control: Provide field testing and performance reports.
- F. Manufacturer's Warranty: Provide manufacturer's warranty for all indicated products in accordance with Section 01 78 36 "Warranties".

1.5 QUALITY ASSURANCE

- A. Obtain all valves of the same style and type, along with the associated manual operators, from a single manufacturer.
- B. All surfaces and materials in contact with water shall conform to ANSI/NSF 61 and be certified by an organization accredited by ANSI and shall meet the CDPHE requirements for contact with potable water.
- C. All gate valves shall conform to AWWA Standard C509 or C515 unless otherwise specified. Valves larger than 12 inches shall be manufactured and tested to meet the requirements of AWWA C515 unless otherwise specified. Body thickness and stem thickness will conform to AWWA C500.
- D. When Gate Valves cannot be installed in a vertical position they shall conform to AWWA C500.
- E. Valve manufacturer shall demonstrate a minimum of five (5) years of experience in similar applications for size of valves furnished, with at least one (1) year of experience in the design of resilient seated gate valves (AWWA C515) being furnished. References shall be provided upon request.
- F. Valve supplier shall maintain a complete stock of parts in the state of Colorado and shall be capable of delivering parts within 48-hours after receipt of request.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. CONTRACTOR shall comply with the requirements of the supplementary Conditions and MANUFACTURER recommendations.
- B. Prepare valves for shipping as follows:
 - 1. Protect internal parts against rust and corrosion.
 - 2. Protect threads, flange faces, grooves, and weld ends.
 - 3. Set angle, gate, and globe valves closed to prevent rattling.
 - 4. Block valves in either closed or open position.
- C. Use the following precautions during storage:
 - 1. Maintain valve end protection.
 - 2. Store valves indoors and maintain at higher than ambient dew-point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.
 - 3. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use handwheels or stems as lifting or rigging points.

1.7 WARRANTY

- A. The warranty shall comply with the requirements of Section 01 78 36 "Warranties," unless otherwise noted.
- B. Special Warranty: Manufacturer's standard form in which MANUFACTURER agrees to repair or replace components that fail(s) in materials or workmanship within specified warranty period.
 - 1. Warranty Period: Two (2) years from date of Substantial Completion.
 - 2. Cost for the removal, shipment, repair and installation by CONTRACTOR shall be included in warranty, as well as correction of defective work.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. ACIPCO American Flow Control
 - a. Series 2500 RW Gate Valve
 - 2. Clow Valve Co.
 - a. C509 2"-12"
 - b. C515 14"-54"
 - 3. Henry Pratt Company
 - 4. Kennedy (American R/D)
 - a. C509 2"-12"
 - b. C515 14"-54"
 - 5. Mueller
 - a. A-2361 RWGV FLxFL 14"-54"
 - 6. M&H
 - a. C509 2"-12"
 - b. C515 14"-54"
 - 7. U.S. Pipe Metroseal
 - a. C509 2"-12"
 - b. C515 14"-54"
- B. Equipment must be provided in accordance with these specifications. Naming of a manufacturer does not indicate approval nor eliminate their responsibility of providing equipment in compliance with the component features as specified herein. All manufacturers are required to comply fully with these specifications. Any deviations without sufficient evidence proving equal or superior quality shall be rejected without further review.

2.2 GENERAL

- A. Valve to include operator, actuator, handwheel, chain wheel, extension stem, floor stand, worm and gear operator, operating nut, chain, wrench, valve boxes, and all accessories and related equipment for a complete operating system as required per this Section. Refer to

Drawings for valves requiring limit switches, electric or pneumatic operators, and related controls.

B. Comply with the following:

1. Suitable for intended service. Renewable parts not to be of a lower quality than specified.
2. Same size as adjacent piping.
3. Ends to suit adjacent piping.
4. Operator sized to operate valve for full range of pressures and velocities.
5. Open by turning counterclockwise, unless otherwise specified.
6. Factory mount operator, actuator and accessories.

C. Obtain all valves and associated manual operators from a single manufacturer.

D. Gate valves shall be of the resilient seated design.

2.3 VALVE DESCRIPTION

A. AWWA C515 Gate Valves, 3-inch and Larger, Resilient-Seated:

1. Construction: Ductile-iron body with full round port opening and integrally cast guides; smooth valve bottom with no recessed areas; bonnet cover.
2. Position: Vertical
3. Gate: Completely covered with EPDM rubber on all interior and exterior ferrous surfaces. The rubber shall be secured to the gate body, including the part which houses the stem nut.
4. Stem: 304 stainless steel, ASTM A479.
5. Stem Seals: Double O-ring, Buna-N protected by grit and dust cap.
6. Stem Nut: Brass or bronze.
7. Seats: Resilient seats bonded to wedge for seating against a corrosion resistance surface.
8. Nylon bushing and Teflon washer for friction protection.
9. Operating Pressure:
 - a. 12-inch and smaller, 200 psig
 - b. 16-inch and 20-inch, 150 psig
10. Flange Ends (Unless otherwise specified):
 - a. Above Ground: Flanged, ANSI B16.1, Class 125.
 - b. Buried Service: Mechanical joints, ANSI/AWWA C111/A21.11.
11. Coating: In accordance with Section 09 90 00 "Painting and Protective Coatings." Comply with requirements of AWWA C515 "Resilient-Seated Gate Valves for Water Supply Service."

2.4 OPERATORS

A. Buried Service:

1. 3-inch and Larger:
 - a. Non-rising stem with stainless steel shaft extension and wrench nut. Minimum extension stem diameter shall be 1-inch or diameter of valve shaft, whichever is

larger. All components shall have continuous welded joints. Provide stem guides or rock shields at 5-foot intervals.

- b. Valve Box: Three-piece screw type 5 ½-inch diameter, cast iron construction.
 - 1) Manufacturer
 - a) Clow, or approved equal

B. Above Ground Service:

- 1. 3-inch and Larger: OS&Y, gear operators all valves 16-inch and larger unless otherwise noted.
- 2. Chain Wheel Operator: Provide for valves having a centerline six feet or more above the floor, unless otherwise noted.

C. Wrench nut, handwheel and gear operator shall comply with the requirements of applicable AWWA Standard previously reference and Section 40 05 51 "Common Requirements for Process Valves."

D. Electric motor operators shall comply with the requirements of the applicable Section 40 05 57.23 "Electric Motor Actuators."

2.5 ACCESSORIES

A. Identification: Provide valve identification tags in accordance with Section 10 90 00 "Identification, Stenciling, and Tagging."

- 1. Minimum valve tag shall include Valve serial number, number of turns to open, manufactures, type, size, and operator/actuator model and size shall be shown on valve tag for each valve furnished. Buried valves shall have tag mounted on concrete at valve box cover. All tags shall have reproduction in O&M Manual.

B. Refer to Section 40 05 51 "Common Requirements for Process Valves" for additional accessories requirements.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Refer to Section 40 05 51 "Common Requirements for Process Valves" for Execution requirements for the installation, field quality control, and manufacturer's services.

3.2 VALVE SCHEDULE

A. Refer to Section 40 06 00 for the Valve Schedule and for type, end connections, and locations for all valves. Schedules are included for the convenience of the ENGINEER and CONTRACTOR and may not be complete listings of all valves, devices and material to be provided under this Contract. The CONTRACTOR agrees to prepare his own valve takeoff lists as necessary to meet the requirements of the Project.

END OF SECTION

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**SECTION 40 05 64
BUTTERFLY VALVES**

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. The CONTRACTOR shall furnish and install double-offset butterfly valves, operators and appurtenances complete as shown on the Plans and specified herein.

1.2 RELATED SECTIONS

A. The following specifications are related to this section:

1. Section 40 05 51, Common Requirements for Process Valves
2. Section 40 05 57.53, Pneumatic Valve Actuators (Vane Type)
3. Section 40 50 57.23, Electric Motor Actuators

1.3 REFERENCES

A. Referenced Standards: Rubber seated shall be tight closing type conforming to the latest version of AWWA C504 standards.

1. AWWA C-540 - "Power-Activating Devices for Valves and Sluice Gates."
2. AWWA C-550 - "Standard Specification for Protective Interior Coatings for Valves and Hydrants."
3. ASTM A-48 - "Standard Specification for Grey Iron Castings."
4. ASTM A-126 - "Standard Specification for Grey Iron Castings for Valves, Flanges, and Pipe Fittings."
5. ASTM A-536 - "Standard Specification for Ductile Iron Castings."
6. ANSI - "American National Standards Institute."
7. ANSI/NSF - "Standard 60/61."

1.4 SUBMITTALS

A. Product Data:

1. Comply with the general requirements of Division 1 and the supplemental requirements below.
2. Submit one drawing or illustration showing unit construction for each type and size valve used.
3. Submit the following information for each valve:
 - a. Specific application in plant expressed in terms of service and contract drawing number where shown.
 - b. Description including type of valve; type, size, and model number of operator with number of turns to open; and accessories included.
 - c. Size and end connections.
 - d. Maximum non-shock working pressure for which valve is designed.
 - e. Materials of construction and coatings for valves, operators and accessories.
 - f. K or Cv value.

- g. Manufacturers' make and model.
 - h. Seat orientation.
 - i. Size, length, and material of extension stems with number of supports required.
 - j. Direction to open.
 - 4. Submit the following information for geared operators:
 - a. Type of gearing.
 - b. Type of lubrication.
 - c. Size of handwheel, lever or crank.
 - d. Input torque required to develop required output torque.
 - e. Orientation and dimensions of operator.
 - f. Manufacturers' make and model.
 - 5. If catalog bulletins are used to communicate above information, mark out inapplicable information.
 - 6. Provide a detailed list of any exceptions taken to these specifications. Include specification reference and proposed alternative with reason stated for exception. If MANUFACTURER and/or CONTRACTOR fails to describe such exceptions, the responsible entity will not be relieved of the responsibility for executing the work as described herein, even though such shop drawings have been reviewed by the ENGINEER.
- B. Operation and Maintenance Data:
 - 1. Comply with the requirements of Division 1.
- C. Quality Assurance/Control Submittals
 - 1. Affidavits:
 - a. Submit affidavits of compliance with the reference standards.
- D. Manufacturer's Warranty: Provide manufacturer's warranty for each indicated product in accordance with Paragraph 1.7

1.5 QUALITY ASSURANCE

- A. Each valve shall have manufacturer's nameplate in stainless steel showing the pressure ratings, serial and model numbers, year manufactured and other pertinent data.
- B. Valve supplier shall maintain a complete stock of spare parts in the State of Colorado or shall indicate that parts will be delivered upon 48 hours of receipt of request.
- C. Butterfly valves and manual operators shall be completely assembled at the factory, adjusted for correct seating, and tested in accordance with the AWWA C-504 standard. Factory adjustments and operational tests shall be performed on each valve with the valve oriented in the same position as the installed field position. The valves shall be cycled five times (full open to full close) and successfully seat tested each cycle to certify proper seating. Seat adjustments and manual indicators shall be set and checked at the factory.
- D. For valves 16 inches and larger, the MANUFACTURER shall conduct ultra-sound testing on each of the valve bodies and discs in addition to hydrostatic testing of each valve. The manufacturer shall perform the hydrostatic valve tests in accordance with AWWA C-504 and provide certified reports of test results. The MANUFACTURER shall notify the OWNER three weeks prior to testing so that the OWNER may witness tests. Hydrostatic test pressures shall

be 150 psi for the bodies and 150 psi for the discs and seats.

- E. All surfaces and materials in contact with water, or in contact with a chemical being added to water that is being treated for potable use, shall conform to ANSI/NSF 61 and be certified by an organization accredited by ANSI, and shall meet the CDPHE requirements for contact with potable water.

1.6 DELIVERY, STORAGE AND HANDLING

- A. Comply with the requirements of the General Provisions and manufacturer's recommendations.
- B. Use the following precautions during storage:
 - 1. Maintain valve end protection.
 - 2. Store valves indoors and maintain at higher than ambient dew-point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.
 - 3. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use handwheels or stems as lifting or rigging points.

1.7 WARRANTY

- A. The warranty shall comply with the requirements of Section 01 78 36 "Warranties," unless otherwise noted.
- B. Special Warranty: Manufacturer's standard form in which MANUFACTURER agrees to repair or replace components that fail(s) in materials or workmanship within specified warranty period.
 - 1. Warranty Period: Two (2) years from date of Substantial Completion.
 - 2. Cost for the removal, shipment, repair, and installation by CONTRACTOR shall be included in warranty, as well as correction of defective work.

1.8 EXPERIENCE REQUIREMENTS

- A. Manufacturers of butterfly valves shall demonstrate a minimum of 10 years of experience in similar applications for sizes of valves being furnished. References shall be furnished upon request.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers:
 - 1. DeZurik
 - 2. VAG, EKN AWWA Series
 - 3. Val-Matic, 2000HP Series
- B. Equipment must be provided in accordance with these specifications. Naming of a manufacturer does not indicate approval nor eliminate their responsibility of providing equipment in compliance with the component features as specified herein. All manufacturers are required to comply fully with these specifications. Any deviations without sufficient evidence proving equal or superior quality shall be rejected without further review.

2.2 GENERAL

- A. Obtain all butterfly valves and associated manual operators of a given type from a single manufacturer.
- B. Valve operators to turn to left, counterclockwise, to open and to right, clockwise, to close. All valves shall have position indicators.
- C. End connections to be compatible with those specified for pipe. Mechanical joints shall conform to ANSI/AWWA C11/A21.11. Flanges shall conform to ANSI B16.1 and have a pressure rating to meet the requirements of the adjoining pipe.
- D. Furnish geared operators for all valves in pressure piping systems (≥ 10 psig working pressure) and valves 8 inches and larger, unless otherwise specified.
- E. Furnish geared operators with the following features unless otherwise specified. Gears shall meet AWWA C 504 requirements.
 - 1. Weatherproof enclosure.
 - 2. Grease lubricated design.
 - 3. Closes valve when turned clockwise.
 - 4. Position indicator.
- F. All internal materials for valves shall withstand corrosion.
- G. Exposed valves shall utilize handwheel or chainwheel operators unless otherwise shown.
- H. All valves in submerged and buried service shall utilize 316 stainless steel hardware and bolts.
- I. Valve serial number, number of turns to open, manufactures, type, size, and operator/actuator model and size shall be shown on valve tag for each valve furnished. Buried valves shall have tag mounted on concrete at valve box cover. All tags shall have reproduction in O&M Manual.
- J. The water being delivered through the valves may be treated with ozone, peroxide, chlorine, chlorine dioxide, and/or chloramines. The materials used to manufacture the valves shall be resistant to ozone, peroxide, chlorine, chlorine dioxide, and chloramine oxidation.
- K. Areas on the disc and body that are subject to cavitation damage shall be constructed of materials that are resistant to the effects of cavitation.
- L. Maximum velocity through the valves should be assumed to be 12 feet per second when fully opened.

2.3 BUTTERFLY VALVES DETAILS

- A. Provide valves in accordance Section 40 06 00.
- B. Valve type: AWWA C504 resilient-seated, double offset butterfly valve.
- C. Non-shock working pressure: 150 psi, minimum, sized to meet test pressure of pipeline:
 - 1. Body type: Short body flanged, unless shown otherwise on the plans.
 - 2. Valve flanges for valves 24-inch and larger and for all exposed valves shall have ANSI Class 125 or Class 250 flanges based on the corresponding pipe class. Buried valves smaller than 24-inch shall utilize MJ joints. Two (2) trunnions for shaft bearings shall be integral with each valve body. Valve bodies shall be hydrostatic tested to a minimum of working pressure class.
- D. Valve construction:

1. Body: Ductile iron (ASTM A-536 Grade 65/45/12).
2. Shaft: ASTM A276, Grade 304; stainless steel or ASTM A564, Type 630 17-4 PH stainless steel.
3. Disc: Ductile iron ASTM A-536, Grade 65/45/12, or AASTM A743, 316 stainless steel. Operating pressure of valve disc shall be 150 psi. Valve discs shall be hydrostatic tested to a minimum of 150 psi.
4. Seats: EPDM, NBR, or Buna-N rubber mechanically secured to the body. Valve seats shall provide tight shut-off at 0 to 150 psi operating pressure. The seat shall be field adjustable and field replaceable using common handtools. The mating surface shall be 18-8 stainless steel or a 95 percent pure nickel overlay. Valve seats and discs shall be hydrostatic tested to a minimum of 150 psi.
5. Bearings: Fitted sleeve type. Bearings shall be corrosion resistant and self-lubricated materials, Teflon-lined, and fiberglass backed that will not deteriorate natural or synthetic rubber.
6. Shaft Seals: Split-V or O-ring type, suitable for buried service requiring no gland adjustment.
7. Bolts: Type 316 stainless steel

2.4 ACCESSORIES (NOT USED)

2.5 FINISHES

- A. Paint exterior of valves and operators as specified in Section 09 90 00, "Painting and Protective Coatings," colors to be selected by OWNER. Interior of valves shall be factory lined with NSF approved epoxy meeting the requirements of Division 9 and AWWA C550. Flange faces shall be protected from atmospheric corrosion.

2.6 ACTUATION

- A. Refer to Section 40 05 57.53, Pneumatic Valve Actuators (Vane Type) for Pneumatic actuator requirements and Section 40 06 00.
- B. Refer to Section 40 05 57.23, Electric Motor Actuators for electric actuator requirements and Section 40 06 00.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install all valves, floorstands, and appurtenances in complete accordance with the drawings, approved shop drawings and manufacturer's instructions and recommendations.
- B. Install valves and valve operators to provide for ease of access and operation. Install seat adjustment side of valve opposite of headers or common piping.
- C. Install butterfly valves with shafts horizontal unless otherwise shown.
- D. Space stem guides at 5 feet center to center maximum or closer if recommended by MANUFACTURER.

3.2 FIELD QUALITY CONTROL

- A. Retain a qualified representative of the MANUFACTURER to perform the following services:

1. Inspect the completed installation and note deficiencies.
 2. Assist the CONTRACTOR during start-up, adjusting, and site testing of completed installation as required.
 3. Instruct OWNER personnel in the operations and maintenance of the equipment.
 4. Stem extensions (and boxes on buried valve) shall be installed plumb within ± 1 -inch in 10 feet.
- B. Field Testing: Plant testing and startup will be in accordance with Division 1. Piping systems will be tested in accordance with Division 40. All valves shall be operated over the full range of travel without excessive force for at least two complete cycles; open-closed-open-closed. Valve shall not hang and shall seat and unseat to/from fully closed position. Testing shall be done after actuators and stem extensions are installed. Verify valve tag is installed and correct. Verify valve position indicator correctly reflects valve positions and limit switches (if used) are set correctly. Valves with motor or pneumatic actuators shall be operated with handwheel as well as automatic actuator.

3.3 SCHEDULE

- A. Refer to Section 40 06 00 for the Valve Schedule and for type, end connections, and locations for all valves. Schedules are included for the convenience of the ENGINEER and CONTRACTOR and may not be complete listings of all valves, devices and material to be provided under this Contract. The Contractor agrees to prepare his own valve takeoff lists as necessary to meet the requirements of the Project.

END OF SECTION

SECTION 40 05 65
CHECK VALVES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes the following valves:
 - 1. Class 125 Swing check valves, 2-inches through 12-inches.
 - 2. AWWA Swing check valves, 2-inches through 48inches.
 - 3. Ball check, iron body, 3-inch and larger.
 - 4. Double-disc check valves, 2-inches through 54inches.
 - 5. Rubber flapper check valves, 2-inches through 36-inches.
 - 6. Spring assisted rubber flapper swing check valve, 2-inches through 48-inches.
 - 7. "Duckbill" elastomeric check valves, 2-inches through 84-inches.
 - 8. Silent check valves, 1-inch and Larger.
- B. Related Sections:
 - 1. Refer to Section 40 05 51 "Common Requirements for Process Valves":
 - a. For information regarding submittals; quality assurance; coordination; material delivery, handling, and storage; projection conditions; design requirements; other materials; installation of piping systems; field testing; and related work.
 - b. For PVC check valves, 4-inches and smaller, and bronze check valves, 3-inches and smaller.

1.3 REFERENCES

- A. American National Standards Institute (ANSI).
- B. National Sanitation Foundation (NSF):
 - 1. NSF/ANSI 61 – Drinking Water Components – Health Effects.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, those listed for the various valves.

2.2 CLASS 125 SWING CHECK VALVE

- A. Class 125 Iron Body Check Valve, 2-inch through 12-inch:
 - 1. Cast Iron body, bolted bonnet, horizontal swing, renewable seat and disc, threaded or flange ends, outside lever and spring, rated 125-psi SWP and 200-psi CWP. Conforms to MSS SP-71 Type 1.
 - 2. Acceptable manufacturers:

- a. Crane
- b. NIBCO
- c. Powell, Wm. Co.

2.3 AWWA SWING CHECK VALVES

- A. AWWA Swing Check Valve, 2-inches through 48inches Rubber Seated Swing Check Valve
 - 1. Referenced Standard: AWWA C508.
 - 2. Non-shock working pressure at 100 °F: 150-psi, unless shown otherwise on the Plans.
 - 3. End connections: Flanged.
 - 4. Body: Full ported ductile iron (ASTM A126-B).
 - 5. Cover: Bolted, ductile iron (ASTM A126-B).
 - 6. Disc: Ductile iron (ASTM A126-B).
 - 7. Seat Ring: Rubber.
 - 8. Shaft: Stainless steel, Type 18-8.
 - 9. Body seat: Stainless steel, Type 316.
 - 10. Cover bolts and trim to be stainless steel, Type 316.
 - 11. Stuffing box: Composition packing.
 - 12. Interior coating: Two part hi-build epoxy.
 - 13. Operator: Adjustable lever arm with weight and hydraulic cushion dashpot with adjustable closing speed. Hydraulic cushion dashpot shall be side mounted.
 - 14. Valves in exposed exterior applications and where indicated to be insulated shall have extended shaft to allow for valve insulation.
 - 15. Acceptable manufacturers:
 - a. GA Industries, Swing Check Valve
 - b. DeZurik/APCO
 - c. Crispin Valve.
 - d. Val-Matic.

2.4 BALL CHECK VALVE

- A. Ball Check Valve, 3-inches and Larger:
 - 1. Flanged end, iron body, with cleanout and hollow steel ball, vulcanized nitrile rubber exterior, suitable for vertical up or horizontal flow, rated 150-psi CWP.
 - 2. Acceptable manufacturers:
 - a. FLYGT Corp.
 - b. GA Industries

2.5 DOUBLE DISC CHECK VALVE

- A. Double Disc Check Valve, 2-Inches through 54-Inches:
 - 1. Wafer style, spring loaded, two piece Type 316 stainless steel disc, Type 316 stainless steel shaft, Type 316 stainless steel torsion spring and have an integrally molded elastomer seat vulcanized to the body. The entire assembly shall be secured to the cast center post of the valve by means of Type 316 stainless steel fasteners.
 - 2. Valve body shall be cast iron for 125-psi rating and cast steel for 150-psi rating, of the

lugged wafer style.

3. Valve shall be designed to fit between ANSI flanges and valves, 5-inches and larger, shall be fitted with a lifting eye bolt for installation purposes.
4. Valve, 2-inches through 12-inches, rated 250-psi CWP, and 14-inches through 54-inches, rated 150-psi CWP.
5. Manufacturer and Product:
 - a. APCO/DeZurik; Series 9000
 - b. Crane Valve Group; Duo-Chek II
 - c. Pratt; Series 740
 - d. TechnoCheck Style 5051-316
 - e. Val-Matic Series 8800

2.6 RUBBER FLAPPER CHECK VALVE

- A. Rubber flapper Check Valve, 2-inch through 36-inches:
 1. Ductile Iron body and cover, rated for 150-psi CWP.
 2. Body Seat: 45-degree angles to the centerline of the pipe.
 3. Bolts: ASTM A307 GR B Carbon Steel.
 4. Disc: Steel-reinforced Buna-N disc.
 5. Domed Access port: Full size top access port allows removal of disc without removing the valve from the line. Access cover includes drilled and tapped port for installation of disc position indicator.
 6. Mechanical Position Indicator: 17-4 stainless steel, lead-free Bronze. Provide clear indication of the valve's disc position and can also be provided with a SCADA compatible limit switch for off-site monitoring.
 7. Coating : Fusion Bonded Epoxy.
 8. Operator: The one piece molded disc is steel and nylon reinforced.
 9. Manufacturer and Product:
 - a. APCO/DeZurik; Series 100.
 - b. Val-Matic; Swing-Flex
 - c. Pratt; RD-Series
 - d. GA Industries
 - e. Crispin Valve

2.7 SPRING ASSISTED RUBBER FLAPPER SWING CHECK VALVE

- A. Rubber flapper Swing Check Valve, 2-inch through 48-inches:
 1. Class 125, ANSI/ASME B16.1
 2. Body and cover: ductile iron
 3. Flapper: Buna-N, steel reinforced
 4. Disc accelerator: stainless steel
 5. Manufacturer and Product:
 - a. Val-Matic; Surgebuster
 - b. Crispin; RF-ASR

- c. Golden Anderson; Slaminator

2.8 "DUCKBILL" ELASTOMERIC CHECK VALVE

A. "Duckbill" Elastomeric Check Valve, 2-Inches through 84-Inches:

1. Type: All rubber and flow operated check type with either a flanged end connection or a slip-on end connection as indicated. The port area shall contour down to a duckbill, which allows the passage of flow in one direction.
2. Material:
 - a. The flange and flexible duckbill sleeve shall be one piece Buna-N rubber construction with nylon reinforcement. The bill portion shall be thinner and more flexible to form into a curve of 180 degrees.
 - b. Flange drilling shall conform to ANSI B16.1 Class 125/ANSI B16.5 Class 150 standards.
 - c. Slip-on check valves shall be secured to the pipe using stainless steel clamps.
3. Opening Requirements: 2-inches of water.
4. Manufacturer and Product:
 - a. Tideflex Technologies:
 - 1) Series TF-1 for slip-on.
 - 2) Series 35 for flanged-end.
 - b. General Rubber
 - 1) Flex-Valve 4100 for slip-on style.
 - 2) Flex-Valve 4200 for flanged-end.

B. "Duckbill" Elastomeric Check Valve, Fits Inside Pipe, 2-Inches through 72-Inches:

1. Type: All rubber and flow operated check type which fits inside pipe and fastened with internal expansion clamp. The port area shall contour down to a duckbill, which allows the passage of flow in one direction.
2. Material: Flexible duckbill sleeve shall be one piece Buna-N rubber construction with nylon reinforcement. Provide stainless steel expansion clamp for securing valve to inside of pipe.
3. Manufacturer and Product:
4. Tideflex Technologies: Series 37G In-Line Check valve.

2.9 SILENT CHECK VALVE

A. Silent Check Valve, Wafer Style, 10-Inch and Smaller:

1. Type: Class 125 cast iron body, ASTM A-126, Class B, bronze seat and plug, ASTM B584, stainless steel spring, wafer style.
2. Spring shall be helical or conical, seat and plug field replaceable, flow area through the body equal to or greater than the cross-section area of the equivalent pipe size.
3. Capable of silent operation when installed in the vertical or horizontal position.
4. Manufacturer and Product:
 - a. APCO/DeZurik; Series 300.

B. Silent Check Valve, Globe Style, Flanged Ends, 3-Inch through 42-Inch:

1. Type: Class 125 and 150 cast iron body, ASTM A-126, Class B, or ductile iron body, ASTM A536, 65-45-12; bronze seat and plug, ASTM B584, stainless steel spring, flanged ends.
2. Plug shall be center guided at both ends with a through integral valve shaft and spring loaded.
3. Spring shall be helical or conical, seat and plug field replaceable, flow area through the body equal to or greater than the cross-section area of the equivalent pipe size.
4. Capable of silent operation when installed in the vertical or horizontal position.
5. Manufacturer and Product:
6. APCO/DeZurik; Series 600.

2.10 ACCESSORIES

- A. Identification: Provide valve identification tags in accordance with Section 10 90 00 "Identification, Stenciling, and Tagging".
- B. Refer to Section 40 05 51 "Common Requirements for Process Valves" for additional accessories requirements.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Refer to Section 40 05 51 "Common Requirements for Process Valves" for Execution requirements for the installation, field quality control, and manufacturer's services.

3.2 VALVE SCHEDULE

- A. Refer to Drawings for type, end connections, and locations for all valves.

END OF SECTION

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SECTION 40 05 78
AIR RELEASE AND AIR/VACUUM VALVES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes the following valves for water and/or sewage service:
 - 1. Air release valves.
 - 2. Combination air release and air/vacuum valves.
 - 3. Air/vacuum valves.
 - 4. Vacuum relief valves.
- B. Related Sections:
 - 1. Division 1.
 - 2. Refer to Section 40 05 51 "Common Requirements for Process Valves " for information regarding submittals; quality assurance; coordination; material delivery, handling, and storage; project conditions; design requirements; other materials; installation of piping systems; field testing; and related work.

1.3 QUALITY ASSURANCE

- A. Referenced Standards:
 - 1. American Water Works Association (AWWA):
 - . C512, Standard for Air-Release, Air-Vacuum, and Combination Air Valves for Waterworks Service.
 - 2. American National Standard Institute (ANSI)
 - 3. Valves shall be certified to NSF 61 "Drinking Water Systems Components – Health Effects."

1.4 SUBMITTALS

- A. Product Data:
 - 1. Comply with the general requirements of Section 01 33 00 "Submittal Procedures" and the supplemental requirements below.
 - 2. Submit one drawing or illustration showing unit construction for each type and size of valve used.
 - 3. Submit the following information tabulated for each valve in the project:
 - . Specific application in plant expressed in terms of service and contract drawing number where shown.
 - a. Description including type of valve, size, model number, and serial number.
 - b. Size and end connections.
 - c. Maximum non-shock working pressure for which valve is designed.
 - d. Materials of construction and coatings for valves and accessories.
 - 4. If catalog bulletins are used to communicate above information, mark out inapplicable

information.

B. Affidavits:

1. Submit affidavits of compliance with the reference standards.

C. Operation and Maintenance Data:

1. Comply with the requirements of Section 01 78 23 "Operation and Maintenance Data".
As-built drawings of the actuators will be supplied in both hard copy and electronic forms.
Indicate any field settings or adjustments made.

1.5 QUALITY ASSURANCE

- A. Valves shall be obtained from single supplier.
- B. Each valve shall have manufacturer's nameplate in stainless steel showing the pressure ratings, serial and model numbers, year manufactured and other pertinent data.
- C. Manufacturers of air valves shall demonstrate a minimum of 10 years of experience in the design, manufacture, and application of air release and air/vacuum valves in similar applications for sizes of valves being furnished. References shall be furnished upon request.
- D. Valve supplier shall maintain a complete stock of spare parts in the State of Colorado or shall indicate that parts will be delivered upon 48 hours of receipt of request.
- E. All surfaces and materials in contact with water, or in contact with a chemical being added to water that is being treated for potable use, shall conform to ANSI/NSF 61 and be certified by an organization accredited by ANSI, or shall meet the CDPHE requirements for contact with potable water.

1.6 DELIVERY, STORAGE AND HANDLING.

- A. Comply with the requirements of the General Conditions and manufacturers' recommendations.

PART 2 - PRODUCTS

2.1 GENERAL:

- A. Top of valve shall have piping extended to permit discharge to grade or drain as shown on the Drawings. Piping shall be provided by the Contractor.
- B. Valve End Connections: 3-inch and smaller; threaded; 4-inches and larger, flanged, ANSI B16.1, Class 125 or Class 250 as required, unless otherwise noted.
- C. All components shall be compatible with the process fluid as specified herein.
- D. Valves shall be hydraulically tested at 1.5 times their rated cold-water pressure.
- E. The exterior of valve shall receive a coating of universal metal primer.

2.2 AIR RELEASE VALVES

- A. Air Release Valves, Water Service (ARV), 1/2-Inch through 6-Inch:
 1. Description: Valves shall be automatic float operated and designed to release accumulated air from a piping system while the system is in operation and under pressure.
 2. Materials: Body and cover constructed of cast iron, ASTM A126, Class B, or ductile iron, ASTM A536, Grade 65-45-12; orifice, float and lineage mechanism constructed of Type

316 stainless steel; Buna-N needle and brass seat; stainless steel fasteners.

3. Valve size, orifice size and options shall be as shown in the drawings.
4. Products:
 - . APCO Series 200A
 - a. Equivalent products of Crispin and Val-Matic.

2.3 AIR/VACUUM VALVE

A. Air/Vacuum Valves, Water Service (AVV), 1/2-Inch through 30-Inch:

1. Description: Valves shall be automatic float operated and designed to release accumulated air during the filling of a piping system and close upon liquid entry. Valve shall re-open during draining or if a negative pressure occurs.
2. Materials: Body and cover constructed of cast iron, ASTM A126, Class B, or ductile iron, ASTM A536, Grade 65-45-12; float, guide shafts, and bushings constructed of Type 316 stainless steel; resilient seats shall be Buna-N; stainless steel fasteners.
3. Provide guides to direct float onto seat.
4. Valve size and options shall be as shown in the drawings.
5. Products:
 - . APCO Series 140 for 1/2-inch thru 3-inch, Series 150, 4-inch and larger.
 - a. Crispin AL Series for 1-inch and larger, A Series for 1/2-inch.

2.4 COMBINATION AIR VALVES, WATER SERVICE (CAV), 1-INCH THROUGH 20-INCH:

1. Description: Air release valves shall be automatic float operated and designed to exhaust large quantities of air during the filling of a piping system and open during draining or if a negative pressure occurs. It also shall release accumulated pockets of air while the system is in operation.
2. Materials: Body and cover constructed of cast iron, ASTM A126, Class B, or ductile iron, ASTM A536, Grade 65-45-12; orifice, float and lineage mechanism constructed of Type 316 stainless steel; resilient seat shall be Buna-N (4-inch thru 12-inches) and stainless steel with Buna-N molded seal (14-inches and larger and Class 250); stainless steel fasteners.
3. Valves, 4-inch and larger, shall be dual body with a separate air release valve mounted on the air and vacuum valve, with isolation valve mounted between valves. Provide the air and vacuum valve with a 1-inch drain pipe with a gate valve and turn down elbow.
4. Air release valve shall comply with the requirements above.
5. Valve size and options shall be as shown in the drawings.
6. Products:
 - . APCO Series 1800, dual body, and Series 140C, single body.
 - a. Equivalent products of Crispin.

2.5 COMBINATION AIR AND VACUUM VALVE WITH SURGE CHECK (CAVSC)

A. Combination Air and Vacuum Valve with Surge Check:

1. Description:
 - . Consists of a standard air/vacuum valve mounted on top of a normally opened surge check valve.
 - a. Air passes through unrestricted but when water rushes in the surge check, a disc

- closes and reduces the rate of water flow into the air valve by means of throttling holes in the disc. This minimizes pressure surges when the valve closes.
- b. When air valve is closed, pressure on both sides of the disc equalizes and the disc automatically returns to its open position.
- c. CAVSC is four valves furnished, assembled, and tested as a single unit as follows:
- d. Dual body combination air valve consisting of an air/vacuum valve with an air release valve mounted on the unit.
- e. Surge check valve shall be a normally open spring loaded valve bolted to the inlet of the air/vacuum valve.
- f. Isolation butterfly valve constructed to AWWA standard, lugged wafer design, disc to pivot eccentrically from closed position to clear center valve area.
- 2. Materials: Covers, bodies constructed cast iron, ASTM A126, Class B; floats and springs stainless steel, ASTM A240; surge check seat and disc, bronze, ASTM B584; air/vacuum valve seat shall be Buna-N (4' thru 12") and stainless steel with Buna-N molded seal (14' and larger and Class 250); stainless steel fasteners.
- 3. Products:
 - . APCO Series 1200
 - a. Equivalent products of Crispin and Val-Matic.

2.6 VACUUM RELIEF VALVE (VRV)

- A. Vacuum Relief Valve, 2-Inch through 42-Inch:
 - 1. Description: Large orifice one-way valve to automatically allow large quantities of air to enter a system on negative pressure. An optional air release valve can be directly piped to relieve air under positive pressure. The valve shall be a globe type body with integrally cast flange ends, incorporating a center-guided, spring loaded disc, and have a top protective hood.
 - 2. Materials: Body and cover constructed of cast iron, ASTM A-126, Class B; seat and plug, brass, ASTM B584, or aluminum bronze, ASTM B148, or plug on size 30-inch and larger, ductile iron, ASTM A536, Grade 65-45-12; compression spring, Type 316 stainless steel.
 - 3. Optional air release valve shall be as specified above, integrally piped with a bronze full port ball valve. The valve air outlet shall have a cross contamination security protection installed.
 - 4. Valve size and options shall be as shown in the drawings.
 - 5. Products:
 - . APCO Series 1500

2.7 ACCESSORIES

- A. Shut-off Valve: All valves specified under this Section shall be furnished with 316 stainless steel ball valves equal to the size of the connection.
- B. Options: When specified in the Drawings one or more of the following options:
 - 1. Cross Contamination and Security Protection (CCSP): When valves installed in vaults or flood prone locations, provide an inflow preventer to prevent the introduction of contaminated water through the air valve outlet.
 - 2. Anti-Slam Device (ASD): Valves, 2-inch and larger, provide to prevent valve pressure surges due to column separation or rapid changes in velocity and pressure.

- 3. Screen Outlet (SO): Provide a stainless steel screened outlet for outdoor locations.
- C. Identification: Provide valve identification tags in accordance with Section 10 90 00 "Identification, Stenciling, and Tagging."
- D. Refer to Section 40 05 51 "Common Requirements for Process Valves" for additional accessories requirements.
- E. Furnish any accessories required to provide a completely operable valve.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Refer to Section 40 05 51 "Common Requirements for Process Valves" for execution requirements for the installation, field quality control, and manufacturer's services.

3.2 VALVE SCHEDULE

- A. Section 40 06 00.

END OF SECTION

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SECTION 40 05 91
COMMON CONTROL PANEL REQUIREMENTS FOR PROCESS EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

- A. Where specified in the equipment manufacturer's specification, the equipment manufacturer's shall furnish a fully functional industrial control panels to manually and automatically operate equipment as specified in the detailed requirements of the equipment sections of Division 40s, and supplemented with logic and schematics diagrams as shown on the Electrical and Instrumentation Drawings.
- B. It is the intent of these specifications to have all starters, VFDs, breakers, control panel devices relays, PLC if required and signal conditioning components included within their respective control panels. The equipment supplier shall be responsible for final sizing of enclosures to meet the clearance requirements of NFPA 70 and NFPA 79 and as specified herein. Should the equipment supplier submit a panel size and layout that is, in the opinion of the OWNER or the ENGINEER, insufficient in size to meet these requirements, the submittal will not be approved and will be returned for revision and resubmission. The equipment supplier shall be required to revise the panel size and layout and resubmit for approval at no additional cost to the OWNER.
- C. All enclosures and panel components shall be of the same manufacture wherever possible.
- D. Installation and configuration of network infrastructure cabling and equipment shall be a cooperative and coordinated effort between OWNER, the CONTRACTOR, and the Control System Integrator. The Equipment Supplier and the Control System Integrator shall furnish all labor necessary for the installation and testing as required to fully meet the applicable specifications of the Contract Documents.
- E. All equipment, field devices and instruments shall utilize tags names as shown on Contract Documents.
- F. All Industrial Control Panels shall have a UL 508A label affix to the inside of the panel. Those panels with equipment or instrumentation is Class I, Division I areas shall also comply with UL 698.
- G. Related Sections include but are not necessarily limited to:
 - 1. Division 00 - Procurement and Contracting Requirements.
 - 2. Division 01 - General Requirements.

1.2 REFERENCES - NOT USED

1.3 ADMINISTRATIVE REQUIREMENTS - NOT USED

1.4 SUBMITTALS

- A. Comply with the submittal requirements of Section 01 30 00 - Administrative Requirements, Individual Equipment Specifications, and as described below.
- B. Product Data: For each type of product indicated, include construction details, material descriptions, dimensions of individual components and profiles, rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

C. Panel Layout Drawings and Wiring Diagrams Submittal

1. Panel Layout Drawings: Drawings shall be furnished for all panels, consoles, and equipment enclosures specified. Panel assembly and elevation drawings shall be drawn to scale and detail all equipment in or on the panel. Panel drawings shall be 11x17 inches in size. At a minimum, the panel drawings shall include the following:
 - a. Interior and exterior panel elevation drawings to scale.
 - b. Nameplate schedule.
 - c. Conduit access locations.
 - d. Panel construction details.
 - e. Cabinet assembly and layout drawings to scale. The assembly drawing shall include a bill of material on the drawing with each panel component clearly defined. The bill of material shall be cross-referenced to the assembly drawing so that a non-technical person can readily identify any component of the assembly by manufacturer and model number.
 - f. Fabrication and painting specifications including color (or color samples).
 - g. Construction details, NEMA ratings, intrinsically safe barrier information, gas sealing recommendations, purging system details, etc. for panels located in hazardous locations or interfacing to equipment located in hazardous areas.
 - h. For every control panel, heating and cooling calculations for each panel supplied indicating conformance with cooling requirements of the supplied equipment and environmental conditions. Calculations shall include the recommended type of equipment required for both heating and cooling.
 - i. Submit evidence that all control panels shall be constructed in conformance with UL 508 and bear the UL seal confirming the construction. Specify if UL compliance and seal application shall be accomplished at the fabrication location or by field inspection by UL inspectors. All costs associated with obtaining the UL seal and any inspections shall be borne by the Control System Integrator.
2. Panel Wiring Diagrams: Panel wiring diagrams depicting wiring within and on the panel as well as connections to external devices. If Loop Wiring Diagrams are specified below, equipment external to the control panel and related external connections do not need to be shown on the Panel Wiring Diagrams. Panel wiring diagrams shall include power and signal connections, UPS and normal power sources, all panel ancillary equipment, protective devices, wiring and wire numbers, and terminal blocks and numbering. Field device wiring shall include the device tag and a unique numeric identifier. The diagrams shall identify all device terminal points that the system connects to, including terminal points where I/O wiring lands on equipment not supplied by the equipment supplier. Wiring labeling used on the drawings shall match that shown on the Contract Documents. I/O wiring shall be numbered with rack number, slot number, and point number. Two-wire and four-wire equipment shall be clearly identified and power sources noted. Submit final wire numbering scheme. Panel drawings shall be 11x17 inches in size.
3. ISA Loop Wiring Diagrams: Individual wiring diagram for each field device or instrument shall be required. Loop diagrams shall comply with the minimum requirements of ISA S5 4. Drawings shall be 11x17-inch sheets for each device. Divide

loop diagram into areas for panel face, back-of-panel, and field. Show the terminal numbers, location of dc power supply, switching contacts in analog loops and output contacts of analog devices. Show circuit and raceway schedule names and terminal numbers. Drawings shall show electrical connections between equipment, consoles, panels, terminal junction boxes, and field mounted instruments. Component and panel terminal board identification numbers and external wire and cable numbers shall be shown. Circuit names shall match Circuit and Raceway Schedule. Intermediate terminations between field elements and panels to terminal junction boxes and pull boxes shall be shown. Diagrams shall bear Subcontractor signature attesting diagrams have been coordinated with electrical drawings.

- D. Memory Map: Submit memory map of PLC or Controller registers to be transmitted to Plant Control System.
- E. Operation and Maintenance Data: For control panels, installed devices, and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 01 78 23 - Operation and Maintenance Data, include the following:
 - F. Routine maintenance requirements for control panels and all installed components.
 - G. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
 - H. Final As-Built drawing shall be supplied in AutoCAD format, utilizing AutoCAD's eTransmit feature, for use by the OWNER in modifying panels for future expansion or required modifications.
- I. Load-Current and Overload-Relay Heater List: Compile after motors have been installed and arrange to demonstrate that selection of heaters suits actual motor nameplate full-load currents.
- J. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed and arrange to demonstrate that dip switch settings for motor running overload protection suit actual motor to be protected.
- K. Configuration Settings: Compile after panel has been installed and tested, all configuration or program settings, of VFDs, meters, controllers, timers, etc. in documentation format.

1.5 QUALITY ASSURANCE

- A. The manufacturer of the control panels shall have produced similar equipment for a minimum period of five years. When requested by the ENGINEER, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.
- B. The control panels shall be assembled in a UL 508 certified facility. A submittal of documentation certifying that the panel fabrication facility is a UL 508 certified facility is required.
- C. All components and material shall be new and of the latest field proven design and in current production. Obsolete components or components scheduled for immediate discontinuation shall not be used.
- D. Control panels submitted shall fit within the space shown on the Drawings. Equipment which does not fit within the space is not acceptable.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Completed industrial control panels and related equipment shall be handled and stored in accordance with manufacturer's instructions. Two copies of these instructions shall be included with the equipment at the time of shipment, and shall be made available to the general CONTRACTOR, the OWNER, and ENGINEER.
- B. Shipping groups shall be designed to be shipped by truck, rail, or ship. Indoor groups shall be bolted to skids. Accessories shall be packaged and shipped with each panel.
- C. Visible shipping damage to any portion of a shipment shall be assumed to have also damaged the surrounding portion. The visibly damaged and the surrounding panels shall be returned to the manufacture's UL 508 facility for examination and damaged equipment replaced.
- D. Industrial Control Panels shall be installed in their permanent finished location shown on the drawings within 7 calendar days of arriving onsite. If the equipment cannot be installed within 7 calendar days, the equipment shall not be delivered to the site, but stored offsite, at the CONTRACTOR's expense, until such time that the site is ready for permanent installation of the equipment or within ENGINEER-approved on-site storage facilities.
- E. Space heaters shall be furnished in industrial control panels and the CONTRACTOR shall provide temporary electrical power and operate space heaters during storage, and after equipment is installed in permanent location, until equipment is placed in service.

1.7 SITE CONDITIONS - NOT USED

1.8 WARRANTY

- A. Extended Equipment Warranty: Refer to Section 01 78 36 - Warranties for extended equipment warranty.
- B. All equipment furnished under this section shall have a special equipment warranty, in accordance with the Contract Documents, for a period of two (2) years after the date of Substantial Completion. The cost of removal, shipment, repair, and installation by CONTRACTOR shall be included in the warranty and correction of defective work.

PART 2 - PRODUCTS

2.1 RATINGS

- A. The service voltage shall be as specified and as shown on the Drawings. The overall short circuit withstand and interrupting rating of the equipment and devices shall be equal to or greater than the overall short circuit withstand and interrupting rating of the feeder device immediately upstream of the Control Panel, but not less than 22,000 Amps rms symmetrical at 480/277 Vac, 480 Vac or 120 Volts per equipment specifications. This includes all circuit breakers and combination motor starters. Systems of motor controllers employing series connected ratings for main and feeder devices shall not be used. Motor starter units shall be tested and UL 508A labeled for the specified short circuit duty in combination with the motor branch circuit protective device.
- B. There shall be selective device coordination between the Main Breaker, Feeder Breakers and control circuit protective devices. When using a circuit breaker or fuses as a main protective device, the instantaneous trip levels of the main protective device shall be higher

than the available fault current to the control panel. If fuses are utilized in the control panel design, the protective devices for 3-phase loads shall contain single phase protection of such equipment. If a fault occurs in the circuit of one load of a design with a backup load, the feeder protective device shall not remove both loads from the control system.

- C. Use ground fault sensing on grounded wye systems.
- D. The complete control panel assembly shall be UL-certified or carry a UL listing for "Industrial Control Panels".
- E. The control panel shall meet all applicable requirements of the National Electrical Code.
- F. The control panel enclosure shall be NEMA rated as specified herein.
- G. Motor controllers, including associated devices, shall be designed for continuous operation at rated current in a 40°C ambient temperature.
- H. For additional ratings and construction notes, refer to the mechanical equipment specifications and the Drawings.
- I. The manufacturer shall produce and install on each panel, an Arc Flash Warning Label listing the various Flash Hazard Protection Boundaries, calculated from NFPA 70E, Annexes, as listed below:
 - 1. Flash Hazard Protection Boundary.
 - 2. Limited Approach Boundary.
 - 3. Restricted Boundary.
 - 4. Prohibited Boundary.
 - 5. Incident Energy Level.
 - 6. Required Personal Protective Equipment Class.
 - 7. Type of Fire Rated Clothing.
- J. Provide an Arc Flash Warning Label, printed in color and affixed to the front of each panel provided. Size of each label shall be not less than 8 inches wide and 6 inches tall.

2.2 MANUFACTURERS

- A. Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, have been named within the various paragraphs of this Section.
- B. The listing of specific manufacturers within the various paragraphs of this Section does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed within the various paragraphs of this Section are not relieved from meeting these specifications in their entirety.

2.3 GENERAL REQUIREMENTS

- A. Ensure that final enclosure sizing and panel arrangements accommodate all required equipment for a fully integrated and operational system as specified herein and in the Contract Documents.
- B. The devices designated for rear-of-panel mounting shall be arranged within the panel in a manner to allow for ease of maintenance and adjustment. Heat generating devices such as

- power supplies shall be located at or near the top of the panel.
- C. All components shall be mounted in a manner that shall permit servicing, adjustment, testing, and removal without disconnecting, moving, or removing any other component. Components mounted on the inside of panels shall be mounted on removable plates and not directly to the enclosure. Mounting shall be rigid and stable unless shock mounting is required otherwise by the manufacturer to protect equipment from vibration. Component mounting shall be oriented in accordance with manufacturer's recommendations. The internal components shall be identified with suitable plastic or metal engraved nametags mounted adjacent to (not on) each component identifying the component in accordance with the drawing, specifications, and equipment supplier's data.
 - D. All exterior panel mounted equipment shall be installed with suitable gaskets, faceplates, etc. required to maintain the NEMA rating of the panel.
 - E. All panel doors shall have a lock installed in the door handle, or a hasp and staple for padlocking. Locks for all panels provided under this Contract shall be keyed alike.
 - F. Nameplates
 - 1. All panels and panel devices shall be supplied with suitable nameplates which identify the panel and individual devices as required. Unless otherwise indicated, each device nameplate shall include up to 3 lines with the first line containing the device tag number as shown on the drawings, the second line containing a functional description (e.g., Recirculation Pump No. 1), and the third line containing a functional control description (e.g., Start).
 - 2. Unless escutcheon plates are specified or unless otherwise noted on the Drawings, nameplates shall be 3/32-inch thick, black and white, Lamicoid with engraved inscriptions. The letters shall be Black against a White background unless otherwise noted. Edges of the nameplates shall be beveled and smooth. Nameplates with chipped or rough edges will not be acceptable.
 - 3. Nameplate fasteners and mounting shall be epoxy adhesive or stainless-steel screws for cabinet mounted nameplates
 - 4. For every panel, provide a panel nameplate with a minimum of 1-inch high letters. Provide legend plates or 1x3-inch engraved nameplates with 1/4-inch lettering for identification of door mounted control devices, pilot lights, and meters.
 - 5. Single lamicoid nameplates with multiple legends shall be used for grouping of devices such as selector switches and pilot lights that relate to one function.

2.4 PANEL REQUIREMENTS

- A. Structure and Enclosure
 - 1. Panels shall be of continuous welded-steel construction. Provide angle stiffeners as required on the back of the panel face to prevent panel deflection under instrument loading or operation. Internally the panels shall be supplied with a structural framework for instrument support purposes and panel bracing. The internal framework shall permit panel lifting without racking or distortion. Provide removable lifting rings designed to facilitate simple, safe rigging, and lifting of the control panels during installation.
 - 2. Each panel shall be provided with full height, fully gasketed access doors where

shown. Doors shall be provided with a three-point stainless steel latch and heavy-duty stainless-steel locking handle. Rear access doors (if included) shall be conveniently arranged and sized such that they extend no further than 24 inches beyond the panel when opened to the 90-degree position. Front and side access doors shall be as shown. Panel access doors shall be provided with full length, continuous, piano type stainless steel hinges with stainless steel pins. Front access doors with mounted instruments or control devices shall be of sufficient width to permit door opening without interference from flush mounted instruments.

3. The panels, including component parts, shall be free from sharp edges and welding flaws. Wiring shall be free from kinks and sharp bends and shall be routed for easy access to other components for maintenance and inspection purposes.
4. The panel shall be suitable for top and bottom conduit entry as required by the Electrical Drawings. For top mounted conduit entry, the panel top shall be provided with nominal one-foot square removable access plates, which may be drilled to accommodate conduit and cable penetrations. All conduit and cable penetrations shall be provided with ground bushings, hubs, gasketed locknuts, and other accessories as required to maintain the NEMA rating of the panel and electrical rating of the conduit system.
5. All panels in indoor, environmental controlled environments (air conditioned) shall be NEMA 12 unless otherwise noted. All panels installed indoors, in non-environmental controlled environments or panels installed in outdoors shall be NEMA 4X unless otherwise noted. All panels located in a hazardous location shall be rated for the type of hazard (e.g., NEMA 7 for Class 1, Division 1).

B. Freestanding and Floor-Mounted Vertical Panels

1. Freestanding and floor-mounted vertical panels shall meet the NEMA classification as shown on the drawings or specified herein. The panels shall be constructed of 12-gauge sheet steel, suitably braced internally for structural rigidity and strength. All NEMA 4X rated panels shall be constructed of type 304 stainless steel, unless FRP is specifically indicated to be provided. Front panels or panels containing instruments shall be not less than 10-gauge stretcher leveled sheet steel, reinforced to prevent warping or distortion.

C. Wall and Support Channel Mounted Panels

1. All wall and support channel mounted panels shall meet the NEMA classification as shown on the drawings or specified herein. The panels shall be constructed of not less than USS 14-gauge steel, suitably braced internally for structural rigidity and strength. All NEMA 4X rated wall mounted panels shall be constructed of type 304 stainless steel with white polyester powder coated paint, factory applied from the manufacturer, unless FRP is specifically indicated.

D. Finish Requirements

1. All sections shall be descaled, degreased, filled, ground and finished. The enclosure when fabricated of steel shall be finished with 2 rust resistant phosphate prime coats and 2 coats of enamel, polyurethane, or lacquer finish which shall be applied by either the hot air spray or conventional cold spray methods. Brushed anodized aluminum panels will not require a paint finish.
2. The panels shall have edges ground smooth and shall be sandblasted and then

- cleaned with a solvent. Surface voids shall be filled and ground smooth.
3. Immediately after cleaning, 1 coat of a rust-inhibiting primer shall be applied inside and outside, followed by an exterior intermediate and topcoat of a 2-component type epoxy enamel. A final sanding shall be applied to the intermediate exterior coat before top coating.
 4. Apply a minimum of 2 coats of manufacturer's standard, flat light-colored lacquer, on the panel interior after priming.
 5. Unless otherwise noted, the finish exterior colors shall be ANSI 61 gray with a textured finish.
 6. NEMA 4X Stainless Steel panels installed outdoors shall have an additional requirement of white polyester powder coated paint, factory applied from the manufacturer.
- E. Print storage pockets shall be provided on the inside of each panel. The storage pockets shall be steel, welded on to the door, and finished to match the interior panel color. The storage pocket shall be sufficient to hold all of the prints required to service the equipment, and to accommodate 8.5x11 inch documents without folding.
- F. Folding shelf shall be provided on the inside of the door on all free-standing and floor-mounted panels. The shelf shall be suitable for a laptop computer and shall be placed such that an open laptop computer does not interfere with any door-mounted devices. The folded shelf shall not interfere with any internal panel components when the door is closed. The folding shelf shall automatically lock in the horizontal position when raised. The folding shelf shall be approximately 18 inches wide by 12 inches deep and shall have a minimum distributed load rating of 100 lbs. All parts shall be made of heavy gauge steel and shall be painted white or finished to match the interior panel color.

2.5 ENVIRONMENTAL CONDITIONING

A. Condensation Control

1. A self-contained enclosure condensation heater with thermostat and fan shall be mounted inside the control panel, if panel is mounted outdoors or in a non-air-conditioned space.
 - a. Enclosure heaters shall be energized from 120 V, single-phase power supply and sized to prevent condensation within the enclosure.
 - b. Locate enclosure heaters to avoid overheating electronic hardware or producing large temperature fluctuations on the hardware.
 - c. Enclosure heaters shall have an internal fan for heat distribution and shall be controlled with adjustable thermostats. The thermostat shall have an adjustment range of 40-90°F. Provide a circuit breaker or fused disconnect switch within the enclosure.
 - d. Enclosure heaters shall be Hoffman type DAH or equal.
2. Strip heaters may be provided if they are 240 V rated, powered at 120 Vac and do not have a surface temperature higher than 60°C. Strip heaters and thermostats shall be as manufactured by Chromalox or equal.
 - a. Strip heaters shall be Chromalox, Type OT, 1.5 inches wide, 240 V, single phase, 150 W, energized at 120 V, with rust resisting iron sheath, Catalog No. OT-715,

Product Code No. 129314, or equal. Provide sufficient wattage in heaters to prevent condensation should the interior temperature of the enclosure drop below the dew point.

- b. A control thermostat mounted inside the control Panel shall be Chromalox, Type WR, single stage, Catalog No. WR-80, Product Code No. 263177, or equal.
 - c. The strip heater terminals shall be guarded by a protective terminal cover.
 - d. High temperature connecting lead wire shall be used between the thermostat and the heater terminals. Wire shall be No. 12 AWG stranded, nickel-plated copper with Teflon glass insulation and shall be the product of Chromalox, Catalog No. 6-CFI-12, Product Code No. 263783, or equal.
3. Each panel shall have a 1/2-inch stainless steel condensate drain installed on a stainless-steel conduit hub, HGTZ Series, T&B or equal, in the bottom of the enclosure. Drain shall be O-Z Gedney DBB-50SS, or equal.

B. Panel Interior Ambient Control

- 1. The manufacturer shall provide ambient temperature control within the panel to maintain internal temperatures below the maximum operating temperatures of the panel components. An ambient temperature range of minus 20-40°C.
- 2. The manufacturer shall provide panel internal heat rise calculations to show that the panel internal temperatures will be maintained below the maximum operating temperatures of the panel components.
- 3. The calculation shall show all the internal and external heat gain loads, the expected internal temperature rise in °C above the specified ambient, If the specified temperature range cannot be met, an air conditioning system shall be provided with sufficient capacity to maintain the temperature within the specified limits. Panels, for which the calculated heat rise exceeds 40°C, shall have an air conditioning system sized as required to reduce the heat rise to 40°C or less, without violating the NEMA rating of the enclosure.
- 4. The air conditioner shall have the following features:
 - a. Use CFC-free R134a refrigerant.
 - b. Have fully gasketed flanges on all four mounting edges for a watertight seal that maintains NEMA 4X rating of the panel.
 - c. Thermostatic low temperature control to provide energy efficient operation and prevents over-cooling.
 - d. EMI/RFI suppressor to minimize transient spikes during compressor on/off cycling.
 - e. Separated blower-driven evaporator and condenser air systems for closed loop cooling.
 - f. UL listed.
 - g. Stainless steel enclosure.
 - h. Internal corrosion resistant coating.
 - i. Low ambient kit.
 - j. Short cycle protector.
 - k. The air conditioning unit shall be Hoffman, Thermo Electric or approved equal.

2.6 CORROSION CONTROL

- A. Panels shall be protected from internal corrosion by the use of corrosion-inhibiting vapor capsules as manufactured by Northern Technologies International Corporation, Model Zerust VC; Hoffman Model AHCI; or equal.

2.7 INTERNAL POWER CIRCUIT DEVICES

A. Main Circuit Protective Device

- 1. Unless otherwise shown on the Drawings, the main circuit protective device shall be a molded case (MCCB), 3-Pole, 600 V, fixed type, manually operated with stored energy closing mechanism. Trip device shall be solid state with adjustable long time pickup and delay; adjustable short time pickup and delay; short time inverse time switch;
- 2. Provide a flange mounted main power disconnect operating handle with mechanical interlock having a bypass that will allow the panel door to open only when the switch is in the "OFF" position. Where panels are shown or specified with inner and outer doors, disconnecting handles and controls shall be located on the inner door.

B. Motor Starter

- 1. Type:
 - a. Magnetic Controller: NEMA ICS 2, Class A, full voltage, non-reversing, across the line, unless otherwise indicated.
 - b. Overload Relay: Ambient-compensated type with inverse-time-current characteristic and NEMA ICS 2, Class 20 tripping characteristic. Provide with heaters or sensors in each phase matched to nameplate full-load current of specific motor to which they connect and with appropriate adjustment for duty cycle.
- 2. Contactors:
 - a. Size contactors according to Drawings. Sizes below NEMA 1 are not acceptable. Provide three main poles, the number and type of auxiliary contacts to perform the required functions and two spare auxiliary contacts, one normally open and one normally closed, rated 10 Amps (NEMA contact rating designation A600).
 - b. Use double break contacts of silver-cadmium oxide or similar material to minimize sticking or welding.
 - c. Provide contactor coils suitable for continuous operation at 120 V, 60 Hz.
- 3. Unless otherwise indicated larger on the Drawings, use the following minimum starter sized for motor horsepower and voltage. Under no circumstances shall smaller sizes be used even if mistakenly shown on the Drawings; IEC starters and dual rated IEC/NEMA starters shall not be acceptable.

Table 1		
NEMA Size Starter	Horsepower 480 V	Horsepower 208 V
1	Up to 7.5	Up to 5
2	20	7.5
3	40	20
4	75	36
5	100	--

C. Variable Frequency Drives

1. Description: NEMA ICS 2, pulse-width-modulated, variable frequency controller; listed and labeled as a complete unit and arranged to provide variable speed of an NEMA MG 1, Design B, 3-phase, induction motor by adjusting output voltage and frequency.
 - a. Provide unit suitable for operation of premium-efficiency motor as defined by NEMA MG 1.
2. Design and Rating: Match load type such as fans, blowers, and pumps; and type of connection used between motor and load such as direct or through a power-transmission connection.
3. Output Rating: 3-phase; 6-60 Hz, with voltage proportional to frequency throughout voltage range.
4. Unit Operating Requirements:
 - a. Input ac voltage tolerance of 380-500 V, plus or minus 10%.
 - b. Input frequency tolerance of 60 Hz, plus or minus 6%.
 - c. Minimum Efficiency: 96% at 60 Hz, full load.
 - d. Minimum Displacement Primary-Side Power Factor: 96%.
 - e. Overload Capability: 1.1 times the base load current for 60 sec.; 2.0 times the base load current for 3 sec.
 - f. Starting Torque: 100% of rated torque or as indicated.
 - g. Speed Regulation: Plus or minus 1%.
 - h. Ambient Temperature: 0-40°C.
5. Isolated control interface allows controller to follow control signal over an 11:1 speed range.
 - a. Electrical Signal: 4-20 mA at 24 V.
6. Internal Adjustability Capabilities:
 - a. Minimum Speed: 5-25% of maximum rpm.
 - b. Maximum Speed: 80-100% of maximum rpm.
 - c. Acceleration: 2 to a minimum of 22 sec.
 - d. Deceleration: 2 to a minimum of 22 sec.
 - e. Current Limit: 50 to a minimum of 110% of maximum rating.
7. Self-Protection and Reliability Features:
 - a. Input transient protection by means of surge suppressors.
 - b. Undervoltage and overvoltage trips; inverter over-temperature, overload, and overcurrent trips.
 - c. Motor Overload Relay: Adjustable and capable of NEMA 250, Class 20 performance.
 - d. Notch filter to prevent operation of the controller-motor-load combination at a natural frequency of the combination.
 - e. Instantaneous line-to-line and line-to-ground overcurrent trips.
 - f. Loss-of-phase protection.

- g. Reverse-phase protection.
 - h. Short-circuit protection.
 - i. Motor over-temperature fault.
8. Automatic Reset/Restart: Attempts three restarts after controller fault or on return of power after an interruption and before shutting down for manual reset or fault correction. Restarting during deceleration shall not damage controller, motor, or load.
 9. Power-Interruption Protection: Prevents motor from re-energizing after a power interruption until motor has stopped.
 10. Panel-Mounted Operator Station: Start-stop and auto-manual selector switches with manual speed control potentiometer and elapsed time meter.
 11. Integral Disconnecting Means: NEMA AB 1, molded-case switch with lockable handle.
 12. Remote Indicating Circuit Terminals: Mode selection, controller status, and controller fault.
 13. Line Reactor: Unit shall have 5% Line Reactor and 5% dc Bus Choke, unless specified otherwise.
 14. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Allen Bradley.
 - b. Danfoss.
 - c. Square D
 - d. General Electric
 - e. Eaton.
 - f. WEG
- D. Power Terminal Blocks
1. Power Wire Terminal Blocks (Motors, Solenoids, Valves, etc.):
 - a. Terminal blocks shall be NEMA Open System. Blocks shall be one-piece molded plastic blocks with screw type terminals and barriers rated for 600 V.
 - b. Terminals shall be double sided and supplied with removable covers to prevent accidental contact with live circuits.
 - c. Terminals shall have permanent, legible identification, clearly visible with the protective cover removed.
 - d. Wires shall be terminated to the terminal blocks with crimp type, pre-insulated, ring-tongue lugs. Lugs shall be of the appropriate size for the terminal block screws and for the number and size of the wires terminated.
 2. Terminal Tags, Covers and Markers:
 - a. Each terminal strip shall have a unique identifying alphanumeric code designation at one end and a plastic marking strip running the entire length with a unique number for each terminal.
 - b. Assign terminal strip numbers from the number "1" and continuing in ascending cardinal order. The terminal strip designation shall be the letters "TB" followed by the terminal strip number. The strip and terminal point designations shall be

machine printed and 1/8-inch high.

E. Phase Failure/Undervoltage Pump Protection

1. Where required in equipment specification, an independent power monitor shall be provided on the load side of the pump disconnects to monitor incoming voltage and provide protection to the motors. These power monitors shall detect incoming service abnormalities including phase-loss, unbalance, reversal, overvoltage, undervoltage and rapid cycling protection and provide automatic cutout of pumps and provide local alarm. Upon detection that incoming power has returned to normal, the unit will restore pump operation and discontinue alarm. This device shall have a nominal 2-4 sec. dropout delay and (2-300 sec.) adjustable restoration time delay.
2. The unit shall protect itself from voltage spikes and transients with internal transient protection meeting IEEE 587 standards.
3. The power monitor system shall also include a stagger time delay function providing time delay between lead and lag pump start to eliminate simultaneous starting of motors upon return of system power. This feature shall be operation in all modes of pump operation. The monitors will be SYMCON 460 VBM.

2.8 PANEL MOUNTED CONTROL OR INDICATING DEVICES

1. Combined Sounder and LED Beacon
 - a. Where indicated panels shall be provided with a "Combined Sounder and LED Beacon". The combined sounder and flashing LED beacon shall have polycarbonate housing and lens, 45 mm size, 22 mm mounting hole, and Type 4X. Control logic shall be provided so that the unit can be silenced, until alarm is cleared and reset. The sounder shall have average dBA at 1 m of 103 and shall be configured as pulsing. The combined sounder and flashing LED beacon shall be as manufactured by Eaton, Model RoLP Maxi Solista; or equal.
2. Push Buttons, Selector Switches and Pilot Lights
 - a. Push buttons, Type 4/4X/13 corrosion-resistant/watertight/oiltight plastic, selector switches and pilot lights shall be 30.5 mm type.
 - b. Push buttons, selector switches and pilot lights shall have electrical ratings of:
 - 1) Dielectric strength: 2200 V for 1 min.
 - 2) Electrical design life cycles: 10,000,000 at maximum rated load
 - c. Push buttons, selector switches and pilot lights shall have an operating range of minus 40-131°F (minus 40-55°C).
 - d. Illuminated devices shall offer universal LED that accepts 12-130 Vac/Vdc voltage input. Lens color shall be as follows;
 - 1) Running, on, open: Red.
 - 2) Stopped, off, closed: Green.
 - 3) Alarm: Amber.
 - 4) White: Power on
 - 5) Blue: All other status indications not covered by the above
 - 6) Lens caps shall be approximately 0.46 inch diameter. Provide legend faceplates engraved to indicate the required function of each device; rated NEMA 4X.

- e. Push buttons shall have a diaphragm seal for protection from liquids, particles and corrosive agents. Button colors shall be as follows;
 - 1) Start, open: Red.
 - 2) Stop, close: Green.
 - 3) Black: All other status indications not covered by the above
- f. Selector switches shall incorporate a positive detent to prevent the switch from hanging up between positions.
 - 1) Selector switches shall incorporate a positive detent to prevent the switch from hanging up between positions.
- 3. Elapsed Time Meters
 - a. Meter shall be heavy duty, electro-mechanical, non-resettable, six digit 99999.9h Unit shall be NEMA 4X rated.
 - b. Mounting of unit with gasket shall maintain rating of enclosure.
- 4. Digital Panel Meter
 - a. Meter shall be electronic, 3.5 digit, 0.56-inch high efficiency LED display and shall provide indicated in engineering units of measured variable. Case type shall be watertight and dust tight (NEMA 4X).

2.9 INTERNAL CONTROL CIRCUIT DEVICES

- A. Panel lighting
 - 1. Panels shall be provided with a door switch activated 24 Vdc LED light.
- B. Panel Service Receptacle
 - 1. Panels, where indicated in equipment specifications. shall be provided with a DIN Rail Mounted straight blade, 125 V, 15 Amp, non-feed-through type receptacle. Comply with NEMA WD 1, NEMA WD 6, UL 498, and UL 943, Class A, and include LED status indicator light.
- C. Panel Incoming Surge Protection
 - 1. Provide modular, pluggable surge protective device of the incoming power feed to the control panel. Units shall be metal oxide varistors (MOVs) and gas-filled surge arresters, with a maximum continuous operating voltage of 150 V.
- D. Circuit Breakers
 - 1. Breakers shall be thermal-magnetic, current-limiting type, UL Listed, 10 kA.
 - 2. Housing shall satisfy Insulation Group II/RAL 7035, shall have IP20 finger-safe design, shall be suitable for DIN rail mounting and shall include status indicator window and scratch-resistant and solvent-resistant printing
- E. 24VDC Power Supplies
 - 1. Provide a 24 Vdc power supply in the control panel to power field instruments, panel devices, etc., as required. Equip the power supply with a power on-off circuit breaker. Size the 24 Vdc power supply to accommodate the design load plus a minimum 50% spare capacity. Power supply shall be primary switched, DIN Rail mounted, with LED indication and status contacts. Provide output overvoltage and overcurrent protective devices with the power supply to protect instruments from damage due to power

supply failure and to protect the power supply from damage due to external failure. Mount the 24 Vdc power supply such that dissipated heat does not adversely affect other panel components.

- F. 120VAC Uninterruptible Power Supply (UPS)
 - 1. Provide a 120 Vac UPS in the control panel to power control components, including PLC, relays, 24 Vdc power supplies, etc. as required. Equip the power supply with a power on/off circuit breaker. Size the UPS to accommodate the design load plus a minimum 50% spare capacity, with 10 min. battery life at full load. UPS shall be DIN Rail mounted, with LED indication and status contacts. Mount the UPS power supply such that dissipated heat does not adversely affect other panel components. Provide a maintenance bypass switch to allow the UPS to be taken out of service for maintenance or replacement.
- G. Fuse Blocks
 - 1. Fuse Blocks shall be DIN Rail mounted, single level, standard size, set screw terminal, with blown fuse indicator.
- H. Terminal Blocks – 120Vac or 24Vdc
 - 1. Terminal blocks shall be DIN-Rail mounted, IEC screw-type, feed-through, single level, rated IP20. Metal components shall be made of corrosion resistant materials. The metal body shall contain a serrated pressure plate that will provide a gas-tight connection with the conductor. Terminal Blocks shall have captive screws. Control terminal blocks shall have a snap-in card marking system. Marking shall be computer generated.
- I. Relays
 - 1. Relays – Time Delay
 - a. Relays shall mount on tube-type bases with pin-style socket mounting. Shall have 10 Amp, B300, DPDT contact ratings and coil voltages as shown on drawings and adjustable timing ranges.
 - 2. Relays – General Purpose
 - a. Relays shall have tube-base/Octal 8-pin or 11-pin terminals and "ON-OFF" flag indicators. Contacts shall be silver nickel and have 10 Amp, B300, DPDT or 3PDT ratings. Shall have an electrical schematic on the faceplate, a clear cover for visual inspection and snap-in marker ability. Relays shall have LED status indicators, push-to-test and manual override.
 - 3. Relays – Miniature
 - a. Relays shall be square-base, 4-pole, plug-in type with blade-style terminals and "ON-OFF" flag indicators. Contacts shall be silver nickel and have 7 Amp or 10 Amp, DPDT or 4PDT ratings. Shall have an electrical schematic on the faceplate and a clear cover for visual inspection and LED status indicators and push-to-test button with incorporated manual override lever.
 - 4. Relays - PLC Interposing
 - a. Relays shall be DIN Rail Mount, screw terminal, slim factor design. Shall be pluggable, with ejector feature. Contacts shall be silver nickel and have 5 Amp, 24 Vdc or 3 Amp, 120 Vac, SPDT electro-mechanical and shall have LED status indicators.

5. Relays - Alternating
 - a. Alternator shall be provided to sequence motors where required for lead-lag operation. Alternator shall be Catalog No. 008-120-13SP or 009-120-23AP by Stacon; Square D, Class 9039, Type HG-21 or equal.
6. Timers – Solid-State
 - a. Timers shall be DIN rail mounted. Contacts shall be available as SPDT or DPDT, 8 Amp. Timers shall be available with On-Delay, Off-Delay, On-Delay and Off-Delay, One-Shot, and Flasher operating modes as required on the drawings. Timers shall have coil surge protection and adjustable timing ranges of 0.05 sec. to 60 hours as shown on drawings.
7. Timers – Programmable
 - a. Timers shall be digital timing relays with LCD display and shall be socket or panel mounted. Contacts shall be SPDT, rated 5 Amp, B300. Timers shall be configurable for Signal On-Delay, Power On-Delay, Off-Delay, Repeat Cycle, One-Shot, and Cumulative operating modes as required on the drawings. Timers shall have timing ranges of 0.000 sec. to 9999 hours, depending on selected mode and as shown on drawings.
- J. Analog Signal Surge Protection
 1. Analog signal surge protection shall be slim-factor hybrid design that combines solid-state electronic and gas filled discharge tube to provide protection to 20 kA.
- K. Signal Isolators
 1. Signal Isolators shall be DIN Rail mounted, solid state, ASIC technology; electronic type, with 0.15 accuracy. There shall be complete isolation between input circuitry, output circuitry, and the power supply. Zero and span adjustment shall be provided. Units shall be as manufactured by Action Instruments, Model Slim Pak; or approved equal.
- L. Fiber Optic Patch Panel
 1. Provide DIN rail mounted patch panels, as indicated in equipment specifications, to terminate cabling from the network elements. Physical locations and number of Type SC connectors supported shall be sufficient to terminate all fibers at each fiber drop point.
- M. CAT 6 Patch Panel
 1. Provide DIN rail mounted patch panels, as indicated in equipment specifications, to terminate cabling from the network elements. Performance parameters, including NEXT, Attenuation and Return Loss shall meet Category 6E Cabling Standard.

2.10 INTERNAL WIRING REQUIREMENTS

- A. 120 Vac and 24 Vdc Wiring
 1. All interconnecting wiring shall be stranded, type MTW, and shall have 600 V insulation and be rated for not less than 90°C. Wiring for systems operating at voltages in excess of 120 Vac shall be segregated from other panel wiring either in a separate section of a multi-section panel or behind a removable Plexiglas or similar dielectric barrier. Panel layout shall be developed such that technicians shall have complete access to 120 Vac and lower voltage wiring systems without direct exposure

- to higher voltages.
2. Power distribution wiring on the line side of fuses or breakers shall be 12 AWG minimum. Control wiring on the secondary side of fuses shall be 14 AWG minimum. Electronic analog circuits shall utilize 18 AWG shielded, twisted pair, cable insulated for not less than 600 V.
 3. Power and low voltage dc wiring systems shall be routed in separate wireways. Crossing of different system wires shall be at right angles. Different system wires routed parallel to each other shall be separated by at least 6-inches. Different wiring systems shall terminate on separate terminal blocks. Wiring troughs shall not be filled to more than 60% visible fill.
 4. Terminations
 - a. All wiring shall terminate onto single tier terminal blocks, where each terminal is uniquely and sequentially numbered. Direct wiring between field equipment and panel components is not acceptable. Wiring for input/output (I/O) points for the PLC shall be allowed to terminate directly to interposing relay or surge protector.
 - b. Multi-level terminal blocks or strips are not acceptable.
 - c. Terminal blocks shall be arranged in vertical rows and separated into groups (power, ac control, dc signal). Each group of terminal blocks shall have a minimum of 25% spares.
 - d. Discrete inputs and outputs (DI and DO) shall have two terminals per point with adjacent terminal assignments. All active and spare PLC and controller points shall be wired to terminal blocks. Wiring for I/O points for the PLC shall be allowed to terminate directly to interposing relay.
 - e. Analog inputs and outputs (AI and AO) shall have three terminals per shielded pair connection with adjacent terminal assignments for each point. The third terminal is for shielded ground connection for cable pairs. Ground the shielded signal cable at the PLC cabinet. All active and spare PLC and controller points shall be wired to terminal blocks. Wiring for I/O points for the PLC shall be allowed to terminate directly to surge protector.
 - f. Wire and tube markers shall be the sleeve type with heat impressed letters and numbers.
 - g. Only one side of a terminal block row shall be used for internal wiring. The field wiring side of the terminal shall not be within 6 inches of the side panel or adjacent terminal or within 8 inches of the bottom of free-standing panels, or within 3 inches of stanchion mounted panels, or 3 inches of adjacent wireway.
 - h. Circuit power from the SCADA cabinet out to field devices (switches, dry contacts etc.) that are used as discrete inputs to the PLC input cards shall be isolated with an isolating switch terminal block with flip cover that is supplied with a dummy fuse. Isolation switch block shall be an Allen Bradley Model 1492-H7 or equal. One isolating switch terminal block per loop numbered piece of equipment and one per spare I/O point is acceptable.
 - i. Wire Tagging:
 - 1) Panel connection wiring shall be tagged at terminations with machine printed slip on type tags.

- 2) Provide wire-cable tag designations on all wiring diagrams submitted to the OWNER. Place tag within 2 inches of any wiring termination, affixing tag to prevent the tag from sliding more than 2 inches from the terminal as the result of gravity and vibration.
5. All wiring to hand switches and other devices, which are live circuits independent of the panel's normal circuit breaker protection, shall be clearly identified as such.
6. All wiring shall be clearly tagged and color coded. All tag numbers and color coding shall correspond to the panel wiring diagrams and loop drawings. All power wiring, control wiring, grounding, and dc wiring shall utilize different color insulation for each wiring system used. The color coding scheme shall be:
 - 1) Incoming 120 Vac Hot: Black
 - 2) 120 Vac Hot wiring downstream of panel circuit breaker: Red
 - 3) 120 Vac Hot wiring derived from a UPS system: Red with Black stripe
 - 4) 120 Vac neutral: White
 - 5) Ground: Green
 - 6) Dc power or control wiring: Blue
 - 7) Dc analog signal wiring: Black (+), White (-)
 - 8) Foreign voltage: Yellow
7. Each field instrument furnished as deriving input power from the control panel(s) shall have a separate power distribution circuit with a circuit breaker or fuse and blown fuse indication. All instruments requiring 120 Vac power shall be powered from the UPS source in the panel where the instrument signals lands.
8. Wiring trough for supporting internal wiring shall be plastic type with snap-on covers. The side walls shall be open top type to permit wire changing without disconnecting. Trough shall be supported to the subpanel by stainless steel screws. Trough shall not be bonded to the panel with glue or adhesives.
9. Each panel shall be provided with an isolated copper grounding bus for all signal and shield ground connections. Shield grounding shall be in accordance with the instrumentation manufacturer's recommendations.
10. Each panel shall be provided with a separate copper power grounding bus (safety) in accordance with the requirements of the National Electrical Code.
11. Field Entrance Internal Wiring:
 - a. Field entrance internal wiring shall be neatly grouped by circuit and bound by plastic tie wraps. Circuit groups shall be supported so that circuit terminations are not stressed. In addition, low signal wiring (mV and mA) shall be bundle separately from the rest of the control wiring.
 - b. All field wiring shall be tagged and coded with an identification number. Coding shall be typed on a heat shrinkable tube applied to each end of the wire. The marking shall be a permanent, non-smearing, solvent-resistant type similar to Raychem TMS-SCE.
 - c. All conduit entering or leaving equipment shall be coordinated, in advance with the panel installer, so that the conduit entrances to the enclosure are directly below the termination area for immediate termination. Conduits shall not enter the top or side of the panel unless approved in writing by the OWNER and

ENGINEER.

12. Fusing of PLC Inputs and Outputs:
 - a. All PLC analog inputs and outputs shall be individually fused for each channel.
 - b. All discrete inputs and outputs shall be buffered with relays from the field connections. Discrete points shall be fused for each circuit group with no less than one fuse per PLC I/O card.
13. Buffering PLC Discrete Inputs and Outputs:
 - a. All PLC discrete inputs and outputs shall be individually buffered with relays as specified. Where field voltage is ac reed type relays shall not be used.
14. Analog Input and Output Wiring:
 - a. Provide a fuse for each analog signal. Each analog I/O and each spare analog I/O shall be furnished with a surge protection device hardwired to the fed-through terminal block.

2.11 PROGRAMMABLE LOGIC CONTROLLER (CHASSIS MOUNTED)

A. General

1. Provide Programmable Logic Controller equipment with the required memory and functional capacity to perform the specified sequence of operation with the scheduled input and output points.
2. Processor Systems shall include processor, power supply, I/O modules, communication modules, redundancy modules, and remote interface modules as required to meet system requirements.
3. All equipment furnished shall be designed and constructed so that in the event of power interruption the systems shall go through an orderly shutdown with no loss of memory and resume normal operation without manually resetting when power is restored.
4. The PLC shall be capable of stand-alone operation in the event of failure of the communication link to the Plant Control System.
5. Backup Remote Input/Output Units shall include input/output modules, interface modules, communication modules, and power supply to meet system input and output requirements.
6. Agency and environmental specifications:
 - a. Electrical supply voltage to the PLC shall be 120 Vac, plus or minus 15%, 48-63 Hz. PLC system power supplies shall be fused for overload protection.
 - b. All products shall have corrosion protection.
7. All necessary cables shall be included. All cables and connectors shall be as specified by the manufacturer. Cables shall be assembled and installed per the manufacturer recommendations.

B. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:

1. Allen-Bradley, Compact Logix
2. General Electric, RX3i
3. Modicon, M340

- C. Programming Languages
1. Each PLC shall support IEC Standard 61131-3 for all of the following programming languages:
 2. Ladder (LD)
 3. Function Block Diagram (FBD)
 4. Structured Text (ST)
 5. PLC shall support user defined functions for customization and user defined tag structures.
 6. PLC shall have application-specific instructions for process, drive, batch, motion, and safety applications built into the controller.
- D. Central Processor Unit (CPU)
1. Each processor shall have the maximum IEC Program Memory size available at time of procurement.
 2. Provide hardware employing identical revisions of software and firmware as applicable.
 3. Processor shall have a minimum IEC program memory size of 1024 kB.
 4. The CPU shall contain a minimum of 1 serial configuration port and 2 Ethernet ports.
 5. The CPU shall be able to do time synchronization for the system.
- E. Physical Construction (Chassis)
1. The PLC shall be of the modular construction, consisting of a back plane, plug in modules for the processor, communication modules, I/O modules and expansion modules.
- F. Power Supply (PS)
1. The power supply shall be 120 V, 60 Hz, and shall be sized for the total quantity of modules including the power requirement of spare I/O module slots.
- G. I/O Modules: The following types of process I/O interface capabilities shall be provided for the PLC:
1. Discrete Input Requirements:
 - a. Responsible for the PLC interface with the status and alarm contacts.
 - 1) For the "dry" contacts: PLC shall sense the states of these contacts by applying a voltage and observing the extent to which current flows.
 - 2) This voltage shall be obtained from a separate, isolated power supply furnished by the CONTRACTOR
 - 3) Voltage applied across the open contacts shall be 24 Vdc (nominal), or 110 Vac.
 - b. Exact input configuration sized to meet the existing discrete input needs as specified on the Drawings.
 - c. Final configuration based on the standard product offering of the PLC manufacturer.
 - d. Discrete inputs shall be 24 Vdc and be individually buffered with external relays.
 - e. Number of Points per Card: 16

2. Discrete Output Requirements:

- a. Discrete output logic shall process the control commands received from the common logic. Control schemes, in which a single message with undetected errors can cause a false command, shall be unacceptable.
- b. Discrete output drive circuitry shall be designed such that any single logic component failure in the PLC does not energize a discrete output.
- c. Exact output configuration sized to meet existing discrete output needs as specified on the Drawings.
- d. Final configuration based on the standard product offering of the PLC manufacturer.
- e. Discrete outputs shall be of the relay type and individually buffered with external relays.
- f. Number of Points per Card: 16

3. Analog Output Requirements:

- a. Provide analog output modules having a 4-20 mA at 24 Vdc; suitable for interfacing to an electronic three mode controller or direct to a variable frequency drive.
- b. Analog outputs are driven from the isolated 24 Vdc power supply supplied in the PLC Panel. The module shall have broken wire fault detection.
- c. Exact output configuration sized to meet analog output needs as specified on the Drawings.
- d. Final configuration based on the standard product offering of the PLC manufacturer.
- e. Number of Points per Card: 8

4. Analog Input Requirements:

- a. Analog inputs from the transducers shall be 4-20 mA dc and all transducer power shall be provided by the dedicated 24 Vdc plus 10% power supply supplied in the PLC Panel, or from an isolated output of the field device. The module shall be Bi-Polar with broken wire and Out of Range fault detection.
- b. Exact input configuration sized to meet the analog input needs as specified on the Drawings.
- c. Final configuration based on the standard product offering of the PLC manufacturer.
- d. Number of Points per Card: 8

- H. PLC Power Supply: PLC power supplies shall be supplied with 110 Vac. PLC power supplies shall contain a "POWER OK" LED.

2.12 OPERATOR INTERFACE TERMINALS (OIT)

- A. OITs shall be mounted on control panels, where shown on drawings.
- B. Manufacturers
 - 1. Provide operator interface terminals (OIT) from one of the following:
 - a. Allen-Bradley PanelView Plus 6 series

- b. GE Loaded QuickPanel View series
 - c. Pro-face AGP3000/ AST3000 series
 - d. Siemens SIMATIC HMI IPC series
- C. Software
 - 1. The Operator Interface Terminal shall be pre-packaged with all configuration and programming software necessary to perform functions as shown on drawings and within the specifications.
 - 2. The integrated OIT software shall have the following features
 - a. Trending
 - b. Data Logging
 - c. Alarms
 - d. Graphic Symbols
 - e. Animations
- D. I/O Ports and Devices
 - 1. The OIT shall have a minimum of one Ethernet 10/100 Mbps for connectivity or programming.
 - 2. The OIT shall have a minimum of one Serial RS 232 port.
 - 3. Compact flash ports shall be Type 2.
 - 4. The OIT shall have a minimum of one USB port.
- E. Display
 - 1. The OIT display size shall be a minimum of 6 inches for wall mounted panels and 12 inches for floor mounted panels
 - 2. The type of display for the OIT shall be Color Active Matrix TFT.
 - 3. Display shall support touch screen input.
- F. Environmental
 - 1. Rating: OIT shall be rated to maintain the rating of the control panel it will be mounted in.
 - 2. Temperature: Operating temperature range of the OIT shall range 0-50°C.
- G. Operator screen shall be provided with a hinged screen to protect screen of sun light. Sun shield shall be Shade Aide by Smith and Loveless, Inc.

2.13 PROGRAMMING CABLES

- A. Provide two programming cables for each type of PLC to be programmed.

2.14 MEMORY MAPS REQUIREMENTS

- A. The control panel vendors shall comply with the following;
 - 1. Submit memory map of PLC registers to be transmitted to SCADA as part of their submittal.
 - 2. All vendors supplying control panels that communicate with the plant SCADA network shall submit a memory map of PLC registers to the Control System Integrator no later than 30 days prior to the scheduled shipment of the vendor equipment to the site.

Vendor shall contact and coordinate with the Control System Integrator to ensure compatible configuration of the vendor PLCs in order to match the facility network. Vendor shall configure the network addresses in their equipment to match the addresses determined by the Control System Integrator. Software communication shall be provided in contiguous registers. One set of registers shall be provided for writing discrete-type information, and one set shall be provided for reading discrete-type information. One set of registers shall be provided for writing floating-point information, and one set shall be provided for reading floating-point information.

2.15 INDUSTRIAL ETHERNET PROTOCOL CONVERTER

- A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:
 - 1. Digi
 - a. Model: Digi One IA Industrial Serial Server
 - 2. B&B Electronics
 - a. Model: MESR900 Series Industrial Modbus Ethernet to Serial Gateways
- B. Environmental
 - 1. Operating temperature: 32-140°F
 - 2. Operating humidity: 10–90% Non-condensing
 - 3. Storage Temperature: 32-140°F
- C. Physical
 - 1. Power Supply: 24 Vdc
 - 2. Microprocessor based managed type.
 - 3. DIN Rail mountable.
 - 4. Class 1 Division 2 rated
- D. Functional Performance
 - 1. Per Port status LED indication.
 - 2. Wire Speed switching.
 - 3. 10/100 BaseT ports with RJ-45 connectors for Category 6 cabling.
 - 4. ST or SC type Fiber Optic Connectors for 100BaseFX, 1000BaseSX for Multimode Fiber and 1000BaseLX for Single Mode Fiber as shown on the drawings.
 - 5. RS 232 Ports with terminals. Selectable link termination (100 ~120 Ω)
- E. Options and Accessories Required:
 - 1. Provide minimum 3-year warranty.
 - 2. The protocol interface shall implement the following:
 - a. All data shall be available and/or mirrored within the Modbus 4x or "Holding Register" memory area.
 - b. Register 4x00001 shall exist and be readable-writable to allow simple, predictable "communication tests".
 - 3. The media protocol converter shall meet the following criteria:
 - a. The converter shall support 10/100Base-T Ethernet. The serial port speed (baud

rate) shall support 230 k Bd. The protocol shall support Ethernet IP, Modbus TCP and Modbus RTU/ASCII. Protocol shall be Web Browser configurable.

2.16 INDUSTRIAL ETHERNET MEDIA CONVERTER

- A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:
 - 1. Beldon
 - 2. B & B Electronics
 - 3. Moxa
 - 4. N-TRON
 - 5. SIXNET
- B. Environmental
 - 1. Operating temperature: 32-104°F
 - 2. Operating humidity: 20-95% Non-condensing
 - 3. Storage Temperature: minus 40-158°F
- C. Physical
 - 1. Power Supply: 24 Vdc
 - 2. Microprocessor based managed type.
 - 3. DIN Rail mountable.
- D. Functional Performance
 - 1. Per Port status LED indication.
 - 2. Wire Speed switching.
 - 3. 10/100BaseT ports with RJ-45 connectors for Category 6 cabling.
 - 4. ST or SC type Fiber Optic Connectors for 100BaseFX, 1000BaseSX for Multimode Fiber and 1000BaseLX for Single Mode Fiber as shown on the drawings.

2.17 MISCELLANEOUS

- A. Face-mounted equipment shall be flush or semi-flush, with flat black escutcheons. Cutouts for future equipment and holes resulted from removal of existing devices shall be blanked off with suitable covers as required to retain the cabinet's NEMA rating. Component identification shall be hot ink stamped on the panel interior.
- B. Hardware and Fittings: All miscellaneous hardware and fittings shall be Type 316 stainless steel.
- C. The bottom 12 inches of free-standing panels shall be free of all devices, including terminal strips, to provide ease of installation and testing. If top fed, the top 12 inches of free-standing panels shall be free of all devices.

2.18 FACTORY TESTING - GENERAL

- A. The entire control panel shall be completely assembled, wired, and adjusted at the factory and shall be given the manufacturer's routine shop tests and any other additional operational test to insure the workability and reliable operation of the equipment.

- B. The operational test shall include the proper connection of supply and control voltage and, as far as practical, a mockup of simulated control signals and control devices shall be fed into the boards to check for proper operation.
- C. Factory test equipment and test methods shall conform to the latest applicable requirements of ANSI, IEEE, UL, and NEMA standards, and shall be subject to the OWNER and ENGINEER's approval.

2.19 EXTRA MATERIALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
- B. Spare part requirements shall be as indicted in the table below.

Description	Percent of Each Type and Size Used	No Less Than
Dc power supplies	20	2
Fuses	20	10
Relays and bases	20	10
Analog surge protectors	20	3
Power line surge protectors	20	2

PART 3 - EXECUTION

3.1 INSTALLER'S QUALIFICATIONS

- A. Installer shall be specialized in installing this type of equipment with minimum 5 years documented experience. Experience documentation shall be submitted for approval prior to beginning work on this project.

3.2 EXAMINATION

- A. Examine installation area to assure there is enough clearance to install the equipment.
- B. Housekeeping pads shall be included for the floor mounted panels as detailed on the drawings.
- C. Check concrete pads and baseplates for uniformity and level surface.
- D. Verify that the equipment is ready to install.
- E. Verify field measurements are as instructed by manufacturer.

3.3 INSTALLATION

- A. The CONTRACTOR shall install all equipment per the manufacturer's recommendations and contract drawings.
- B. Conduit hubs for use on raceway system pull and junction boxes shall be watertight, threaded aluminum, insulated throat, stainless steel grounding screw.
- C. Install required safety labels.

3.4 RACEWAY SEALING

- A. Where raceways enter control panels containing electrical or instrumentation equipment, all entrances shall be sealed with 3M 1000NS Watertight Sealant.
- B. This requirement shall be strictly adhered to for all raceways in the conduit system.

3.5 FIELD QUALITY CONTROL

- A. Inspect installed equipment for anchoring, alignment, grounding and physical damage.
- B. Check tightness of all accessible electrical connections. Minimum acceptable values are specified in manufacturer's instructions.
- C. Provide laminated copies of the control schematics along with the final approved I/O list in each enclosure door pocket.

3.6 CLEANING

- A. Remove all rubbish and debris from inside and around the panel. Remove dirt, dust, or concrete spatter from the interior and exterior of the equipment using brushes, vacuum cleaner, or clean, lint free rags. Do not use compressed air.

3.7 EQUIPMENT PROTECTION AND RESTORATION

- A. Touch-up and restore damaged surfaces to factory finish, as approved by the manufacturer. If the damaged surface cannot be returned to factory specification, the surface shall be replaced.

3.8 TESTING, COMMISSIONING AND TRAINING

- A. Testing and Commissioning: Accomplished in accordance with the requirements of Section 01 70 00 - Execution and Closeout Requirements.
- B. Training: Accomplished in accordance with the requirements of Section 01 70 00 - Execution and Closeout Requirements.

END OF SECTION

SECTION 40 06 00
SCHEDULES FOR PROCESS INTERCONNECTIONS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Piping schedule, designations, materials, locations, and test conditions.
 - 2. Valve schedule, designations, materials, locations, and test conditions.
 - 3. Reference respective piping and valve specifications for products and execution.
 - 4. Reference Contract Drawing PID-003 for equipment, process pipe, and valve tag designations.
 - 5. Reference process, mechanical, or other pertinent Contract Drawings for pipe and valve designations.
- B. Related Sections:
 - 1. Section 40 05 19 – Piping System, Ductile Iron Pipe
 - 2. Section 40 05 31 - Thermoplastic Process Pipe.
 - 3. Section 40 05 24 – Piping System, Steel Pipe
 - 4. Section 40 05 57 - Actuators for Process Valves and Gates.
 - 5. Section 40 05 61 - Gate Valves.
 - 6. Section 40 05 64 - Butterfly Valves.

PART 2 - PRODUCTS - NOT APPLICABLE

PART 3 - EXECUTION

3.1 SCHEDULES

- A. Attached to this specification:
 - 1. Process and Buried Pipe Schedules.
 - 2. Valve Schedules.

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PROCESS PIPE SCHEDULE														
ABREV	DESCRIPTION	INSTALLATION	MATERIAL	SIZE (INCHES)	MIN. PRESSURE CLASS	MIN. THICKNESS CLASS	SECTION	TEMP (F°)	TEST PRESSURE (psig)	TEST TYPE	LINING	COATING	EMBEDMENT	HTI (YES/NO)
TVE	Treatment Vessel Effluent	Exposed	DIP	8	350	52	40 05 19	33 - 80	150	Hydrostatic, ASTM E1003	Cement Mortar	Painted	N/A	No
TVE	Treatment Vessel Effluent	Buried	DIP	8	350	52	40 05 19	33 - 80	150	Hydrostatic, ASTM E1003	Cement Mortar	Bituminous	Class IV	No
RW	Raw Water	Exposed	DIP	4	350	52	40 05 19	40 05 19	150	Hydrostatic, ASTM E1003	Cement Mortar	Painted	N/A	Insulation Only
RW	Raw Water	Exposed	DIP	8	350	52	40 05 19	33 - 80	150	Hydrostatic, ASTM E1003	Cement Mortar	Painted	N/A	No
RW	Raw Water	Buried	DIP	8	350	52	40 05 19	33 - 80	150	Hydrostatic, ASTM E1003	Cement Mortar	Bituminous	Class IV	No
BWW	Backwash Waste	Exposed	DIP	8	350	52	40 05 19	33 - 80	50	Hydrostatic, ASTM E1003	Cement Mortar	Painted	N/A	No
BWW	Backwash Waste	Buried	PVC	8	Sch. 80	N/A	40 05 31	33 - 80	150	Hydrostatic, ASTM E1003	N/A	N/A	Class IV	No
NAOCl	Sodium Hypochlorite	Exposed	PVC	1/2	Sch. 80	N/A	40 05 31	33 - 80	100	Hydrostatic, ASTM E1003	N/A	N/A	N/A	No
NaOH	Sodium Hydroxide	Exposed	PVC	1/2	Sch. 80	N/A	40 05 31	33 - 80	100	Hydrostatic, ASTM E1003	N/A	N/A	N/A	No
PD	Pump Discharge	Buried	PVC	3	Sch. 80	N/A	22 11 19	33 - 80	50	Hydrostatic, ASTM E1003	N/A	N/A	Class IV	No
D	Drain	Buried	PVC	4	Sch. 80	N/A	22 11 19	33 - 80	50	Hydrostatic, ASTM E1003	N/A	N/A	Flowable Fill or Concrete	No
D	Drain	Buried	SPVC	6	Sch. 80	N/A	40 05 31	33 - 80	50	Hydrostatic, ASTM E1003	N/A	N/A	Class IV	No
PW	Plant Water	Exposed	DIP	4	350	52	40 05 19	33 - 80	150	Hydrostatic, ASTM E1003	Cement Mortar	Painted	N/A	No
PW	Plant Water	Buried	DIP	4	350	52	40 05 19	33 - 80	150	Hydrostatic, ASTM E1003	Cement Mortar	Bituminous	Class IV	No
BWS	Backwash Supply	Exposed	DIP	6, 8	350	52	40 05 19	33 - 80	150	Hydrostatic, ASTM E1003	Cement Mortar	Painted	N/A	Insulation Only
BWS	Backwash Supply	Buried	DIP	8	350	52	40 05 19	33 - 80	150	Hydrostatic, ASTM E1003	Cement Mortar	Bituminous	Class IV	No

VALVE SCHEDULE (2-INCHES AND LARGER)

TAG	TYPE	Process	END TYPE	Operator	SPEC SECTION	BODY MATERIAL	DIAM.	N.O. /N.C. ^a	ACTUATION	FUNCTION / NOTES
GV-610	Gate Valve	RW	MJ	2-inch nut	40 05 61	Ductile Iron	8-inch	NO	Manual	Raw Water Treatment Building Isolation Valve
GV-611	Gate Valve	TVE	MJ	2-inch nut	40 05 61	Ductile Iron	8-inch	NO	Manual	Treatment Vessel Effluent Treatment Building Isolation Valve
GV-413	Gate Valve	BWS	MJ	2-inch nut	40 05 61	Ductile Iron	8-inch	NC	Manual	Backwash Supply Isolation Valve
FCV-630	Butterfly Valve	BWS	FLG	Electric	43 31 13.13	Ductile Iron	8-inch	NO	Modulating	Backwash Supply Control Valve
BFV-631	Butterfly Valve	RW	FLG	Handwheel	40 05 64	Ductile Iron	8-inch	NO	Manual	Treatment Vessel Isolation Valve
BFV-632	Butterfly Valve	RW	FLG	Handwheel	40 05 64	Ductile Iron	8-inch	NC	Manual	Treatment Vessel Bypass Valve
PRV-620	Pressure Reducing Valve	BWS	FLG	Hydraulic	40 05 51	Ductile Iron	6-inch	NO	Pilot	Backwash Supply Pressure Reducing Valve
Notes: a. N.O. = Normally Open; N.C. = Normally Closed b. Manual valves 6 inches and larger are shown in the schedule. Refer to Drawings for all Valves. c. Valves provided as part of the treatment vessel system are not included herein. Refer to PIDs and Section 43 31 13.13.										

END OF SECTION

SECTION 40 08 00
FIELD TESTING OF PROCESS INTERCONNECTIONS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
1. Provide all necessary labor, materials, and equipment, including test pumps and gauges, as well as temporary valves and piping to perform the testing operations of piping systems as specified herein.
 2. All piping systems will be tested.
 3. Contractor's Responsibility:
 - a. Take such precautions as required to prevent damage to lines and appurtenances being tested.
 - b. Repair any damage resulting from tests.
 - c. Repair and retest all items which do not pass the tests as specified herein.
 - d. Conduct all tests in the presence of the Engineer, and to the satisfaction of the Engineer and all State and local authorities having jurisdiction.
 - e. All necessary pumps, water, pipe connections, meters, gauges, and any necessary apparatus to perform and conduct the tests shall be furnished by the Contractor. Contractor shall furnish all necessary equipment and make all tests at Contractor's expense without separate measurement and payment, but said expense shall be subsidiary to installation of pipe.
 4. Test pressures are specified in Test Pressures for Pressure Lines in Part 3 of this Section or in the pipe schedule.
 5. Water used for testing purposes shall be potable water only.

1.3 DEFINITIONS AND REFERENCES

- A. Definitions:
1. Gravity lines: shall refer to PVC, clay pipe, reinforced concrete (non-cylinder-type) pipe, and other such pipes designed to normally operate in a partially full condition.
 2. Pressure lines: shall refer to ductile iron, PVC, RCCP, steel, and other such pipes designed to operate in a full condition, with the system's energy grade line at or above the top of the pipe during normal operating conditions.
 3. FRP: Fiberglass-reinforced plastic.
 4. LLDPE: Linear low-density, polyethylene.
 5. PE: Polyethylene plastic.
 6. CPVC: Chlorinated polyvinyl chloride.
 7. PVC: Polyvinyl chloride.
- B. References:
1. American Water Works Association (AWWA):
 - a. C600 – Standard for Installation of Ductile-Iron Water Mains and Their Appurtenances
 - b. C605 – Standard for Underground Installation of Polyvinyl Chloride (PVC) Pressure Pipe and Fittings for Water
 - c. M11 – Steel Pipe: A guide for Design and Installation

- d. M23 – PVC Pipe: Design and Installation
- 2. ASTM International (ASTM):
 - a. C924 – Practice for Testing Concrete Pipe Sewer Lines by Low-Pressure Air Test Method
 - b. F1417 – Test Method for Installation Acceptance of Plastic Gravity Sewer Lines Using Low-Pressure Air
- 3. Unibell PVC Plastic Pipe Association:
 - a. “Handbook of PVC Pipe: Design and Construction, Latest Edition”
 - b. UNI-B-6, “Recommended Practice for Low-Pressure Air Testing of Installed Sewer Pipe.”

1.4 SUBMITTALS

- A. Comply with the general requirements of Section 01 33 00 "Submittal Procedures" and the supplemental requirements below.
- B. Shop Drawings:
 - 1. Submit a description of proposed testing methods, procedures, and apparatus for review prior to testing.
 - 2. Submit description of weir and weir tables to be used in infiltration test, if applicable.
- C. Field Quality-Control Reports:
 - 1. Submit a certified test report for each test to Engineer certifying the test pressures, duration of the test, leakage and pertinent observations and comments.

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

- A. Test equipment shall be selected, obtained, and maintained by the Contractor. All gauges shall be calibrated prior to beginning testing and as often as is necessary to provide accurate, reliable information.

PART 3 - EXECUTION

3.1 GENERAL REQUIREMENTS

- A. Obtain the Engineer’s approval of proposed testing methods, procedures, and apparatus, before performing any test. Upon receipt of the Engineer’s approval, submit a schedule of testing dates and times at least 48 hours in advance of testing.
- B. Inspect interior of piping to determine whether line displacement or other damage has occurred. Inspect after approximately 24 inches of backfill is in place, and again at completion of Project.
 - 1. Submit separate reports for each system inspection.
 - 2. Defects requiring correction include the following:
 - a. Alignment: Less than full diameter of inside of pipe is visible between structures.
 - b. Deflection:
 - 1) Maximum average ID shall be equal to the average OD minus two minimum wall thicknesses per applicable ASTM Standard. Manufacturing and other tolerances shall not be considered for determining allowable deflections.
 - 2) Maximum allowable deflections shall be as follows:
 - a) Drainage Pipe: 6.5% nominal inside diameter.

- b) PVC Composite Pipe: 3.0% maximum ID.
- c) Plastic Pipe: Percentage of maximum average ID shall be as listed in Table 1

Table 1	
Maximum Percentage Deflection Allowed	
Nominal Pipe Size, Inches	Percentage Deflection Allowed
Up to and including 12	5.0
Over 12, up to and including 30	4.0
Over 30, up to and including 60	3.0
Over 60, up to and including 90	2.5
Over 90, up to and including 120	2.0
Over 120	1.5
Source: NCTCOG Standard Specifications for Public Works Construction, Latest Edition	

- c. Crushed, broken, cracked, or otherwise damaged piping.
- d. Infiltration: Water leakage into piping.
- e. Exfiltration: Water leakage from or around piping.
- 3. Replace defective piping using new materials, and repeat inspections until defects are within allowances specified.
- 4. Reinspect and repeat procedure until results are satisfactory.
- C. Test new piping systems, and parts of existing systems that have been altered, extended, or repaired, for leaks and defects.
 - 1. Do not enclose, cover, or put into service before inspection and approval.
 - 2. Test completed piping systems according to authorities having jurisdiction.
 - 3. Schedule tests and inspections by authorities having jurisdiction with at least 48 hours advance notice.
 - 4. Submit separate report for each test.
 - 5. Gravity-Flow Sewage and Drainage Piping: Test according to requirements of authorities having jurisdiction, UNI-B-6, and the following:
 - a. Exception: Piping with soil tight joints unless required by authorities having jurisdiction.
 - b. Option: Test plastic piping according to ASTM F 1417.
 - c. Option: Test concrete piping according to ASTM C 924.
 - 6. Force-Main and Pressure Piping: Perform hydrostatic test after thrust blocks, supports, and anchors have sufficiently hardened. Test at pressure not less than 1.5 times the maximum system operating pressure, but not less than 150 psig.
 - a. Ductile-Iron Piping: Test according to AWWA C600, "Hydraulic Testing" Section.
 - b. PVC Piping: Test according to AWWA C605, "Hydrostatic Testing Maintenance" Section.
 - c. Steel Piping: Test according to AWWA C200, "Hydrostatic Testing" section.

3.2 CLEANING, TESTING, AND DISINFECTION OF POTABLE WATER LINES

- A. Piping Tests: Conduct piping tests before joints are covered and after concrete thrust blocks have hardened sufficiently. Fill pipeline 24 hours before testing and apply test pressure to stabilize system. Use only potable water.
- B. Hydrostatic Tests:

1. Ductile Iron and Plastic Piping Systems: Test with a pressure of not less than 150 psi maintained over a period of time of not less than 4 hours. Test Polyethylene Piping Systems per paragraph below.
 2. Concrete Piping Systems: Test with a maximum pressure of 120% of design operating pressure maintained over a period of time of not less than 4 hours.
 3. Steel Piping Systems: Test with a maximum pressure of 150% and not less than 120% of design operating pressure maintained over a period of time of not less than 4 hours.
 4. Water lines of materials in combination shall be tested for the type of pipe material with the least stringent hydraulic test pressure maintained over a period of time of not less than 4 hours.
 5. Rate of leakage of all pipes tested shall not exceed 11.65 gallons-per-inch of nominal diameter of pipe per mile over a 24 hour period. Acceptable values for 4 hour at a test pressure of 150-psi are listed in Table 2.
 6. Newly laid pipe, or any valve section thereof, shall be subjected to the test with the gauge located at the lowest point in the system to be tested. If the line cannot be tested at its lowest point, a correction factor of minus 0.43 lb/vertical feet shall be made.
 7. If test indicates a leakage in excess of Table 2 rate, CONTRACTOR shall repair the leak and retest. Even if test requirements are met, all apparent leaks shall be stopped.
 8. OWNER cannot guarantee that an old existing system valve shall hold the required pressure. CONTRACTOR has the option of testing against the existing valve and, if it does not hold pressure, plugging the new pipe, testing, and then connecting to the existing valve, or accomplish the latter initially.
 9. Prepare reports of testing activities.
- C. Polyethylene Piping Systems:
1. Test pressure shall be measured at the lowest elevation in the test section.
 2. Hydrostatic test at a maximum pressure of 150% of design operating pressure maintained over a period of time of not less than 4 hours when the test section is all polyethylene pressure piping.
 3. Hydrostatic test pressure is the pressure rating of the lowest pressure rated, non-polyethylene component in the system when the test section contains non-polyethylene components.
 4. Thermoplastic piping has reduced strength at elevated temperatures. Therefore the test pressure must be reduced when the test section is at elevated temperature resulting from service conditions or from environmental conditions by multiplying the test pressure by the appropriate Table 3 multiplier.

Table 2																
Allowable Leakage for 4 Hours at Test Pressure 150-psi (Gallons)																
Length (Feet)	Pipe Diameter (Inches)															
	6	8	10	12	14	16	18	20	24	30	36	42	48	54	60	66
5	0.01	0.01	0.02	0.02	0.03	0.03	0.03	0.04	0.04	0.06	0.07	0.08	0.09	0.10	0.11	0.12
10	0.02	0.03	0.04	0.04	0.05	0.06	0.07	0.07	0.06	0.11	0.13	0.15	0.18	0.20	0.22	0.24
15	0.03	0.04	0.06	0.07	0.08	0.09	0.10	0.11	0.13	0.17	0.20	0.23	0.26	0.30	0.33	0.36
20	0.04	0.06	0.07	0.09	0.10	0.12	0.13	0.15	0.18	0.22	0.26	0.31	0.35	0.40	0.44	0.49
25	0.06	0.07	0.09	0.11	0.13	0.15	0.17	0.18	0.22	0.28	0.33	0.39	0.44	0.50	0.55	0.61
50	0.11	0.15	0.18	0.22	0.26	0.29	0.33	0.37	0.44	0.55	0.66	0.77	0.88	0.99	1.10	1.31
75	0.17	0.22	0.28	0.33	0.39	0.44	0.50	0.55	0.63	0.83	0.99	1.16	1.32	1.49	1.66	1.82
100	0.22	0.29	0.37	0.44	0.51	0.59	0.66	0.74	0.88	1.10	1.32	1.54	1.77	1.99	2.21	2.43
200	0.44	0.59	0.74	0.88	1.03	1.18	1.32	1.47	1.77	2.21	2.65	3.09	3.53	3.97	4.41	4.85
300	0.66	0.88	1.10	1.32	1.54	1.77	1.99	2.21	2.65	3.31	3.97	4.63	5.30	5.96	6.62	7.28
400	0.88	1.18	1.47	1.77	2.06	2.35	2.65	2.94	3.53	4.41	5.30	6.18	7.06	7.94	8.83	9.71
500	1.10	1.47	1.84	2.21	2.57	2.94	3.31	3.68	4.41	5.52	6.62	7.72	8.83	9.93	11.03	12.14
600	1.32	1.77	2.21	2.65	3.09	3.53	3.97	4.41	5.30	6.62	7.94	9.27	10.59	11.92	13.24	14.56
700	1.54	20.6	2.57	3.09	3.60	4.12	4.63	5.15	6.18	7.72	9.27	10.81	12.36	13.90	15.45	16.99
800	1.77	2.35	2.94	3.53	4.12	4.71	5.30	5.88	7.06	8.83	10.59	12.36	14.12	15.89	17.65	19.42
900	1.99	2.65	3.31	3.97	4.63	5.30	5.96	6.62	7.94	9.93	11.92	13.90	15.89	17.87	19.86	21.85
1000	2.21	2.94	3.68	4.41	5.15	5.88	6.62	7.36	8.83	11.03	13.24	15.45	17.65	19.86	22.07	24.27
Valve	0.19	0.25	0.31	0.37	0.44	0.50	0.56	0.62	0.75	0.94	1.12	1.31	1.50	1.68	1.87	2.06

Test Temperature, T							
°F	T ≤80	80< T ≤ 90	90< T ≤100	100< T ≤110	110< T ≤120	120< T ≤130	130< T ≤140
°C	T ≤27	27< T ≤32	32< T ≤38	38< T ≤43	43< T ≤49	49< T ≤54	54< T ≤60
Multiplier	1.00	0.90	0.80	0.75	0.65	0.60	0.50
Maximum service temperature for polyethylene piping is 140°F (60°C) Source: NCTCOG Standard Specifications for Public Works Construction, 2004 Edition, Item 506.5 Hydrostatic Test							

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3. Fire-protection water piping connected to potable water supply: Use purging and disinfecting procedure prescribed by authorities having jurisdiction or, if method is not prescribed by authorities having jurisdiction, use procedure described in AWWA C651 or do as follows:
 - a. Fill system or part of system with water/chlorine solution containing at least 50 ppm of chlorine; isolate and allow to stand for 24 hours.
 - b. Retain last subparagraph above or first subparagraph below.
 - c. Drain system or part of system of previous solution and refill with water/chlorine solution containing at least 200 ppm of chlorine; isolate and allow standing for 3 hours.
 - d. After standing time, flush system with clean, potable water until no chlorine remains in water coming from system.
 - e. Submit water samples in sterile bottles to authorities having jurisdiction. Repeat procedure if biological examination shows evidence of contamination.
4. Prepare reports of purging and disinfecting activities.

3.3 TESTING OF PRESSURE LINES (EXCEPT POTABLE WATER LINES)

- A. General:
 1. Allow concrete blocking to cure for at least 28 days before testing.
 2. Backfill and compact soil behind all blocking.
 3. Backfill over pipe to extent necessary to restrain the piping. Backfill shall extend to within 1-foot of proposed final grade.
 4. Conduct water leakage test after completing hydrostatic pressure tests.
 5. Lines which fail to hold the specified test pressure for at least four (4) hours or which exceed an allowable leakage rate specified below, shall be repaired to the satisfaction of the Engineer and retested at the Contractor's expense.
 6. System shall be tested in sections between valves and shall not exceed 2,000 feet unless authorized by Engineer.
- B. Procedures for Hydrostatic Pressure Tests:
 1. Slowly fill isolated section of line with water.
 2. Insure that all air has been expelled through air and vacuum release valves, taps, or connections shown on Plans for permanent piping, valves, or accessories. Do not make additional taps solely for air expulsion purposes unless approved by Engineer. No additional compensation will be made for additional taps.
 3. Allow concrete pipe to stand full of water at least 24 hours before starting leakage test.
 4. Apply specified test pressure based on the elevation of the lowest section of line under test and corrected to elevation of test gauge. Duration of test shall be four (4) hours.
 5. At the end of the four (4) hours of the test, the entire route of the pipeline shall be inspected to locate any leaks or breaks. Any defective joints, cracked or defective pipe, fittings, or valves discovered in consequence of this pressure test shall be removed and replaced with sound material in the manner provided and the test shall be repeated until satisfactory results are obtained. Any and all noticeable leaks shall be repaired regardless of whether the actual leakage is within the allowable. The pipe shall be retested over a period of two hours.
 6. All piping systems shall be tested for leakage by a hydrostatic pressure test. Lines shall be filled slowly, with a maximum velocity of 1-foot per second, while venting all air. If permanent air vents have not been installed, the Contractor shall install corporation cocks at all high points to expel air during initial filling and testing of the lines.

7. The duration of each leakage test shall be two hours unless otherwise specified, and during the test the line shall be subjected to a continuous specified test pressure at the lowest elevation.
8. Leakage is defined as the net quantity of water that must be supplied into the newly laid pipe, or any valved section thereof, necessary to maintain pressure within 5-psi of the specified leakage test pressure after the pipe has been filled with water and the air in the pipeline has been expelled. No installation shall be accepted if the leakage is greater than that determined by the following formula:

$$L = \frac{S \times D \times P \times 0.5}{133,200}$$

Where:

L = allowable leakage in gallons per hour

D = nominal diameter of the pipe, inches

P = average test pressure during the leakage test, psig

S = length of pipe tested, in feet

9. The test pressure shall be applied by means of a pump connected to the pipe and to an approved water container, or other approved method, for accurate measurement. The test pressure shall be maintained (by additional pumping, if necessary) for the specified time.
 10. While the line is under pressure, the system and all exposed pipe, fittings, valves, and hydrants shall be carefully examined for leakage. All defective elements shall be repaired or replaced and the test repeated until all visible leakage has been stopped and the allowable leakage requirements have been met.
 11. On completion of tests, any newly installed, approved taps shall be tightly plugged with brass fittings.
 12. Thoroughly purge all compressed air lines after testing.
- C. Clean and disinfect piping in contact with water being treated for potable use as follows:
1. Purge new water piping systems and parts of existing systems that have been altered, extended, or repaired before use in accordance with Section 33 01 10.58 "Disinfection of Potable Water Piping and Tanks".
 2. Prepare reports of purging and disinfecting activities."

3.4 TEST PRESSURES FOR PRESSURE LINES

- A. Piping shall be tested to pressures shown on Plans. If not shown, test as follows:
1. All process piping shall be tested to 75-psi.
 2. Pump discharge and force main to 200-psi.
 3. Chemical piping to 100-psi.
 4. Plant water and potable piping to 150-psi.
 5. Drain and sewage lines using pressure pipe to 50 psi.

3.5 TESTING OF DRAINS, SEWERS, AND OTHER GRAVITY LINES

- A. General:
1. For all pipe, the method of testing shall be an exfiltration test using either a hydrostatic test or a pneumatic test. For any flexible, non-metallic or non-concrete pipe, such as plastic (PVC, CPVC, PE, etc.) or fiber reinforced plastic pipe or similar flexible pipe materials, a deflection test shall also be performed.

2. Deflection Test: Upon completion of flexible wastewater pipe installation, Contractor shall test pipe for vertical deflection. Deflections tests shall be accomplished no sooner than 30 days after completion of pipe placement and compaction of backfill.
 3. Contractor may make first test promptly after first section of line is laid and backfilled. A section of pipe will normally be a run between two manholes, or between a structure and the first manhole.
 4. Do not lay additional piping of the type being tested until test of first section is complete.
 5. Do not perform any City required leak test until backfill has been installed to grade for a minimum of 30 days.
 6. Individual leaks will ordinarily be revealed by looking through sewer (larger than 24-inch diameter) with a light while ground water level is over sewer, during water tamping operations, or immediately after water from exfiltration tests is emptied from sewer.
 7. Settlement in backfill during exfiltration tests will be taken as an indication of leakage.
- B. Hydrostatic Exfiltration Test Procedure:
1. Seal ends of section being tested with watertight plugs.
 2. Fill section with water 24 hours prior to start of test.
 3. Vent line during filling so that no air is trapped in line.
 4. Leave outlets of stacks, inlets, and service lines exposed and unplugged until after exfiltration test has been made.
 5. Outlets terminating below level of test water surface to be temporarily extended upward by installing lengths of pipe.
 6. Measure leakage or exfiltration during test period by adding measured quantities of water to maintain water level in test structure.
 7. Quantity of water added to maintain water level is amount of leakage or exfiltration.
 8. Test for at least four hours with minimum head of four feet measured above top crown, inside pipe at upper end of section being tested. Allow for increase in height due to ground water level, if any.
 9. Storm sewer leads to be tested with water level at gutter grade.
 10. After completion of satisfactory test, remove lengths of pipe added for test.
 11. Allowable Leakage: Allowable leakage for exfiltration test in any individual section or entire sewer line under construction shall not exceed 10 gallons per inch of inside diameter per mile of pipe per 24 hours.
- C. Hydrostatic Exfiltration Test Procedure for Agri Drain Structures and Associated Piping: Following installation of pipe, Agri Drain structures, and backfill, all joints as a system shall be tested by the exfiltration test as follows:
1. Seal open ends of pipe upstream and downstream of the Agri Drain structure with watertight plugs.
 2. Fill Agri Drain structure to the top with water.
 3. Vent pipes during filling so that no air is trapped in line.
 4. Measure leakage or exfiltration after a 24-hour period by observing the level of water from the top of the Agri Drain structure.
 5. The difference in depth between the water level and the top of the Agri Drain structure is the amount of leakage or exfiltration.
 6. Allowable Leakage: Allowable leakage for exfiltration test shall be a difference in depth less than 1.25 inches.
- D. Low Pressure Air Joint Test:
1. All pipe joints shall be tested in accordance with this Section.

2. Equipment shall be the product of manufacturers having more than five years of regular production of successful joint testers. Joint tester shall be as manufactured by Chane Industrial, Inc., of Edina, Minnesota, or equal.
 3. Testing shall be performed on all joints after backfill has been installed and properly compacted, and as installation progresses. At no time shall pipe installation exceed 100 feet beyond the last joint tested.
 4. Joints failing to meet the requirements of this test should be repaired to the satisfaction of the Engineer or the defective pipe shall be replaced. Rejected pipe shall be removed from the project. Installation shall be stopped until defective joints are repaired or replaced.
 5. The testing equipment shall be assembled and positioned over the center of the pipe joint and the end element tubes inflated to a maximum of 25 psi.
 6. Pressurize the center joint test area to 4.0 psig and allow the temperature and pressure to stabilize at the minimum of 2.5 psig for a period of 2.0 minutes prior to testing.
 7. To test, adjust the pressure to 4.0 psig and measure the time required to decrease the pressure from 4.0 psig to 2.0 psig.
 8. The joint is acceptable if the time for the pressure to drop from 4.0 psig to 2.0 psig is greater than 15 seconds.
- E. Pneumatic Test Method (Air Test):
1. Air tests shall be made by the pressure drop versus time method, in accordance with UNI-B-6, "Recommended Practice for Low-Pressure Air Testing of Installed Sewer Pipe."
 2. Equipment: The equipment used shall meet the following minimum requirements:
 - a. Pneumatic plugs shall have a sealing length equal to or greater than the diameter of the pipe to be inspected.
 - b. Pneumatic plugs shall resist internal test pressures without requiring external bracing or blocking.
 - c. All air used shall pass through a single control panel.
 - d. Three individual hoses shall be used for the following connections:
 - 1) From the control panel to pneumatic plugs for inflation.
 - 2) From the control panel to a sealed line for introducing the low-pressure air.
 - 3) From a sealed line to control panel for continually monitoring the air pressure rise in the sealed line.
 - e. Air compressor of adequate capacity for charging the system.
 3. Procedures: All pneumatic plugs shall be seal-tested before being used in the actual test installation. One length of pipe shall be laid on the ground and sealed at both ends with the pneumatic plugs to be checked. Air shall be introduced into the plugs to 25 psig. The sealed pipe shall be pressurized to 5 psig. The plugs shall hold against this pressure without bracing and without movement of the plugs out of the pipe.
 4. After a manhole-to-manhole reach of pipe has been backfilled and the pneumatic plugs have been checked by the above-mentioned procedure, the plugs shall be placed in the line at each manhole and inflated to 25 psig. Low pressure air shall be introduced into this sealed line until the internal air pressure reaches 4 psig. Allow at least two minutes for the air temperature to stabilize, adding only the amount of air required to maintain pressure.
 5. If the pipe to be tested is submerged in ground water, insert a pipe probe by boring or jetting into the backfill material adjacent to the center of the pipe, and determine the pressure in the probe when air passes slowly through it. This is backpressure due to ground water submergence over the end of the probe. All gauge pressure in the test

should be increased by this amount. After the stabilization period (3.5 psig of minimum pressure in the pipe) start stopwatch. Determine time in seconds that is required for the internal air pressure to reach 2.5 psig.

6. Allowable Leakage: For sections of pipe less than 36-inch average inside diameter, the minimum time allowable for the pressure to drop from 3.5 pounds per square inch gauge to 2.5 pounds per square inch gauge shall be computed from the following equation:

$$T = 0.0850(D)(K)/(Q)$$

Where:

T = shortest time for pressure to drop 1.0 PSI gauge in seconds

K = $0.000419(D)(L)$, but not less than 1.0

D = average inside diameter in inches

L = length of line in feet of same pipe size being tested

Q = rate of loss, 0.0015 cubic feet per minute per square foot internal surface shall be used.

7. Since a K value of less than 1.0 shall not be used, there are minimum testing times for each pipe diameter as follows:

Table No. 4 Minimum Testing Times			
Pipe Diameter (inches)	Minimum Time (seconds)	Length for Minimum Time (feet)	Time for Longer Length (seconds)
6	340	398	0.855 (L)
8	454	298	1.520 (L)
10	567	239	3.374 (L)
12	680	199	3.419 (L)
15	850	159	5.342 (L)
18	1020	133	7.693 (L)
21	1190	114	10.471 (L)
24	1360	100	13.676 (L)
27	1530	88	17.309 (L)
30	1700	80	21.369 (L)
33	1870	72	25.856 (L)

3.6 TELEVISION INSPECTION (NOT USED)

3.7 PIPELINE REPAIR

- A. Leaks and loss in test pressure constitute defects that must be repaired. Replace leaking piping using new materials, and repeat testing until leakage is within allowances specified.

3.8 QUALITY CONTROL

- A. The Pipe Testing report template located after the END OF SECTION is part of this Section.

END OF SECTION

**QUALITY CONTROL
PIPE TESTING REPORT**

Project: _____		
Contractor: _____		
Pipe Diameter: _____	Location: _____	Date: _____
From Station: _____	To Station: _____	_____
TEST MEDIUM (circle one) Water Air Other (specify) _____		
TEST EQUIPMENT: (list) _____ _____ _____ _____		
SPECIFIED TEST PRESSURE: _____ psi		Specified Duration: _____
Time (gauge on): _____ Pressure (start): _____		
Time (check): _____ Pressure (check): _____	Pressure Drop: _____ Water Added: _____	
Time (check): _____ Pressure (check): _____	Pressure Drop: _____ Water Added: _____	
Time (check): _____ Pressure (check): _____	Pressure Drop: _____ Water Added: _____	Time (gauge off): _____ Pressure (finish): _____
REMARKS: _____ _____ _____ _____		
WITNESSING SIGNATURES:		
Contractor: _____		
Signature	Title	Date
Engineer: _____		
Signature	Title	Date

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SECTION 40 42 13
PIPING INSULATION

GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Insulation Materials:
 - a. Cellular glass.
 - b. Flexible elastomeric.
 - c. Mineral fiber.
 - 2. Adhesives, mastics, sealants, and tapes.
 - 3. Factory-applied and field-applied jackets.
- B. Refer to Section 40 05 01 "Piping Systems, Basic Materials and Methods".
- C. Refer to Pipe Schedule in Section 40 06 00 "Schedules for Process Interconnections" for Piping Insulation and Heat Tracing Requirements.

1.3 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings:
 - 1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
 - 2. Detail attachment and covering of heat tracing inside insulation.
 - 3. Detail insulation application at pipe expansion joints for each type of insulation.
 - 4. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
 - 5. Detail removable insulation at piping specialties, equipment connections, and access panels.
 - 6. Detail application of field-applied jackets.
 - 7. Detail application at linkages of control devices.
 - 8. Detail field application for each equipment type.
 - 9. Manufacturer's warranty for products indicated.

1.4 QUALITY ASSURANCE

- A. Fire-Test-Response Characteristics: Insulation and related materials shall have fire-test-response characteristics indicated, as determined by testing identical products per ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing and inspecting agency.

1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Deliver insulation, coverings, cements, adhesive, and coatings to site in containers with manufacturer's stamp or label, affixed showing fire hazard indexes of products.
- B. Protect insulation against dirt, water, and chemical and mechanical damage. Do not install damaged or wet insulation; remove from project site.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

- A. General Requirements:
 1. Products shall not contain asbestos, lead, mercury, or mercury compounds.
 2. 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.
 3. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.
 4. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.
- B. Cellular Glass: Inorganic, incombustible, foamed or cellulated glass with annealed, rigid, hermetically sealed cells.
 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Cell-U-Foam Corporation; Ultra-CUF.
 - b. Pittsburgh Corning Corporation; Foamglas Super K.
 2. Block Insulation: ASTM C 552, Type I.
 3. Special-Shaped Insulation: ASTM C 552, Type III.
 4. Board Insulation: ASTM C 552, Type IV.
 5. Preformed Pipe Insulation with Factory-Applied ASJ-SSL: Comply with ASTM C 552, Type II, Class 2.
 6. Factory fabricated shapes according to ASTM C 450 and ASTM C 585.
- C. Flexible Elastomeric: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials and Type II for sheet materials.
 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Aeroflex USA Inc.; Aerocel.
 - b. Armacell LLC; AP Armaflex.
 - c. RBX Corporation; Insul-Sheet 1800 and Insul-Tube 180.
- D. Mineral-Fiber, Preformed Pipe Insulation:
 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Fibrex Insulations Inc.; Coreplus 1200.

- b. Johns Manville; Micro-Lok.
 - c. Knauf Insulation; 1000 Pipe Insulation.
 - d. Manson Insulation Inc.; Alley-K.
 - e. Owens Corning; Fiberglas Pipe Insulation.
- 2. Type I, 850 deg F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, with factory-applied ASJ-SSL.

2.2 INSULATING CEMENTS

- A. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C 449/C 449M.

2.3 ADHESIVES

- A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated. Adhesive shall be as recommended by the supplier of the insulation and jacket materials.

2.4 MASTICS

- A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-C-19565C, Type II, and as recommended by insulation supplier.
- B. Vapor-Barrier Mastic: Water based; suitable for indoor and outdoor use on below ambient services.
 - 1. Water-Vapor Permeance: ASTM E 96, Procedure B, 0.013 perm at 43-mil dry film thickness.
 - 2. Service Temperature Range: Minus 20 to plus 180 deg F.
 - 3. Solids Content: ASTM D 1644, 59 percent by volume and 71 percent by weight.
 - 4. Color: White.

2.5 SEALANTS

- A. Joint Sealants:
 - 1. Joint sealants shall be as recommended by pipe insulation supplier and the Materials shall be compatible with insulation materials, jackets, and substrates.
 - 2. Permanently flexible, elastomeric sealant.
 - 3. Service Temperature Range: Minus 100 to plus 300 deg F.
 - 4. Color: White or gray.
- B. ASJ Flashing Sealants, and Vinyl, PVDC, and PVC Jacket Flashing Sealants:
 - 1. Materials shall be compatible with insulation materials, jackets, and substrates.
 - 2. Fire- and water-resistant, flexible, elastomeric sealant.
 - 3. Service Temperature Range: Minus 40 to plus 250 deg F.
 - 4. Color: White.

2.6 FACTORY-APPLIED JACKETS

- A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:
 - 1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.

2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.

2.7 FIELD-APPLIED JACKETS

- A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.
- B. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.
 1. Adhesive: As recommended by jacket material manufacturer.
 2. Color: White.
 3. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.
 - a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.
 4. Factory-fabricated tank heads and tank side panels.
- C. Aluminum Jacket: Comply with ASTM B 209, Alloy 3003, 3005, 3105 or 5005, Temper H-14.
 1. Minimum Thickness:
 - a. Outdoors: 0.024 inches.
 - b. Indoors: 0.016
 2. Finish: Stucco-embossed.
 3. Moisture Barrier for Indoor Applications: 1-mil- thick, heat-bonded polyethylene and Kraft paper.
 4. Moisture Barrier for Outdoor Applications: 3-mil- thick, heat-bonded polyethylene and Kraft paper or 2.5-mil- thick Polysurlyn.
 5. Factory-Fabricated Fitting Covers:
 - a. Same material, finish, and thickness as jacket.
 - b. Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
 - c. Tee covers.
 - d. Flange and union covers.
 - e. End caps.
 - f. Beveled collars.
 - g. Valve covers.
 - h. Field fabricate fitting covers only if factory-fabricated fitting covers are not available.
- D. Underground Direct-Buried Jacket: 125-mil- thick vapor barrier and waterproofing membrane consisting of a rubberized bituminous resin reinforced with a woven-glass fiber or polyester scrim and laminated aluminum foil.

2.8 ACCESSORIES

- A. Tapes supplied with products per manufacturer's recommendations.
- B. Securements: Aluminum bands, insulation pins and hangers, staples, wire, corner angles and related components supplied with products per manufacturer's recommendations.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.
- B. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.
- C. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

3.2 GENERAL INSTALLATION REQUIREMENTS

- A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of equipment and piping including fittings, valves, and specialties.
- B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of equipment and pipe system as specified in insulation system schedules.
- C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.
- D. Install insulation with longitudinal seams at top and bottom of horizontal runs.
- E. Install 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. Keep insulation materials dry during application and finishing.
- H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
- I. Install insulation with least number of joints practical.
- J. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
 - 1. Install insulation continuously through hangers and around anchor attachments.
 - 2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
 - 3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
 - 4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.
- K. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

- L. Install insulation with factory-applied jackets as follows:
 - 1. Draw jacket tight and smooth.
 - 2. Cover circumferential joints with 3-inch- wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches on center.
 - 3. Overlap jacket longitudinal seams at least 1-1/2 inches. Install 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 2 inches on center.
 - a. For below ambient services, apply vapor-barrier mastic over staples.
 - 4. Cover joints and seams with tape as recommended by insulation material manufacturer to maintain vapor seal.
 - 5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.
- M. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.
- N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.
- O. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.
- P. For above ambient services, do not install insulation to the following:
 - 1. Vibration-control devices.
 - 2. Testing agency labels and stamps.
 - 3. Nameplates and data plates.
 - 4. Manholes.
 - 5. Handholes.
 - 6. Cleanouts.

3.3 PENETRATIONS

- A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.
 - 1. Seal penetrations with flashing sealant.
 - 2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 - 3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
 - 4. Seal jacket to roof flashing with flashing sealant.
- B. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.
- C. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
 - 1. Seal penetrations with flashing sealant.

2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
 4. Seal jacket to wall flashing with flashing sealant.
- D. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.
- E. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.
- F. Insulation Installation at Floor Penetrations:
1. Pipe: Install insulation continuously through floor penetrations.
 2. Seal penetrations through fire-rated assemblies.

3.4 GENERAL PIPE INSULATION INSTALLATION

- A. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.
- B. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:
1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity, unless otherwise indicated.
 2. Do not insulate flexible pipe couplings and expansion joints.
 3. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
 4. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
 5. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
 6. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below ambient services, provide a design that maintains vapor barrier.

7. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
 8. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below ambient services and a breather mastic for above ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
 9. For services not specified to receive a field-applied jacket except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.
 10. Stencil or label the outside insulation jacket of each union with the word "UNION." Match size and color of pipe labels.
- C. Insulate sample tap connections and instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes, vessels, and equipment. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.
- D. Install removable insulation covers at locations indicated. Installation shall conform to the following:
1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.
 2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.
 3. Construct removable valve insulation covers in same manner as for flanges except divide the two-part section on the vertical center line of valve body.
 4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.
 5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

3.5 CELLULAR-GLASS INSULATION INSTALLATION

- A. Insulation Installation on Straight Pipes and Tubes:
1. Secure each layer of insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
 2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.

3. For insulation with factory-applied jackets on above ambient services, secure laps with outward clinched staples at 6 inches on center.
 4. For insulation with factory-applied jackets on below ambient services, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.
- B. Insulation Installation on Pipe Flanges:
1. Install preformed pipe insulation to outer diameter of pipe flange.
 2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of 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 same thickness as pipe insulation.
 4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch, and seal joints with flashing sealant.
- C. Insulation Installation on Pipe Fittings and Elbows:
1. Install preformed sections of same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
 2. When preformed sections of insulation are not available, install mitered sections of cellular-glass insulation. Secure insulation materials with wire or bands.
- D. Insulation Installation on Valves and Pipe Specialties:
1. Install preformed sections of cellular-glass insulation to valve body.
 2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
 3. Install insulation to flanges as specified for flange insulation application.

3.6 FLEXIBLE ELASTOMERIC INSULATION INSTALLATION

- A. Seal longitudinal seams and end joints with manufacturers recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- B. Insulation Installation on Pipe Flanges:
1. Install pipe insulation to outer diameter of pipe flange.
 2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
 3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as pipe insulation.
 4. Secure insulation to flanges and seal seams with manufacturers recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- C. Insulation Installation on Pipe Fittings and Elbows:
1. Install mitered sections of pipe insulation.
 2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed valve covers manufactured of same material as pipe insulation when available.
2. When preformed valve covers are not available, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.
4. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.7 MINERAL-FIBER INSULATION INSTALLATION

- A. Insulation Installation on Straight Pipes and Tubes:
 1. Secure each layer of preformed pipe insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
 2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
 3. For insulation with factory-applied jackets on above ambient surfaces, secure laps with outward clinched staples at 6 inches (150 mm) on center.
 4. For insulation with factory-applied jackets on below ambient surfaces, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.
- B. Insulation Installation on Pipe Flanges:
 1. Install preformed pipe insulation to outer diameter of pipe flange.
 2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of 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. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch (25 mm), and seal joints with flashing sealant.
- C. Insulation Installation on Pipe Fittings and Elbows:
 1. Install preformed sections of same material as straight segments of pipe insulation when available.
 2. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.
- D. Insulation Installation on Valves and Pipe Specialties:
 1. Install preformed sections of same material as straight segments of pipe insulation when available.
 2. When preformed sections are not available, install mitered sections of pipe insulation to valve body.
 3. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
 4. Install insulation to flanges as specified for flange insulation application.

3.8 FIELD-APPLIED JACKET INSTALLATION

- A. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints; for horizontal applications, install with longitudinal seams along top and bottom of tanks and vessels. Seal with manufacturers recommended adhesive.
 - 1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.
 - 2. Install PVC fitting covers on insulated interior piping, on all mineral fiber insulated piping, and on all heat traced piping.
- B. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weather-proof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches on center and at end joints.
 - 1. Install aluminum jackets on exterior above grade piping and fittings and on interior piping insulated using cellular-glass.

3.9 FINISHES

- A. Equipment and Pipe Insulation with ASJ or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Division 9 painting Sections.
 - 1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.
 - a. Finish Coat Material: Interior, flat, latex-emulsion size.
- B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.
- C. Color: Final color as selected by Owner. Vary first and second coats to allow visual inspection of the completed Work.
- D. Do not field paint aluminum or stainless-steel jackets.

3.10 PIPING INSULATION SCHEDULE

- A. General Requirements:
 - 1. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.
 - 2. All exposed outdoor piping and piping installed in unheated vaults, 8-inches in diameter and smaller (Unless otherwise indicated on the Drawings) shall be insulated.

PIPE INSULATION SCHEDULE

Flowstream	Pipe Diameter (Inches)	Insulation Thickness (Inches)		Insulation Type ⁽³⁾
		Indoor	Outdoor ⁽²⁾	
Instrument Sensing Lines ⁽¹⁾	----	NA		
Domestic Hot Water		3/4	3/4	Flexible Elastomeric
Domestic Cold Water			1	Flexible Elastomeric
Water and Waste Water	Less than 2	NA	1-1/2	Cellular-glass Mineral Fiber
Water and Waste Water	2 to 6	NA	2	Cellular-glass Mineral Fiber
Water and Waste Water	8 to 12	NA	2	Cellular-glass Mineral Fiber
Vent, Air Release	1 to 2	NA	1	Flexible Elastomeric Mineral Fiber
Blower Air Piping ⁽⁴⁾				Mineral Fiber
Sample	1/2 to 1	NA	3/4	Flexible Elastomeric
1. Instrument sense lines include tubing used for differential pressure measurements in venture flow meters, pressure indicating devices, and other instruments. 2. Outdoor includes piping exposed to atmosphere; areas inside unheated vaults, utility corridors, chases, etc. 3. When more than one insulation type is named, Contractor may select. 4. Apply insulation to hot blower discharge piping in accessible areas for personnel protection.				

B. Heat Trace (NOT USED):

3.11 INDOOR, FIELD-APPLIED JACKET SCHEDULE

- A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket. If more than one material is listed, selection from materials listed is Contractor's option.
1. Piping, Concealed:
 - a. None.
 2. Piping, Exposed:
 - a. PVC: 30 mils thick.
 - b. Aluminum, Stucco Embossed: 0.016 inch thick.

3.12 OUTDOOR, FIELD-APPLIED JACKET SCHEDULE

- A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket. If more than one material is listed, selection from materials listed is Contractor's option.
- B. Piping:
1. PVC: 30 mils thick.
 2. Aluminum, Stucco Embossed with Z-Shaped Locking Seam: 0.024 inch thick.

END OF SECTION

SECTION 40 61 00
INSTRUMENTATION AND CONTROL SYSTEM GENERAL PROVISIONS

PART 1 - GENERAL

1.1 SUMMARY

- A. The CONTRACTOR shall procure the services of a Control System Integrator to furnish and install all materials, equipment, labor and services, required to achieve a fully integrated and operational system as specified herein, in the Specification Sections listed below, and in related drawings, except for those services and materials specifically noted;
 - 1. Section 40 61 01 - Instrumentation and Control System Abbreviations
 - 2. Section 40 61 21 - Instrumentation and Control System Testing and Commissioning
 - 3. Section 40 61 26 - Instrumentation and Control System Training
 - 4. Section 40 68 00 - Control System Software
 - 5. Section 40 62 00 - Control System Computers and Peripheral Equipment
 - 6. Section 40 63 43 - Programmable Logic Controllers (PLCs)
 - 7. Section 40 66 00 - Control System Network Communication Equipment
 - 8. Section 40 66 81 - Control System Fiber Optic Cable
 - 9. Section 40 67 00 - Control System Panels
 - 10. Section 40 70 00 - Instrumentation Measurement Devices
 - 11. Section 40 61 96 - Control System Configuration
 - 12. Section 40 61 93 - Control System Input/Output List
- B. The term "Control System Integrator" as used in the Contract Documents is a firm or organization that has specialized capabilities, training and education to design, fabricated, install, and program a control system. The term as used in documents shall be performed by the Control System Integrator under the direction and authority of the CONTRACTOR. When used within the Contract Documents, it implies that the CONTRACTOR has directed or is responsible for their actions regarding the Contract Documents and responsibility to the OWNER. The Control System Integrator can act as the CONTRACTOR, but shall comply with the qualifications listed in this Section and shall meet all other requirements of the Contract Documents."
- C. Programmable Logic Controller (PLC) programming and Human Machine Interface (HMI) graphics configuration and development as defined in Section 40 61 96 - Control System Configuration.
- D. Auxiliary and accessory devices necessary for system operation or performance, such as transducers, relays, signal amplifiers, intrinsic safety barriers, signal isolators, software, and drivers to interface with existing equipment or equipment provided by others under other Sections of these specifications, shall be included whether they are shown on the Drawings or not.
- E. All equipment and installations shall satisfy applicable Federal, State, and local codes.
- F. Use the equipment, instrument, and loop numbering scheme shown on the Drawings and Specifications in the development of the submittals. Do not deviate from or modify the numbering scheme without the ENGINEER's approval.

- G. Related Sections include but are not necessarily limited to:
 - 1. Division 00 - Procurement and Contracting Requirements.
 - 2. Division 01 - General Requirements.

1.2 REFERENCES

- A. Refer to Section 40 61 01 - Instrumentation and Control System Abbreviations and References. In case of conflict between the requirements of this Section and those of the listed standards, the requirements of this Section shall prevail.
- B. Where reference is made to one of the standards, the revision in effect at the time of bid opening shall apply.
- C. All material and equipment, for which a UL standard exists, shall bear a UL label. No such material or equipment shall be brought onsite without the UL label affixed.
- D. If the issue of priority is due to a conflict or discrepancy between the provisions of the Contract Documents and any referenced standard, or code of any technical society, organization or association, the provisions of the Contract Documents shall take precedence if they are more stringent or presumptively cause a higher level of performance. If there is any conflict or discrepancy between standard specifications, or codes of any technical society, organization or association, or between Laws and Regulations, the higher performance requirement shall be binding on the Control System Integrator unless otherwise directed by the OWNER/ENGINEER.
- E. In accordance with the intent of the Contract Documents, the Control System Integrator accepts the fact that compliance with the priority order specified shall not justify an increase in Contract Price or an extension in Contract Time nor limit in any way, the Control System Integrator's responsibility to comply with all Laws and Regulations at all times
- F. All control panels shall be constructed and the labeled with a UL 508A label.

1.3 ADMINISTRATIVE REQUIREMENTS

- A. Coordination Meetings
 - 1. The Coordination meetings shall be held at the Owner's designated location and shall include attendance by the OWNER, the ENGINEER, the CONTRACTOR, and the Control System Integrator's Project ENGINEER. Other Division 40 specifications may require additional meetings. Prepare and distribute an agenda for this meeting a minimum of one week before the scheduled meeting date. Meeting shall be scheduled a minimum of one week before the requested meeting date.
 - a. A project kickoff coordination meeting shall be held within two weeks after submitting the Project Plan. The purpose of the meeting shall be to discuss the Control System Integrator's Project Plan, to summarize the Control System Integrator's understanding of the project; discuss any proposed substitutions or alternatives; schedule testing and delivery deadline dates; provide a forum to coordinate hardware and software related issues; and request any additional information required from the Owner. The meeting will last up to one business day.
 - b. A submittal review coordination meeting shall be held after the Hardware, Panel Drawing, and Loop Drawing Submittal package has been reviewed by the

ENGINEER and returned to the Control System Integrator. The purpose of this meeting shall be to review comments made on the submittal package; to refine scheduled deadline dates; coordinate equipment installation activities; and provide a forum for any further required coordination between the Control System Integrator. The meeting will last up to one business day.

1.4 SUBMITTALS

A. General Requirements:

1. Submittals shall be made in accordance with the requirements of this Section, the requirements of individual Division 40 Sections, and in accordance with Section 01 31 00 - Project Management and Coordination.

B. Qualifications Submittal

1. Submit, within 30 calendar days after Notice to Proceed, detailed information on staff and organization to show compliance with the Quality Assurance requirements of this Section. The Qualifications submittal shall be submitted and approved before any further submittals will be accepted. Failure to meet the minimum requirements shall be grounds for rejection as a PCSS. The Qualifications Submittal shall, as a minimum, contain the following:
 - a. Copies of ISA CCST Level 1 certificates for all field technicians or resumes demonstrating field experience.
 - b. Notarized statement from the firm's financial institution demonstrating ability for the firm to meet the obligations necessary for the performance of the work.
 - c. Copy of UL-508 certificate for panel fabrication facilities.
 - d. Project references for water or wastewater projects as defined in the Quality Assurance paragraphs.
 - e. Documentation to demonstrate the ability to complete this project including: resumes of key staff, financial capacities, details on engineering, design, fabrication, and field service capacity, and location of staff responsible for responding to the site within four hours to resolve startup issues.

C. Project Plan, Deviation List, and Schedule Submittal

1. Submit, within 45 calendar days after Notice to Proceed, a Project Plan. The Project Plan shall be submitted and approved before further submittals shall be accepted. The Project Plan shall, at a minimum, contain the following:
 - a. Overview of the proposed control system describing the understanding of the project work, a preliminary system architecture drawing, interfaces to other systems, schedule, startup, and coordination. A discussion of a startup, replacement of existing equipment with new, switchover (Maintaining Plant Operations during system transition), approach to testing and training, and other tasks as required by these specifications shall be included as applicable.
 - b. Preliminary list of HMI software, PLC software, and PLC hardware, including version numbers, solely to determine compliance with the requirements of the Contract Documents prior to beginning development of system programming. Review and approval of software and hardware systems as part of this Project Plan stage shall not relieve the Control System Integrator of meeting all the

- functional and performance requirements of the system as specified herein. Substitution of manufacturer or model of these systems after the submittal is approved is not allowed without ENGINEER approval.
- c. Project personnel and organization, including the Control System Integrator project manager, project ENGINEER, and lead project technicians. Include resumes of each these individuals and specify in writing their commitment to this project. These do not need to be submitted again if already submitted in the Qualification submittal.
 - d. Sample formats of the shop drawings to be submitted and in conformance with the requirements of the Specifications. At a minimum include samples of panel fabrication drawings, loop, and Input/Output wiring diagrams.
2. Exceptions to the Specifications or Drawings shall be clearly defined in a Deviation List. The Deviation List shall consist of a paragraph by paragraph review of the Specifications indicating acceptance or any proposed deviations, the reason for the exception, the exact nature of the exception and the proposed substitution so that an evaluation may be made by the ENGINEER. If no exceptions are taken to the specifications or drawings, the Control System Integrator shall make a statement as such. If there is no statement by the Control System Integrator, then it is acknowledged that no exceptions are taken.
 3. Project schedule shall be prepared in Gantt chart format clearly showing task linkages for all tasks and identifying critical path elements. Control System Integrator schedule must be based on the General CONTRACTOR schedule and must meet all field installation, testing, and start-up milestones in that schedule. The project schedule shall illustrate instrumentation and control related major project milestones including the following:
 - a. Schedule for all subsequent project submittals. Include the time required for CONTRACTOR submittal preparation, ENGINEER's review time, and a minimum of two complete review cycles.
 - b. Proposed dates for all project coordination meetings.
 - c. Hardware purchasing, fabrication, and assembly (following approval of related submittals).
 - d. Software purchasing and configuration (following approval of related submittals).
 - e. Shipment of instrument and control system equipment.
 - f. Installation of instrument and control system equipment.
 - g. Testing: Schedule for all testing.
 - h. Schedule for system cutover, startup, and going on-line for each major system. At a minimum include the schedule for each process controller and HMI server/workstation provided under this Contract.
 - i. Schedule for all training, including submittal and approval of O&M manuals, factory training, and site training.
 - j. Incorporate time constraints for control system configuration activities as outlined in Section 40 61 96 - Control System Configuration.
 4. All Control System Panel shall have a UL 508A label affix to the inside of the panel.

Provide documentation for review and approval on how this will be accomplished by control system integrators who are not a UL 508 facility.

D. Field Instruments Submittal

1. Shall be a mode in accordance with the general requirements of Section 01 31 00 - Project Management and Coordination and with specific submittal requirements of Section 40 70 00 - Instrumentation Measurement Devices.

E. Hardware and Software Packages Submittal

1. Refer to the sections below for specific Hardware and Software Packages submittal requirements
 - a. Section 40 68 00 - Control System Software
 - b. Section 40 62 00 - Control System Computers and Peripheral Equipment
 - c. Section 40 63 43 - Programmable Logic Controllers (PLCs)
 - d. Section 40 66 00 - Control System Network Communication Equipment
 - e. Section 40 66 81 - Control System Fiber Optic Cable
 - f. Section 40 67 00 - Control System Panels
2. For each hardware and software packages component specified in the sections above, submit a cover page that lists, at a minimum, date, specification number, product name, manufacturer, model number, Location(s), and power required. The preferred format for the cover page is ISA-TR20.00.01-2001 (updated in 2004-2006), general data sheet; however, other formats will be acceptable provided they contain all required information.

F. Control System Panel Drawings Submittal

1. Shall be a mode in accordance with the general requirements of Section 01 31 00 Project Management and Coordination and with specific submittal requirements of Section 40 67 00 - Control System Panels.

G. Testing and Commissioning Submittals

1. Shall be made in accordance with the general requirements of Section 01 70 00 - Execution Requirements and with specific submittal requirements of Section 40 61 21 - Instrumentation and Control System Testing and Commissioning.

H. Training Plan Submittals

1. Shall be made in accordance with the general requirements of Section 01 70 00 - Execution Requirements and with specific submittal requirements of Section 40 61 26 - Instrumentation and Control System Training.

I. Control System Configuration

1. Shall be a mode in accordance with the general requirements of Section 01 31 00 - Project Management and Coordination and with specific submittal requirements of Section 40 61 96 - Control System Configuration.

J. Spares, Expendables, and Test Equipment Lists Submittal

1. Submit a list of, and descriptive literature for, spares, expendables, and test equipment.
2. Submit a list of, and descriptive literature for, additional spares, expendables, and test

- equipment recommended by the manufacturer.
3. Submit unit and total costs for the additional spare items specified or recommended for each subsystem.
- K. Operations and Maintenance (O&M) Manuals
1. Shall be made in accordance with the requirements of this Section, the requirements of individual Division 40 Sections, and in accordance with Section 01 31 00 - Project Management and Coordination.
 2. The operations and maintenance manuals shall, at a minimum, contain the following information:
 - a. Table of Contents
 - 1) A Table of Contents shall be provided for the entire manual with the specific contents of each volume clearly listed. The complete Table of Contents shall appear in each volume.
 - b. Instrument and Equipment Lists
 - 1) The following lists shall be developed in Microsoft Excel format and provided not only as a hardcopy in O&M but also electronically on a CD.
 - 2) An instrument list for all devices supplied including tag number, description, specification section, and paragraph number, manufacturer, model number, serial number, range, span, location, manufacturer phone number, local supplier name, local supplier phone number, completion year replacement cost, and any other pertinent data.
 - 3) An equipment list for all non-instrument devices supplied a listing description, specification section and paragraph number, manufacturer, model number, serial number, location, manufacturer phone number, local supplier name, local supplier phone number, completion year replacement cost, and any other pertinent data.
 - c. Equipment Operations and Maintenance Information
 - 1) ISA-TR20.00.01-2001 (updated in 2004-2006) data sheets shall be provided for all field instruments. For non-field instrumentation devices, provide a cover page for each device, piece of equipment, and OEM software that lists date, specification number, product name, manufacturer, model number, Location(s), and power required. The preferred format for the cover page is ISA-TR20.00.01-2001 (updated in 2004-2006), general data sheet; however, other formats will be acceptable provided they contain all required information
 - 2) Vendor O&M documentation for each device, piece of equipment, or OEM software shall be either new documentation written specifically for this project or modified standard vendor documentation. All standard vendor documentation furnished shall have all portions that apply clearly indicated with arrows or circles. All portions that do not apply shall be neatly lined out or crossed out. Groups of pages that do not apply at all to the specific model supplied shall be removed.
 - 3) Provide the record documentation of the system testing as specified in Section 40 61 21 - Instrumentation and Control System Testing and

- Commissioning.
- 4) Include the calibration forms developed as specified in Section 40 70 00 - Instrumentation Measuring Devices.
- d. As-Built Drawings
- 1) Complete as-built drawings, including all drawings and diagrams specified in this section under the "Submittals" section. These drawings shall include all termination points on all equipment the system is connected to, including terminal points of equipment not supplied by the Control System Integrator.
 - 2) As built documentation shall include information from submittals, as described in this Specification, updated to reflect the as-built system. Any errors in or modifications to the system resulting from the Factory and Functional Acceptance Tests shall be incorporated in this documentation.
- e. Original Licensed Software
- 1) Submit original software diskettes or CD-ROMs of all software provided under this Contract. Submit an original paper-based and electronic documentation for all software provided. Submit license agreement information, including serial numbers, license agreements, User Registration Numbers, and related information. All software provided under this Contract shall be licensed to the Owner at the time of purchase. Provide media in software sleeves within O&M manual.
- f. Electronic O&M Information
- 1) In addition to the hard copy of O&M data, provide an electronic version of all equipment manuals and data sheets, along with any software back-up of configuration files, on CDROM or DVD. Electronic documents shall be supplied in Adobe Acrobat format.
 - 2) Provide electronic files for all custom-developed manuals, including training manuals. Text shall be supplied in both Microsoft Office format and Adobe Acrobat format.
 - 3) Provide electronic files for all drawings produced. Drawings shall be in AutoCAD ".dwg" format and Adobe Acrobat format. Drawings shall be provided using the AutoCAD eTransmit feature to bind external references, pen and line styles, fonts, and the drawing file into individual zip files.
 - 4) Each computer system hardware device shall be backed up onto CDROM or DVD after Substantial Completion and shall be turned over to the Owner.
 - 5) If specified in the training section, provide digital copies of all training videos. Videos shall be in a format that is readable by standard DVD players and by standard PC DVD drives. Format shall be a minimum of 800 by 600 pixels and shall include sound.
- g. System Maintenance Manuals:
- 1) The manual shall be detailed to the component level, including assemblies, subassemblies, and other related components. It shall contain a detailed analysis of each major component so that maintenance personnel can effectively service, inspect, maintain, adjust, troubleshoot, and repair the equipment. Each manual shall include a Table of Contents, arranged in

- systematic order, and divided into separate sections.
- 2) The manual shall also include all applicable visual examinations, hardware testing, diagnostic hardware/software routines. Instruction on how to load and use any test and diagnostic programs and any special or standard test equipment shall be included.
 - 3) System Administrator's Manuals:
 - 4) This manual shall be provided to assist the Owner's system administrator in maintaining the new control system; it shall include details on all aspects of HMI, networking, PLC system maintenance. It also describes in detail, the overall system configuration for the equipment provided. The functional description shall include algorithms necessary to fully understand the functions. The material shall be organized for quick access to each detailed description of the system administrator's procedure. This manual shall be limited only to the description and procedures for functions that are performed by the Owner's system administrator.
- h. Plant Operator's Manuals:
- 1) This manual shall be provided to assist the Operator to properly operate the system. The manual shall be written in non-technical English and shall be organized for quick access to each detailed description of the operator's procedure. This manual shall be limited to the description and procedures that are performed by the Plant Operator.
 - 2) This manual shall serve as a complete instruction to the system and equipment and shall describe in detail the Operator interfaces and operator procedures.
 - 3) This manual shall be provided for each specific remote site
 - 4) In addition to the Operator interaction sequences, the following shall be provided, as a minimum:
 - a) Summary description of all major functions
 - b) Presentation of data on displays
 - c) Description of how the operator interfaces with equipment monitoring and control and how to set control parameters such as lead/lag sequencing, flow, and level control setpoints, etc.
 - d) Description of how the system and equipment react to situations such as heavy alarming, loss of communication links, heavy operator interaction, and loss of power and restoration of power.
 - e) Description of how the systems and equipment react to system failures such as loss of CPU, loss of mass storage, loss of operator display capabilities, and loss of communication.
 - f) Description of the hardware configuration and device switching capabilities.
 - g) Description of every message and alarm that the system and equipment are capable of outputting and explanation of what the message indicates and what action the system operator should take.
 - h) The description of how to generate and print reports

3. The cover and edge of each volume shall contain the information as specified in Section 01 31 00 - Project Management and Coordination.

1.5 QUALITY ASSURANCE

- A. The Control System Integrator shall be a "Systems Integrator" regularly engaged in the design, installation, and maintenance of instrumentation and control systems specifically for the Water and Wastewater industry. Subject organizations shall meet or exceed all of the following requirements:
 1. Have been in business under the same ownership/management for a minimum of 5 years.
 2. Have successfully completed at least ten projects of similar size and complexity in the last five most recent years.
 3. Employ at least one full time licensed Professional Engineer (P.E.) who shall supervise all software development and programming related to this project. Submittals related to Section 40 61 96 - Control System Configuration shall bear required seal and signature.
 4. Employ an adequate number of full-time degreed engineers and technicians who have a minimum of 10 years' experience working on projects and systems of similar size and complexity.
 5. Have and maintain an ISA accredited certification program for all employed technicians and installers.
 6. Have and maintain a stand-alone "Service Department" with a proven history of actively pursuing and executing on-going maintenance service contracts, including emergency services 24 hours 7 days a week.
 7. Have and maintain a fully staffed Industrial Network department capable of performing and supporting IT and related networking or communications project requirements.
 8. Have and maintain environmentally controlled space dedicated to the production, assembly, check-out, and testing of custom control panels. The organization must be a certified UL-508 panel facility or shall demonstrate how panels will obtain UL-508A labels in the project plan.
 9. Shall be a certified solution provider or value-added re-seller where the manufacturer provides certification for the major control components; Programmable Logic Controllers or Human Machine Interfaces for those products used on the project.
- B. The Control System Integrator shall be one of the following:
 1. Brows Hill Engineering & Controls
 2. The listing of specific Control System Integrator organizations above does not imply acceptance of their products and capabilities that do not meet the specified ratings, features, and functions. Control System Integrator's listed above are not relieved from meeting these specifications in their entirety.
- C. Installer Qualifications: manufacturer's authorized representative who is trained and approved for installation of units required for this Project.
- D. Source Limitations: Provide equipment that is the product of one manufacturer to the maximum practical extent. Where this is not practical, all equipment of a given type shall be

- the product of one manufacturer.
- E. Calibration Instruments: Each instrument used for calibrating control system equipment shall bear the seal of a reputable laboratory certifying that instrument has been calibrated within the previous 12 months to a standard endorsed by the National Institute of Standards and Technology.
 - F. 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.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Deliver, handle, and store control system components in accordance with manufacturer's written instructions and the requirements of Section 01 60 00 - Product Requirements.
- B. The specific requirement for the control system:
- C. Provide site and warehouse storage facilities for control system equipment.
- D. Prior to shipment, include corrosive-inhibitive vapor capsules in shipping containers and related equipment as recommended by capsule manufacturer.
- E. Prior to installation, store items in dry indoor locations. Provide heating in storage areas for items subject to corrosion under damp conditions.
- F. Cover panels and other elements that are exposed to dusty construction environments.
- G. Computer and network equipment shall not be placed into service until the room or building is fully enclosed and has functional HVAC equipment.

1.7 SITE CONDITIONS

- A. Operating Conditions:
 - 1. Ambient Conditions: Provide equipment suitable for ambient conditions in accordance with environment requirement paragraphs specified below.
 - 2. Field Locations: Field equipment may be subjected to ambient temperatures from 0-120° F, with direct radiation, and relative humidity from 45 to 96% with condensation. Field equipment will also experience rain, freezing rain, and snow.
 - 3. Power Supply: Power supply will be 120 Vac, single-phase, 60 Hz commercial power. Voltage variations will be at least plus or minus 8%. Certain loops shall have integral power supply as indicated on the drawings.
- B. Standard Environment Requirements: Unless otherwise noted, design equipment for continuous operation in these environments.
 - 1. Inside, dry and environmental controlled environments (Heat, Ventilated, and air-conditioned: NEMA 4.
 - 2. Inside, wet and damp locations or those in chemical areas: NEMA 4X.
 - 3. Outside: NEMA 4X

1.8 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of the control system that fail(s) in materials or workmanship within the specified warranty period.

1. Warranty Period: Two (2) years from the date of completion of the Site Acceptance Test.
 2. Cost for the removal, shipment, repair or replacement, and installation of components by CONTRACTOR shall be included in the warranty, as well as replacement of defective work.
- B. Corrective Maintenance
1. Services: Provide services of factory-trained service technicians for performing corrective maintenance on all system hardware and software for maintenance on the control system.
 - a. Provide a 24-hour, 7 day-a-week service hotline for telephone notification of system malfunctions.
 - b. Within 2 hours from notification by the OWNER of defective control system operation, a qualified service representative will establish telephone contact with the OWNER'S maintenance personnel to discuss short-term corrective measures.
 - c. If it is not possible to correct the defective operation as a result of the telephone contact, provide a qualified service representative at the location of the installed control system within 24 hours from initial notification.
 - d. Service representative shall perform all necessary inspections and diagnostic tests to determine the source of the defect and to establish a corrective action plan. The corrective action plan shall be developed such that the defect is corrected as quickly as possible and with the least impact on the operation of the OWNER's facilities.
 - e. Prior to beginning any repair or replacement procedure, review the corrective action plan with the OWNER informing of the planned course of action and to allow assessment of any impact it might have on the operation of the OWNER's facilities.
 - f. Replacement or repair of the defective component will be accomplished using replacement parts from the spare parts inventory delivered with the system. If not, the corrective action plan shall include a detailed schedule for the planned course of action.
 - g. Once the defect has been corrected, the corrective action plan shall be updated indicating the source of the defect and specific corrective action taken. A copy of the updated corrective action plan shall be delivered to the OWNER on the day the work is performed.
 - h. Any spares from the onsite supply of spares used in correcting the system malfunction shall be replaced within 15 days.
 - i. At OWNER'S option, OWNER maintenance personnel may participate in any corrective maintenance procedures.
 2. If 24-hour response time is not provided, or other corrective maintenance requirements are not met, the OWNER shall have the right to obtain corrective maintenance from other sources and charge the Control System Integrator reasonable costs of the alternative maintenance services, including parts, labor, travel, and subsistence.

- C. The OWNER, at Owner's option, may elect to employ its own maintenance staff to locate and remove a defective component. In this case, the OWNER will return the defective component to a repair location as instructed by the Control System Integrator. The Control System Integrator shall repair or replace the defective component and return the properly working unit to the OWNER within 15 days.

1.9 MAINTENANCE CONTRACT

1. A written proposal for a maintenance contract executed by the Control System Integrator shall be provided to the Owner for on-site preventive maintenance services related to the Instrumentation and Control System. The cost of this maintenance contract shall not be included in the Contract Price.
2. This proposal shall be provided within 30 days after final acceptance for the purpose of entering a contract for annual maintenance subsequent to the first year of maintenance. Standard per diem rates for providing breakdown service shall be outlined in the contract. Such rates shall be fair and reasonable and reflect the lowest rates offered to most favored customers. The fee quoted shall be firm for a minimum of 90 days from date of issue.
3. This maintenance contract shall include all labor, parts, and emergency calls providing an on-site response within 24 hours, to provide complete system maintenance for a period of one year after the date of Substantial Completion of the system for all equipment and software provided as part of the Control System Integrator's scope of work.
4. Provide software updates throughout the maintenance contract period. Provide the latest officially released version for all software provided under this Contract. The OWNER shall have the latest software releases at the end of the maintenance contract period.
5. The maintenance contract shall also include a minimum of 4 preventive maintenance visits by qualified service personnel of the Supplier who is familiar with the type of equipment provided for this project. Each preventive maintenance visit shall include routine adjustment, calibration, cleaning, and lubrication of system equipment and verification of correct operation.
6. Visits to the sites to correct deficiencies under warranty shall not be included in this preventive maintenance service contract.
7. Emergency maintenance procedures or plant visits may coincide with a preventive maintenance visit. However, they shall not replace the work intended to be performed during a preventive maintenance visit. The Supplier shall have full responsibility for the system hardware preventive and corrective maintenance.
8. During the one-year maintenance period, observation of maintenance operations by plant personnel, and the instruction of said personnel in the details of the maintenance work being performed shall be provided.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

- A. Control system functions as shown on Drawings and as required for each loop. Furnished equipment items and devices as required. Furnish all materials, equipment, and software

- required to affect the required system and loop performance.
- B. Manufacturers: Subject to compliance with requirements, control system design is based on the named manufacturers of equipment and materials.
 - 1. If an item is proposed other than the named manufacturer, obtain approval from the ENGINEER for such changes in accordance with Section 01 31 00 - Project Management and Coordination.
 - 2. If the proposed item requires, i.e., different installation, wiring, raceway, enclosures, intrinsically safe barriers, and accessories, furnish equipment, and work.
 - C. Like Equipment Items:
 - 1. Use products of one manufacturer and the same series or family of models to achieve standardization for appearance, operation, maintenance, spare parts, and manufacturer's services.
 - 2. Implement all the same or similar functions in the same or similar manner — for example, control logic, the sequence of controls, and display layouts.
 - D. Special Project Coordination Requirements: As a part of this contract, the instrumentation systems CONTRACTOR shall coordinate with all the sub-systems suppliers and manufacturers, during bidding, construction, testing, installation and start-up phases of the project. The coordination is to assure that the instruments and sub-systems are in compliance with the specifications and the central controls and that the tie-ins and the interface signals are provided as required.

2.2 COORDINATION MEETINGS

- A. The Coordination meetings shall be held at the Owner's designated location and shall include attendance by the OWNER, the ENGINEER, the CONTRACTOR, and the Control System Integrator's Project ENGINEER. Other Division 40 specifications may require additional meetings. Prepare and distribute an agenda for this meeting a minimum of one week before the scheduled meeting date. Meeting shall be scheduled a minimum of one week before the requested meeting date.
 - 1. A project kickoff coordination meeting shall be held within two weeks after submitting the Project Plan. The purpose of the meeting shall be to discuss the Control System Integrator's Project Plan, to summarize the Control System Integrator's understanding of the project; discuss any proposed substitutions or alternatives; schedule testing and delivery deadline dates; provide a forum to coordinate hardware and software related issues; and request any additional information required from the Owner. The meeting will last up to one business day.
 - 2. A submittal review coordination meeting shall be held after the Hardware, Panel Drawing, and Loop Drawing Submittal package has been reviewed by the ENGINEER and returned to the Control System Integrator. The purpose of this meeting shall be to review comments made on the submittal package; to refine scheduled deadline dates; coordinate equipment installation activities; and provide a forum for any further required coordination between the Control System Integrator. The meeting will last up to one business day.

2.3 INFORMATION ON DRAWINGS

- A. The following information is indicated in the drawings:

1. Loop diagram on flow sheet for each control loop. Diagrams are schematic in nature and intended only as a guide to working to be performed.
 2. Approximate location of primary elements, instrument panels, and final control elements.
 3. Approximate location of instrumentation power junction boxes for instrument electrical power connection.
 4. Location of electrical distribution panel boards for instrument electrical power.
 5. Location of equipment having alarms and equipment status contacts.
 6. Location of equipment being controlled by the system.
 7. The general layout of instrument cabinets.
 8. Instrument installation details.
- B. The following information is not shown on drawings but shall be the responsibility of the CONTRACTOR to determine, furnish, and coordinate with other divisions, based upon systems specified. Show this information on project record drawings.
1. Instrument Loop Drawings per ISA S5.4 minimum, desired, and optional items.
 2. Location of electrical distribution panel boards supplying power to any device supplied under this contract.
 3. Detailed enclosure and instrument panel layouts, fabrication details and wiring diagrams.
 4. Detailed system configuration.
 5. Raceway and cable routing for instrumentation wiring.
- C. Instrument Tag Numbers: A shorthand tag numbers are used in the Contract Documents.

2.4 CONTROL SYSTEM CONTROL NARRATIVES

- A. Refer to Section 40 61 96 - Control System Configuration for a description of control loops for the control system.
- B. Functional Requirements for Control Loops.
- C. Shown on Drawings, in Panel Control Diagrams and Process and Instrumentation Diagrams (P&ID).

2.5 INSTRUMENT AND CONTROL COMPONENTS

- A. Major components for each instrument are listed in the Instrument Data Sheets referenced in Section 40 70 00 - Instrumentation Measurement Devices.
1. Comply with the various component specifications located in Division 40 Sections, as well as in applicable Division 26 Sections.
 2. Component General Requirements:
 - a. Provide equipment of solid-state construction utilizing second source semiconductors, unless otherwise specified. De-rate components to assure dependability and long-term stability.
 - b. Provide printed or etched circuit boards of glass epoxy, hand or wave soldered, of sufficient thickness to prevent warping. Coat printed circuit boards in field-mounted equipment with Plasite 7122, or approved equal, to protect against

- corrosion.
 - c. Alignment and adjustments shall be non-critical, stable with temperature changes or aging, and accomplished with premium grade potentiometers. Do not insert components of specially selected values into standard electronic assemblies to meet performance requirements.
 - d. Use parts indicated in instruction manuals, replaceable with standard commercial components of the same description without degrading the performance of the completed assembly. Do not use silver edge connectors or pins.
- B. Test Equipment: Use test equipment and instruments to simulate inputs and read outputs suitable for the purpose intended and rated to an accuracy of at least 5 times greater than the required accuracy of the device being calibrated. Such test equipment shall have accuracies traceable to the National Bureau of Standards as applicable.
- C. Components, Hazardous Area Location:
1. Assure equipment located in hazardous areas is suitable for applicable classification by use of explosion-proof housings or equipment and barriers approved as "intrinsically safe" by either UL or FM.
 2. Locate barriers in cabinets at hazardous area boundaries. Use dual barriers in loops in order to prevent grounding loop at the barrier.

2.6 EXTRA MATERIALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
- B. Spare Parts:
1. During the system warranty period, the Control System Integrator shall provide system repairs by initially replacing the defective component with one from the spares inventory.
 2. The Control System Integrator shall then replace the spare component. Rather than place the new component in the spares inventory, the Control System Integrator shall replace the spare that had been installed in the system during the initial repair. This procedure shall ensure that all new components provided as spares are fully tested and compatible with the installed system.
 3. Spare requirements as specified in other Division 40 sections.
- C. Special Tools: One of each type of special hand tool required to open or operate equipment, to remove or replace replaceable parts, remove or replace cable connectors, or to make required operational or maintenance adjustments. A special hand tool is any tool not readily available from local retail hardware stores.

PART 3 - EXECUTION

3.1 GENERAL INSTALLATION

- A. Instrumentation and accessory equipment shall be installed in accordance with manufacturer instructions. The indicated locations of equipment, transmitters, alarms, and similar devices indicated are approximate only. Exact locations of all devices shall be as

approved by the ENGINEER during construction. Obtain in the field, all information relevant to the placing of process control equipment and case of interference with other work, proceed as directed by the ENGINEER and furnish all labor and materials necessary to complete the work in an approved manner at no additional cost to the OWNER.

- B. Provide brackets and hangers required for mounting of equipment.
- C. The shield on each process instrumentation cable shall be continuous from source to destination and be grounded at only one ground point for each shield.
- D. Investigate each space in the building through which equipment must pass to reach its final location. If necessary, ship material in sections sized to permit passing through restricted areas in the building. Provide on-site service to oversee the installation, the placing, and location of system components, their connections to the process equipment panels, cabinets, and devices, subject to the ENGINEER's approval. Certify that field wiring associated with the equipment is installed in accordance with best industry practice. Coordinate work under this section with that of the electrical work specified under applicable Sections of Division 26.
- E. Provide sunshades for equipment mounted outdoors in direct sunlight. Sunshades shall include standoffs to allow air circulation around the cabinet. Orient equipment outdoors to face to the North or as required to minimize the impact of glare and ultraviolet exposure on digital readouts.

3.2 TESTING

- A. Testing and Commissioning: Accomplished in accordance with the requirements of Section 01 70 00 "Execution and Closeout Requirements" and Section 40 61 21 - Instrumentation and Control System Testing and Commissioning.
- B. Testing shall be scheduled and coordinated with the OWNER/ENGINEER at least 2 weeks in advance. Provide qualified test personnel, instruments and test equipment, including manufacturer's services, as specified in the individual Specification sections.
- C. Where test reports show unsatisfactory results, the OWNER/ENGINEER will require the removal of all defective or suspected materials, equipment, apparatus, and their replacement with new items, all at no cost to the OWNER. The CONTRACTOR shall bear all the cost for any retesting.

3.3 TRAINING

- A. Training: Accomplished in accordance with the requirements of Section 40 61 26 - Instrumentation and Control System Training and Section 01 70 00 - Execution and Closeout Requirements.

END OF SECTION

SECTION 40 61 01
INSTRUMENTATION AND CONTROL SYSTEM REFERENCES AND ABBREVIATIONS

PART 1 - GENERAL

1.1 SUMMARY - NOT USED

1.2 REFERENCES

A. Industry Standards and Codes

1. Applicability of Standards: Unless the Contract Documents include more stringent requirements, applicable construction industry standards have the same force and effect as if bound or copied directly into the Contract Documents to the extent referenced. Such standards are made a part of the Contract Documents by reference.
2. Publication Dates: Comply with standards in effect as of date of the Contract Documents unless otherwise indicated.
3. Copies of Standards: Each entity engaged in construction on Project should be familiar with industry standards applicable to its construction activity. Copies of applicable standards are not bound with the Contract Documents.
 - a. Where copies of standards are needed to perform a required construction activity, obtain copies directly from publication source.
4. Abbreviations and Acronyms for Standards and Regulations: Where abbreviations and acronyms are used in Specifications or other Contract Documents, they shall mean the recognized name of the organizations responsible for the standards and regulations.

B. STANDARDS

1. American National Standards Institute (ANSI):
 - a. ANSI/ISA -101.01 - 2015 - Human Machine Interfaces for Process Automation Systems
 - b. B 16.1 - Gray Iron Pipe Flanges and Flanged Fittings.
 - c. Supplement to C37.90, Relays and Relay Systems Associated with Electric Power Apparatus (IEEE Std. 313), C37.90a.
 - d. C39.5, Safety Requirements for Electrical and Electronic Measuring and Controlling Instrumentation
 - e. ANSI 61 - Drinking Water System Components - Health Effects
2. American Petroleum Institute (API):
 - a. RP 520 - Recommended Practices for the Design and Installation of Pressure-Relieving Systems in Refineries.
 - b. RP 550 – Manual on Installation of Refinery Instruments and Control Systems.
3. ASTM International, Inc. (ASTM):
 - a. A 36 - Specification for Carbon Structural Steel
 - b. A 182 – Specification for Forged or Rolled Alloy and Stainless Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service
 - c. A 269 – Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service

- d. A 276 – Specification for Stainless Steel Bars and Shapes
- e. A 312 – Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes
- f. B 32 – Specification for Solder Metal
- g. B 68 – Specification for Seamless Copper Tube, Bright Annealed
- h. B 88 – Specification for Seamless Copper Water Tube
- i. D 1047 – Specification for Poly(Vinyl Chloride) Jacket for Wire and Cable
- 4. American Society of Mechanical Engineers (ASME)
 - a. B 16.18 - Cast Copper Alloy Solder Joint Pressure Fittings
 - b. B 16.22 - Wrought Copper and Copper Alloy Solder Joint Pressure Fittings
- 5. Electronics Industry Association/Telecommunications Industry Association (EIA/TIA)
 - a. EIA-STD-RS-455 - Standard Test Procedures for Fiber Optic Fibers, Cables, Transducers, Connecting and Terminating Devices
 - b. TIA/EIA-604 - Fiber Optic Connector Intermateability Standards (FOCIS)
- 6. Fiber Optic Association (FOA)
 - a. FOTP-86 Fiber Optic Cable Jacket Shrinkage
- 7. Insulated Cable Engineers Association (ICEA)
 - a. ICEA S-97-682 - Utility Shielded Power Cables Rated 5 Through 46 kV
- 8. International Electrotechnical Commission (IEC)
 - a. IEC 255-4 - Electrical Relays - Single Input Energizing Quantity Measuring Relays With Dependent Specified Time
 - b. IEC 60068 - Environmental testing
 - c. IEC 61000-4-5: Electromagnetic compatibility (EMC) - Part 4-5: Testing and measurement techniques - Surge immunity test
 - d. IEC 61131 - Programmable controllers
 - e. IEC 68-2-6 - Environmental Testing - Part 2-6: Tests - Test Fc: Vibration (sinusoidal)
 - f. IEC 68-2-7 - Environmental Testing - Part 2-27: Tests - Test Ea and guidance: Shock
- 9. Institute of Electrical and Electronics Engineers (IEEE)
 - a. IEEE Standard 383 - Flame Retardant.
 - b. IEEE Standard 37.90.1 -2012 - IEEE Standard for Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus
 - c. IEEE Standard 802 - LAN/MAN Standards Committee
 - d. IEEE Standard 802.3 - IEEE Standard for Ethernet
 - e. IEEE Standard 1202 - Flame Testing of Cables for Use in Cable Tray
- 10. International Organization for Standardization (ISO)
 - a. ISO/IEC 26300:2006 - Information technology -- Open Document Format for Office Applications (OpenDocument) v1.0
- 11. Instrumentation Society of Automation (ISA)

- a. S5.1 – Instrument Symbols and Identification
 - b. S5.2 - Binary Logic Diagrams For Process Operations.
 - c. S5.3 - Graphic Symbols for Distributed Control/Shared Display Instrumentation, Logic, and Computer Systems.
 - d. S5.4 – Instrument Loop Diagrams
 - e. S5.5 - Graphic Symbols for Process Displays
 - f. S5.6 - Functional Requirements Documentation for Control Software Applications.
 - g. S7.3 – Quality Standards for Instrument Air
 - h. S8.1 – Instrument Enclosures for Industrial Environments
 - i. S20 - Specification Forms for Process Measurement and Control Instrumentation, Primary Elements, and Control Valves
 - j. S39.1 – Control Valve Sizing Equations
 - k. S39.2 – Control Valve Capacity Test Procedures
 - l. S50.1 - Compatibility of Analog Signals for Electronic Industrial Process Instruments
 - m. S51.1 - Process Instrumentation Terminology
 - n. RP 3.1 – Flow Meter Installations, Seal and Condensate Chambers
 - o. RP 7.1 – Pneumatic Control Circuit Pressure Test
 - p. RP12.6 – Installation of Intrinsically Safe Systems for Hazardous (Classified) Locations
 - q. RP 20.1, 20.2 – Specification Forms for Instruments
 - r. TR 20.00.01-2001 - Specification Forms for Process Measurement and Control Instruments
12. Japanese Standards Association (JSA)
- a. JIS C 0911:1984 - Vibration Testing Procedure for Electric Machines and Equipment
 - b. JIS C0912:1984 - Shock Testing Procedure For Electric Machines And Equipment
13. National Electrical Manufacturers Association (NEMA)
- a. NEMA ICS 2-230.40
 - b. NEMA WC-63.1 - Performance Standard For Twisted Pair Premise Voice And Data Communications Cables
14. National Fire Protection Association (NFPA)
- a. NFPA 70 - National Electrical Code (NEC)
 - b. NFPA 70E - Standard for Electrical Safety in the Workplace
 - c. NFPA 79 - Electrical Standard for Industrial Machinery
15. National Electrical Manufacturers Association (NEMA)
- a. ICS 6 Enclosures for Industrial Controls and Systems
 - b. 250 Enclosures for Electrical Equipment (1000 Volts Maximum)
 - c. ICS 1-101 Diagrams, Designations and Symbols
 - d. ICS 4 Terminal Blocks for Industrial Use.

- e. LS1 Low Voltage Surge Protection Devices
 - f. Control System 1 – General Standards for Industrial Control and Systems
16. Underwriters Laboratories, Inc. (UL)
- a. UL 50, the Standard of Safety for Enclosures for Electrical Equipment.
 - b. UL 508, the Standard of Safety for Industrial Control Equipment
 - c. UL 508A, the Standard of Safety for Industrial Control Panels
 - d. UL 910 - UL Standard for Safety Test for Flame-Propagation and Smoke-Density Values for Electrical and Optical-Fiber Cables Used in Spaces Transporting Environmental Air.
 - e. UL 1581 VW 1 - Vertical Tray Cable Flame Test
 - f. UL 1283 Standard for Safety-Electromagnetic Interference Filters.
 - g. UL 1449 Third Edition Surge Protective Devices
 - h. UL 1666 - UL Standard for Safety Test for Flame-Propagation Height of Electrical and Optical-Fiber Cables Installed in Vertical Shafts.
17. United States Military Standard (MIL-STD)
- a. MIL-STD-461 - Electromagnetic Emission and Susceptibility Requirements for the Control of Electromagnetic Interference

C. Terminology Abbreviations

1. The abbreviations used in the Division 40 specifications or in any Section referencing Division 40, shall be as defined in ISA Standard S51.1, unless otherwise specified. Where terms used are not defined in ISA 51.1, or in these specifications, ANSI/IEEE Standard 100-1984, ANSI/ISA S50.1 or other ISA standards shall apply.
- a. AI: Analog Input
 - b. AO: Analog Output
 - c. CPU: Central Processing Unit
 - d. CSI: Control System Integrator
 - e. DI: Discrete Input
 - f. DO: Discrete Output
 - g. HMI: Human-Machine-Interface
 - h. I/O: Input/Output
 - i. OIT: Operator Interface Terminal
 - j. PLC: Programmable Logic Controller
 - k. TCP/IP Transmission Control Protocol/Internet Protocol
 - l. RTU: Remote Terminal Unit
 - m. UPS: Uninterruptible Power Supply
 - n. VFD: Variable Frequency Drive

D. Terminology Definitions

1. The definitions of terminology used in the Division 40 specifications or in any Section referencing Division 40, shall be as defined in ISA Standard S51.1, unless otherwise specified. Where terms used are not defined in ISA 51.1, or in these specifications, ANSI/IEEE Standard 100-1984, ANSI/ISA S50.1 or other ISA standards shall apply.

- a. Analog Device: Any sensor, transmitter, indicator, recorder, controller, computing relay, or control valve which transmits or receives an analog signal. Excludes the portion of a digital system or Input/Output subsystems.
- b. Analog Signal: A signal that has an infinite number of values and varies in strength.
- c. Control Circuit: Any circuit operating at 24 Vac or Vdc or more, whose principal purpose is the conveyance of information and not the conveyance of energy for the operation of an electrically powered device.
- d. Control Room: An environmentally controlled room intended for housing digital control equipment, computers, large control panels, etc., and generally intended to be regularly occupied by operators.
- e. Data Sheets: Data sheets as used in this specification shall comply with the requirements of ISA S20 as modified.
- f. Device: An electronic or mechanical apparatus designed to perform a specific measurement of control function.
- g. Discrete Signal: A signal that has only two values, on and off.
- h. Equipment: Machinery used in a process, e.g., pumps, mixers, fans, etc.
- i. Field: When used to refer to locations at the treatment facility, or in the transmission system, shall mean all outdoor locations, as well as all process and equipment areas. Unless otherwise specified, all areas shall be considered "field" locations except for administration and other office areas; control rooms; motor control centers and other electrical equipment rooms; dedicated HVAC rooms; and maintenance buildings.
- j. Field Termination Point: Termination of a run of raceway from an instrument panel to the vicinity of a field instrument.
- k. Fixed Input/Output: A PLC style consisting of a fixed number of Input/Output, a processor, and a power supply all in one enclosure. Some fixed PLCs have limited expansion ability.
- l. HMI: Human-Machine-Interface. The control system hardware and software associated with providing the LCD-based interface between system users and the control system
- m. Loop: Any combination of interconnected transmitters, receivers, switches, alarms, indicators, controllers, computers, or final control elements.
- n. Operator Interface Terminal: A terminal usually embedded in a control panel that allows the operator to view and modify control system parameters. Operator Interface Terminals are not capable of running commercially available software.
- o. Panel: An instrument support system which may be a flat surface, a partial enclosure, or a complete enclosure for instruments and other devices used in process control systems. Unless otherwise specified, the term "panel" shall be interpreted as a general term which includes flat panels, enclosures, cabinets, and consoles.
- p. PLC: Programmable Logic Controller. Field installed unit which monitors and controls devices located within the plant. The PLC control system shall contain

all logic necessary to monitor and control the system process located at the PLC location.

- q. Process: A progressively continuing operation that consists of a series of controlled actions systemically directed toward a particular result, e.g., a process to mix, filter, heat, and/or cool air to a particular condition.
- r. RTU: Remote Terminal Unit. Field installed unit which monitors and controls devices, located away from the plant at remote locations. The RTUs contain all logic necessary to monitor and control the system process located at the remote location.
- s. Subsystem: A discrete subdivision of a system and an assemblage of parts, devices, or software modules designed to perform one or more of the specific tasks required for the system to accomplish its functions.
- t. System: As assemblage of sometimes diverse parts, devices, or software modules serving a common set of measurement and control functions.
- u. Two-Wire Transmitter:
 - 1) A transmitter which derives its operating power supply from the signal transmission circuit and therefore requires no separate power supply connections.
 - 2) As used in this specification, two-wire transmitter refers to a transmitter which provides a 4 to 20 milliampere current regulation of signal in a series circuit with an external 24 volt direct current driving potential and a maximum external circuit resistance of 600 ohms.
- v. Unit: Any combination of equipment items interconnected in a predetermined manner, performing one or more controlled actions toward a particular result. A discrete subdivision of a process.

1.3 ADMINISTRATIVE REQUIREMENTS - NOT USED

1.4 SUBMITTALS - NOT USED

1.5 QUALITY ASSURANCE - NOT USED

1.6 DELIVERY, STORAGE, HANDLING - NOT USED

1.7 SITE CONDITIONS - NOT USED

1.8 WARRANTY - NOT USED

PART 2 - PRODUCTS - NOT USED

PART 3 - EXECUTION - NOT USED

END OF SECTION

SECTION 40 61 21
INSTRUMENTATION AND CONTROLS SYSTEM TESTING AND COMMISSIONING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. This section covers the testing requirements for all devices and systems furnished and installed by the Control System Integrator as detailed in the Drawings and as described in the related work sections.
2. The Control System Integrator shall provide all labor and materials necessary to coordinate and perform the testing of the Process Control System as specified herein.
3. The Control System Integrator shall provide all test equipment necessary to perform the testing activities specified herein.
4. The Control System Integrator shall submit certified Instrument Calibration Certificates to the ENGINEER for field instruments and devices specified or shown on the Drawings immediately upon completion of calibration. Submit Instrument Calibration Certificates for existing instruments requiring re-calibration as well.
5. Receipt of any Instrument Calibration Certificates shall in no way imply acceptance of any work or of instruments supplied.
6. Each Instrument Calibration Certificates shall be signed and dated by an authorized representative of the Control System Integrator.

B. Related Sections include but are not necessarily limited to:

1. Division 00 - Procurement and Contracting Requirements.
2. Division 01 - General Requirements.
3. Section 40 61 01 - Instrumentation and Control System Abbreviations
4. Section 40 61 26 - Instrumentation and Control System Training
5. Section 40 68 00 - Control System Software
6. Section 40 62 00 - Control System Computers and Peripheral Equipment
7. Section 40 63 43 - Programmable Logic Controllers (PLCs)
8. Section 40 66 00 - Control System Network Communication Equipment
9. Section 40 66 81 - Control System Fiber Optic Cable
10. Section 40 67 00 - Control System Panels
11. Section 40 70 00 - Instrumentation Measurement Devices
12. Section 40 61 96 - Control System Configuration
13. Section 40 61 93 - Control System Input/Output List
14. Division 26 Electrical

1.2 REFERENCES

- A. Refer to Section 40 61 01 - Instrumentation and Control System Abbreviations and References. In case of conflict between the requirements of this Section and those of the listed standards, the requirements of this Section shall prevail.**

1.3 ADMINISTRATIVE REQUIREMENTS - NOT USED

1.4 SUBMITTALS

A. Action Submittals

1. Each Section submittal shall be complete, contain all of the items listed in the Specification Section, and shall be clearly marked to indicate which items are applicable on each cut sheet page. The Submittal shall list any exceptions to the Specifications and Drawings, and the reason for such deviation. Shop drawings, not so checked and noted, will be returned un-reviewed.
2. The CONTRACTOR shall check shop drawings for accuracy and Contract Requirements prior to submittal to the ENGINEER. Errors and omissions on approved shop drawings shall not relieve the CONTRACTOR from the responsibility of providing materials and workmanship required by the Specifications and Drawings. Shop drawings shall be stamped with the date checked and a Statement indicating that the shop drawings conform to Specifications and Drawings. Only one Specification Section submittals will be allowed per transmittal unless sections are indicated for grouping in the individual sections.
3. Startup Plan Submittal:
 - a. The CONTRACTOR shall submit a startup plan for OWNER/ENGINEER review. Upon successful review, the CONTRACTOR shall coordinate with Operations on an agreed upon date and time for commissioning each site.
4. Testing Plan and Schedule Submittal
 - a. Submit a Testing Plan and Schedule Submittal. The Testing Plan shall be made and approved before any testing shall be accepted. The Testing Plan, Schedule submittal shall, as a minimum, contain the following:
 - 1) Overview of the Process Control System, clearly describing the Control System Integrator's understanding of the project work and interfaces to other systems; and including a preliminary system architecture drawing and proposed project work schedule detailing all Control System Integrator's work activities.
 - 2) Approach to work clearly describing how the Control System Integrator intends to execute the work, including detailed discussion of switchover, startup, replacement of existing equipment with new, and other tasks as required by these specifications as applicable.
 - 3) Preliminary HMI software, PLC software, and PLC hardware submittal information shall be included solely for determining compliance with the requirements of the Contract Documents prior to beginning development of application programming. Review and approval of software and hardware systems as part of this Project Plan stage shall not relieve the Control System Integrator of meeting all the functional and performance requirements of the system as specified herein. Substitution of manufacturer or model of these systems after the submittal is approved shall not be permitted without prior ENGINEER approval.
 - 4) Details of personnel assigned to the project and organizational structure including the Control System Integrator's project manager, project

- ENGINEER, and lead project technicians. Include resumes of each key individual and specify in writing their commitment to this project.
- 5) Preliminary coordination meeting agendas as specified herein.
 - 6) Preliminary training plan
 - 7) Samples of shop drawings to be submitted in conformance with the requirements of the Specifications shall be submitted. At a minimum include samples of panel fabrication drawings, loop, and Input/Output wiring diagrams.
- b. Exceptions to the Specifications or Drawings shall be clearly defined in a separate Deviation List. The Deviation List shall consist of a paragraph by paragraph review of the Specifications indicating acceptance or any proposed deviations, the reason for exception, the exact nature of the exception and the proposed substitution so that an evaluation may be made by the ENGINEER. The acceptability of any device or methodology submitted as an "equal" or "exception" to the specifications shall be at the sole discretion of the ENGINEER. If no exceptions are taken to the Specifications or Drawings, the Control System Integrator shall make a statement indicating so. If there is no statement included by the Control System Integrator, it shall be interpreted by the ENGINEER to mean that no exceptions are taken.
 - c. A Project Schedule shall be prepared and submitted using an ISO/IEC 26300:2006 formatted file. The schedule shall be prepared in Gantt chart format clearly showing task linkages for all tasks and identifying critical path elements. The Control System Integrator's schedule shall be based on and coordinated with the CONTRACTOR's schedules and must meet all field installation, testing, and startup milestones in those schedules.
 - d. The Control System Integrator schedule shall illustrate all major project milestones including the following:
 - 1) Schedule for all subsequent project submittals: include in the time allotment, the time required for CONTRACTOR submittal preparation, ENGINEER's review, and a minimum of two complete review cycles.
 - 2) Proposed dates for all required project Coordination Meetings.
 - 3) Hardware purchasing, fabrication, and assembly (following approval of related submittals)
 - 4) Software purchasing and configuration (following approval of related submittals)
 - 5) Shipment of all instrumentation and control system equipment
 - 6) Installation of all instrumentation and control system equipment
 - 7) Duration and dates for all required testing activities. Testing schedule shall include submittal of test procedures a minimum of 30 days prior to commencement of testing. Schedule shall also include submittal of completed documentation of testing activities for review and approval by the ENGINEER prior to equipment shipment, startup, or subsequent project work.
 - 8) The Control System Integrator shall arrange the schedule to develop, test, troubleshoot, and train the OWNER's staff on the control system network,

PLC and HMI applications. The timing of these coordination efforts shall be determined by the Control System Integrator. The Control System Integrator shall include all necessary costs to accommodate the minimum time slots in their overall project schedule. All time allotments shall exclude any legal holidays, or days lost due to delays caused by the CONTRACTOR.

- 9) Include a schedule for system cutover, startup, and/or placing in service for each individual site under this Contract. At a minimum, include the schedule for all work on the primary Operations Control Center, Backup Operations Control Center and associated work on new backup radio tower, radio link testing between all sites, 900 MHz radio and cellular modem installation and testing, HMI, OIT, PLC programming timeline, HMI server transition to FactoryTalk testing, and all other related testing.
- 10) Schedule for all training including submittal and approval of O&M manuals, factory training, and field training

5. Testing Documentation Submittals

- a. System Test Plan: The Control System Integrator shall prepare and submit for review a System Test Plan.
- b. Test Procedures: The Control System Integrator shall prepare and submit for review a Test Procedures.
- c. Test Reports: The Control System Integrator shall prepare and submit for review a Test Report.

B. Commissioning Submittals

1. Provide Control System Test Plan, procedures for system testing, and test reports in accordance with Section 01 70 00 - Execution and Closeout Requirements and as specified in Part 3 of this Section.
2. Following the network, instrumentation and control system checkout and start-up, the CONTRACTOR shall perform a complete system test in the presence of the OWNER/ENGINEER to verify that all equipment and software is operating properly as a fully integrated system, and that the intended monitoring and control functions are fully implemented and operational. Commissioning shall be performed on a site by site basis.
 - a. Commissioning shall begin only after networking equipment, all instruments and control panels are installed, wired and previously tested by the CONTRACTOR, in accordance with Paragraph 1.02 of this Section.
 - b. CONTRACTOR shall submit to the ENGINEER a schedule for Commissioning, including a proposed start date, at least three weeks in advance.
3. Commissioning shall include, as a minimum, the following checks:
 - a. All wiring shall be checked at each termination point for correct wire size, type, color, termination and wire number.
 - b. All instruments and devices shall be checked to verify compliance with the specifications and approved shop drawings. The calibration of analog devices shall be verified including the zero and span.
 - c. Analog wiring shall be checked for correct polarity and ground continuity at each termination point in the loop.

- d. All analog loops shall be verified at each termination point at 0%, 25%, 50%, 75%, and 100% signal levels.
- 4. CONTRACTOR shall provide the following documentation for use during the Commissioning effort.
 - a. Complete panel schematic and internal point-to-point wiring interconnect drawings.
 - b. Complete electrical control schematics in accordance with JIC standards.
 - c. Complete panel layout drawings.
 - d. Complete field wiring diagrams.
 - e. Complete instrument loop diagrams.
 - f. Completed Calibration/Recalibration Certificates for all field and panel devices that require adjustment or calibration.
 - g. CONTRACTOR shall provide one set of Commissioning documentation for the OWNER's personnel, one set for the ENGINEER's use, one set for field use, and the required number of sets for the CONTRACTOR's use.
 - h. The drawings corrected and modified during Commissioning shall form the basis for the "As-Built" record drawing requirement.
- 5. All PLC/RTU hardware and software shall be thoroughly tested to verify proper operation as an integrated system. System testing shall include, as a minimum, the following:
 - a. All digital inputs shall be activated at the field element to verify proper response to the status change on graphic displays, reports, and in automatic control algorithms.
 - b. All analog inputs shall be tested at the field transmitter over a full range to verify proper response on graphic displays, reports, and in automatic control algorithms.
 - c. All digital and analog outputs shall be forced to verify proper control operation.
 - d. Communications, including PLC/RTU data highway, computer local area network, PLC/RTU remote I/O, and serial communications shall be tested between all components, including existing equipment.
 - e. Alarm displays and printing shall be tested for all analog and digital alarm points.
 - f. All automatic control algorithms shall be completely tested over various ranges and input conditions to verify proper operation. Graphic displays shall be observed to verify proper response to automatic control operations.
 - g. All historical data collection, trending, computation, totalizers and reporting functions shall be checked and tested to confirm proper operation and accuracy of the data.
- 6. Any defects or problems found during the Commissioning effort or field test shall be corrected by the CONTRACTOR and then retested to demonstrate proper operation.
- 7. Following testing and demonstration of all system functions, the new control system shall be fully operational for a continuous 48-hour period. The Field Demonstration Test specified below shall not begin until the continuous 48 hour proving run has been successfully completed and OWNER and ENGINEER agree that the Field Test can

begin.

8. Cutover Sequence Plan

- a. If applicable, the Control System Integrator will review the specified construction sequence and develop a submittal plan of switchover the existing PLC's and Control Sequence without interruption to control and monitoring of the system.

C. Closeout Submittals

1. Record Documentation

- a. The Control System Integrator, within 30 days after successful completion of Site Demonstration Test (SDT), shall submit a preliminary version of the Record Documents. Final Record Documents shall be submitted prior to the conclusion of the Site Availability Demonstration (SAD). The SAD shall not be considered complete until the final Record Documents submittal has been Successfully Reviewed.
- b. The System Operator's Manuals shall describe the configuration and all functions for the systems and equipment provided. Functional descriptions shall include algorithms necessary to fully understand the functions. The manuals shall be organized for quick access to each detailed description of the operator's procedure. The manuals shall be limited only to description of procedures for functions that are performed by the operator. The System Operator's Manuals shall serve as a complete instruction to the system and equipment and shall describe in detail the operator interfaces and operator procedures. In addition to the Operator interaction sequences, the following shall be provided, as a minimum:
 - 1) Summary description of all major functions
 - 2) Presentation of data on displays.
 - 3) Description of how the system and equipment react to situations such as heavy alarming, loss of communication links, heavy operator interaction, and loss of power and restoration of power.
 - 4) Description of the hardware configuration and device switching capabilities.
 - 5) Description of every message and alarm that the system is capable of outputting, an explanation of what the message indicates, and what action the system operator should take.
- c. System Administrator Guide:
 - 1) The System Administrator Guide shall be a user's manual for all the corresponding systems programs. It shall include information on system generation from file backups, starting and bootstrapping the system, editing and expansion techniques (including display/report compiler, database, and applications edit), batch mode operation of software utilities, and troubleshooting to be used in conjunction with the system dumps, error and abort messages. User instructions for each of the peripherals and for all Software ENGINEER procedures shall be in the guide.
- d. Software support materials:

- 1) Program Media:
 - a) The Control System Integrator shall furnish complete sets of program media documentation. These documents shall include source of all programs written by the Control System Integrator specifically for the proposed system. This includes, RTU and PLC programs, HMI scripting, OIT applications, and objects of all programs necessary for the operation and maintenance of the systems programs. If any changes are made to programs during system test and acceptance, the Control System Integrator shall provide, within [5] [choose a number] days, corrected copies of source, object, and system media.
- 2) Program Listings:
 - a) Each program listing shall include revision information. Each time a change is made in the listing, its revision level shall be documented by the party making the change. Program listings will include all in-program comments and documentation, and must be clearly understandable by programmers familiar with the language used. Undocumented code is not acceptable.
- 3) Programmer Manuals:
 - a) The purpose of these manuals will be to enable systems and applications programmers, to maintain, modify, and expand the capacity and functionality of the system. These manuals shall comprise the standard manuals furnished by the computer system manufacturer covering the Operating System, Utilities, Diagnostics, and High Level Language(s) supplied, together with Control System Integrator furnished manuals that are specific to the system. The manuals shall include descriptions of the procedures to be used for:
 - i. Computer system startup, restart, manual failover, and operation.
 - ii. Modifying and expanding the system databases and testing revised versions.
 - iii. Defining, linking to the database, and testing revised and new displays, logs, reports, data acquisition, process control, and data processing procedures including the addition of communication links, CFEs, RTUs, PLC's, and Input/Output points.
 - iv. System operational troubleshooting including descriptions of the system error messages and the interpretation of crash dumps.
 - v. Instructions for configuring and rebuilding servers and workstations as if starting a new system, as well as rebuilding from backups (this will apply to peripherals applicable to the system as a whole, including network items).
 - vi. Provide effective procedures and techniques for creating, expanding, and editing control system and PLC applications. Include useful backup procedures required for system recovery.
- 4) System Configuration Inventory List:
 - a) An inventory list shall be furnished for all contract material, software,

documentation, spare parts, and test equipment. Hardware identification of each unique module by serial number and each software unique module shall be included on the list. The inventory list shall include, but not be limited to, the following information:

- vii. Manufacturer's name, part number, and serial number
- viii. Quantity of units supplied with the deliverable System/subsystem
- ix. Software modules supplied
- x. Operating system software provided for all CPUs/microprocessors
- xi. Operating systems enhancements provided
- xii. System documentation supplied
- xiii. Applicable cabinet, rack number or slot, and cables.

- b) The inventory list, which shall be prepared and updated by the Control System Integrator, shall be subdivided by hardware, software, test equipment, spares, documentation, and training courses. Each of these major divisions shall be further subdivided to the individual deliverable item level. Each item must be defined in sufficient detail to permit identification in shipping documents and inventory checks. The organization of the inventory list shall include provision for annotating each item with forecast and actual dates for:

- xiv. Review (Documentation)
- xv. Shipping and Delivery (All items Except Documentation)
- xvi. System Testing (Hardware and Software)
- xvii. Site Demonstration Tests (Hardware and Software)
- xviii. Final Acceptance (Spares, Documentation, etc.)
- xix. Delivery (Training Courses).

- c) A preliminary version of the System Configuration Inventory List that demonstrates the form and content to be provided shall be submitted for review. A completed System Configuration Inventory List shall be submitted no later than 30 days prior to the scheduled start of System Testing. The SDT shall not be initiated until the System Configuration Inventory List submittal has been Successfully Reviewed. A System Configuration Inventory List updated to reflect any additions or changes during system installation shall be included as part of the Record Documents.

1.5 QUALITY ASSURANCE

A. Control System Availability Requirements:

- 1. A fundamental objective of the Control System Integrator's proposed system design shall be to ensure that no single equipment failure or temporary error condition can disable the system operation or generate any spurious control commands to the system equipment.
- 2. Single Point of Failure:

- a. The control system equipment configuration shall prevent any single hardware or software failure from causing loss of any system function or from causing overall system malfunction. Single hardware failures may cause loss of specific communication channels temporarily until failed equipment is replaced.
- 3. Control System Operational Checks: The Control System Integrator's proposed system shall continually check the operation of all devices in the system and report any problem to the user. Upon detecting a malfunction, the failed operation shall be attempted a number of times (programmable) in order to determine whether the malfunction is temporary or permanent. Permanent malfunctions shall be alarmed and logged. Temporary malfunctions shall not be alarmed but shall be logged for maintenance purposes. Failed devices shall be automatically replaced by spare or backup devices if such devices are available.
- B. System Availability: During the System Availability Demonstration, the control system shall achieve an average availability rate for all functions of at least 99.95%. This is equivalent to a total downtime of approximately 4 hours per year for the System.

1.6 DELIVERY, STORAGE, AND HANDLING - NOT USED

1.7 SITE CONDITIONS - NOT USED

1.8 WARRANTY - NOT USED

PART 2 - PRODUCTS - NOT USED

PART 3 - EXECUTION

3.1 STARTUP PERSONNEL REQUIREMENTS:

- A. During the start-up phase, the Control System Integrator shall provide a minimum of 2 people on site full-time.
- B. OWNER will provide personnel in the control room (dedicated to testing activities), and other personnel in the field to support installation and testing activities, such as to observe and inspect the work associated with installation of the PLC's and assisting with end-to-end and control software tests.
- C. ENGINEER will provide testing support as required.

3.2 TESTING GENERAL

- A. Confirmation of an operational control system is dependent upon results obtained through the testing activities specified in this section. All equipment furnished shall be tested at the factory prior to shipment to the project site and at the project site as specified herein. Unless otherwise specified in the individual specification sections, all equipment provided shall be tested at the factory and at the project site as a single fully integrated system.
- B. The Control System Integrator shall formally notify the OWNER and ENGINEER in writing through the project administration web site of their intent to commence each phase of testing, witnessed and un-witnessed, specified herein. Testing shall not be permitted to proceed unless the OWNER and ENGINEER confirm all required submittals anticipated up to that point in the construction activities have been received by the OWNER and ENGINEER and favorably reviewed.

- C. All witnessed testing dates shall be scheduled with the OWNER and ENGINEER.
- D. At a minimum, the testing shall include the following:
 - 1. Un-witnessed Factory Test (UFT)
 - 2. System Integration Test (SIT)
 - 3. Factory Acceptance Test (FAT)
 - 4. Operational Readiness Test (ORT)
 - 5. Functional Demonstration Test (FDT)
 - 6. 30-day Site Acceptance Test (SAT)
- E. Each test shall be in the cause and effect format. The individual conducting the test shall initiate an input (cause) and, upon the system's or subsystem's producing the correct result (effect), the specific test requirement will be deemed to have been satisfied.
- F. The Control System Integrator shall provide all special testing materials and equipment. Wherever possible, perform tests using actual process variables, equipment, and data. Where it is not practical to test with real process variables, equipment, and data, provide a suitable means of simulation. These simulation techniques shall be defined in the test procedures.
- G. The Control System Integrator shall coordinate all required testing with the General CONTRACTOR, all affected subcontractors, the ENGINEER, and the OWNER.
- H. The Control System Integrator shall furnish the services of field service engineers, all special calibration and test equipment, and labor necessary to perform the field tests.
- I. All tests shall be conducted in accordance with approved (by ENGINEER and OWNER) procedures, forms, and checklists as submitted in accordance with the requirements of Section 40 61 00 - Instrument and Control Systems General Provisions.
- J. Each test to be performed shall be described and a space shall be provided after the description for sign-off by the appropriate parties after its satisfactory completion. Include punch list forms with the test procedures to document issues that arise during the testing. Punch list forms, at a minimum, shall include a specification cross reference; an issue description field; a resolution description field; and a sign-off area for the Control System Integrator, OWNER, and ENGINEER.
- K. Copies of the signed-off test procedures, forms, checklists and other documents required herein shall constitute the required testing documentation. The test result forms shall be submitted to the ENGINEER for approval within 10 days of completion of each test.
- L. The ENGINEER reserves the right to test or retest all specified functions, whether or not explicitly stated on the Test Procedures, as required, to determine compliance with the functional requirements of the overall system. This testing, if necessary, to determine compliance with the specified requirements, shall be performed at no additional cost to the OWNER. The ENGINEER's decision shall be final regarding the acceptability and completeness of all testing.
- M. No equipment shall be shipped to the project site until the ENGINEER and OWNER have received all test results and other documentation of successful factory testing and given approval that the system is ready for shipment.

N. Correction of Deficiencies

1. All deficiencies in workmanship and items not meeting specified testing requirements shall be corrected to meet specified requirements at no additional cost to the OWNER.
2. Testing, as specified herein, shall be repeated after correction of deficiencies until the specified requirements are met. This work shall be performed at no additional cost to the OWNER.

3.3 FACTORY TESTING UN-WITNESSED FACTORY TEST (UFT)

- A. Prior to shipment of the equipment, the entire system, except primary elements, final control elements, and field-mounted transmitters, shall be interconnected and tested to ensure the system will operate as specified. All analog and discrete input/output points not interconnected at this time shall be simulated to ensure proper operation of all alarms, monitoring devices/functions, and control devices/functions.
- B. All panels, consoles, and assemblies shall be inspected and tested to verify their conformance with related submittals, Specifications, and Drawings.
- C. During the tests, all digital system hardware and software shall be operated for at least five days continuously without a failure to verify the system is capable of continuous operation.
- D. Tests to be performed shall include, but not be limited to, the following. Each of these tests shall be specifically addressed in the Test Procedure submittal.
 1. All panels and enclosures being provided shall undergo a thorough inspection to verify the integrity of the cabinet enclosures, frame structures, paint work and finish, etc. Additionally, the Control System Integrator shall review the panel drawings with the OWNER and/or ENGINEER to ensure they accurately reflect the panel layout and wiring.
 2. Panel wire pull tests shall be performed on all wiring to ensure all wiring has been connected to the appropriate torque to prevent wires from coming loose.
 3. For panels provided in new enclosures, heat loading tests shall be performed to ensure proper cooling and ventilation is being provided.
 4. UPSs shall be tested with all equipment connected to verify the UPSs have been sized correctly to maintain the specified run time.
 5. An I/O point checkout of at least 50% of each I/O module shall be performed to verify proper operation of the input/output points. The verification of the signals will be accomplished via the use of the PLC programming software. At a minimum, the I/O checkout shall consist of four steps.
 - a. Digital input signals shall be temporarily connected within the termination connections of the PLC panels and verification of proper alarming, statuses, etc., shall be performed utilizing the tools available in the PLC programming software.
 - b. Analog input signals shall be connected to a signal generator at the termination connections and signals shall be verified at zero%, 25%, 50%, 75%, and 100% of full scale. The appropriate scaled value shall be verified utilizing the tools available in the PLC programming software.
 - c. Digital output signals shall be initiated by the user by writing to the signals

utilizing the PLC programming software. Verification shall occur in the PLC panel by connecting a digital multi-meter to measure the continuity at the terminations, thus verifying the command from the PLC has properly executed the contact closure.

- d. Analog output signals shall be initiated by the user by writing to the signals utilizing the PLC programming software. Verification shall occur in the PLC panel by utilizing a digital multi-meter to measure the current/voltage generated at the termination points.
- E. All control panels provided or modified under the related sections of Division 40 shall be included in these tests.
- F. Upon successful completion of the UFT, the Control System Integrator shall submit a copy of the test results to the OWNER and ENGINEER.

3.4 FACTORY TESTING SYSTEM INTEGRATION TEST (SIT)

- A. The SIT shall be conducted a minimum of 3 weeks before the Factory Acceptance Test. The test shall be an un-witnessed test, and the Control System Integrator shall include time within his construction schedule for this test.
- B. The purpose of the SIT is to allow the Control System Integrator to verify the functionality, performance, and stability of the hardware and software as a complete integrated system prior to the FAT. The Control System Integrator will load the application software on the PLCs, control system servers, and historian server. The entire system will then be tested. All process control strategies shall be simulated to ensure proper operation.
- C. The Control System Integrator shall utilize the approved test procedures to conduct the testing and document the results.
- D. Minimum testing to be performed during the SIT shall include, but not be limited to, the following:
 - 1. Verification of proper scanning, communication, and complete data acquisition of the entire system
 - 2. Verification of all redundant functionality of components
 - 3. Verification of proper power failure recovery
 - 4. Verification of proper indication for communication error issues
 - 5. A complete I/O point checkout shall be performed to verify proper operation of each input/output point. The I/O checkout shall consist of four steps.
 - a. Digital input signals shall be jumpered within the termination connections of the PLC panels and verification of proper alarming, statuses, etc., shall be performed at the HMI.
 - b. Analog input signals shall be connected to a signal generator at the termination connections and signals shall be verified at zero%, 25%, 50%, 75%, and 100% of full scale. The appropriate scaled value shall be verified at the HMI. Simultaneously, verification of alarming shall occur. The alarming verification shall, at a minimum, include High High, High, Low, Low Low, Rate of Change, and Alarm Deadband.
 - c. Digital output signals shall be initiated by the user from the HMI system.

Verification shall occur within the PLC panel by connecting a digital multi-meter to measure the continuity at the terminations, thus verifying the command from the PLC has properly executed the contact closure.

- d. Analog output signals shall be initiated by the user from the HMI system. Verification shall occur in the PLC panel by utilizing a digital multi-meter to measure the current/voltage generated at the termination points.
- E. Upon successful completion of the SIT, the Control System Integrator shall submit a copy of the test results to the OWNER and ENGINEER and request the scheduling of the FAT as specified herein.

3.5 FACTORY TESTING FACTORY ACCEPTANCE TEST (FAT)

- A. The Control System Integrator shall plan for a Functional Acceptance Test to last for at least five working days.
- B. The purpose of the FAT is to verify the functionality, performance, and stability of the hardware and software. The system shall operate continuously throughout the FAT without failure, except where initiated in accordance with the established test procedures. Any unanticipated failures during the FAT may, at the OWNER and/or ENGINEER's discretion, result in the FAT being deemed unsuccessful. Successful completion of the FAT, as determined by the OWNER and ENGINEER, shall be the basis for approval of the system to be shipped to the project site.
- C. The FAT shall be performed by the Control System Integrator conducted at the Control System Integrator's facility. All system tests performed and specified for the UFT and the SIT shall be repeated in the presence of the ENGINEER and OWNER at the FAT.
- D. The Control System Integrator shall notify the ENGINEER and OWNER in writing that the system is ready for the FAT. The ENGINEER and OWNER shall schedule a test date within 14 days of receipt of notification. At the time of notification, the Control System Integrator shall submit any revisions to the detailed test procedures previously approved by the ENGINEER and OWNER.
- E. The various tests performed during the FAT shall be designed to demonstrate that hardware and software fulfill all the requirements of the Contract Documents. The test conditions shall resemble, as closely as possible, the actual installed conditions. Any additional hardware or software that may be required to successfully verify system operation shall be supplied at no cost to the OWNER.
- F. Tests to be performed during the FAT shall include, but not be limited to, the following:
 - 1. A system audit to verify all components have been staged for the test
 - 2. Inspection of the system inventory to verify all components have been documented properly with correct model numbers, serial numbers, etc.
 - 3. For each hardware enclosure, inspection shall include, but not be limited to, enclosures, frame structure, paint work and finish, dimensions, and hardware operability (i.e., fans, door hinges, keylocks, etc.).
 - 4. For each subpanel, inspection shall include, but not be limited to, I/O subsystem physical layout, power supply sizing and mounting, cable routing, wire runs across hinges properly installed, fans and blowers unobstructed and mounted to maximize air flow, power conditioning correctly installed, and overall layout and installation of

components meets manufacturer's recommendations and standard industry-accepted practices.

5. Demonstration of operability of all equipment
 6. 100% point check of I/O, including wiring. Analog signals shall include verification of zero%, 25%, 50%, 75%, and 100% of scale. Additionally, out of range testing (over and under scale) shall be accomplished.
 7. Demonstration of the ability to monitor and change at least 20 pieces of digital and analog data in each PLC from the HMI software at all operator workstations
 8. Demonstration of the ability to share data between operator workstations and servers
 9. Demonstration of the ability of each workstation to print reports on all designated network report printers.
 10. Demonstration of the ability for each workstation to read and write to and from designated files from other workstations on the network
 11. Demonstration of the operability of all mass storage equipment
 12. Demonstration of communication failure and system restart
 13. Demonstration of total power failure and recovery (the UPS shall be removed for this test)
 14. Demonstration of the failover capabilities of all redundant components
 15. Demonstration of the ability of the UPSs to meet the runtime requirements upon loss of power
 16. Demonstration of logical failure conditions for control strategies (i.e., instrument failures, equipment failures, loss of communication between the I/O Server and the controller, loss of peer-to-peer communication, etc.)
- G. During the test, for a period of time equal to at least 20% of the test duration, the ENGINEER's and OWNER's representative shall have unrestricted access to the system to perform any additional testing desired or to re-test any previously tested components.
- H. All analog control panels shall be included in these tests.
- I. All deficiencies identified during these tests shall be corrected and re-tested prior to completing the FAT as determined by the OWNER and ENGINEER.
- J. The following documentation shall be made available to the ENGINEER and OWNER at the test site both before and during the FAT:
1. All Contract Documents, addenda, and change orders
 2. Master copy of the Test Procedures
 3. Bill of Material for all hardware and software to be tested, including make, model, and serial number
 4. Design-related Hardware Submittal applicable to the equipment being tested
 5. Software Licenses
 6. Software Documentation Submittal
- K. The daily schedule during the test shall be as follows:
1. Morning meeting to review the day's test schedule
 2. Scheduled tests and sign-offs

3. End of day meeting to review the day's test results and to review or revise the next day's test schedule
 4. Unstructured testing period by the witnesses
- L. All test data and procedures followed during testing shall be logged, and certified copies of the logs shall be provided to the ENGINEER and OWNER.

3.6 FIELD TESTING OPERATIONAL READINESS TEST (ORT)

- A. Following installation of the process control system components and prior to startup and the Functional Demonstration Test, the entire system shall be certified (inspected, wired, calibrated, tested, etc., and documented) that it is installed and ready for the FDT as defined below.
- B. Loop/Component Inspections and Tests: the entire system shall be checked for proper installation, calibrated, and adjusted on a loop-by-loop and component-by-component basis to ensure that it is in conformance with related approved submittals and these Specifications.
- C. The Loop/Component Inspections and Tests shall be implemented using ENGINEER-approved forms and checklists. Each loop shall have a Loop Status Report to organize and track its inspection, adjustment, and calibration. These reports shall include, at a minimum, the following information and check-off items with spaces for sign-off by the system supplier:
 1. Project Name, Test Date, Control System Integrator Name, and Lead Control System Integrator Technician Name
 2. Loop Number.
 3. Tag for each component.
 4. Check-offs/sign-offs for each component: Tag; installation; termination (wiring and tubing); scale, range, and setpoint as applicable; and calibration/ adjustment (four-point for analog, set point for switches) rising and falling.
 5. Check-offs/sign-offs for the loop: Panel interface terminations; I/O interface terminations; I/O signal operation; inputs/outputs operational (received/sent, processed, adjusted); total loop operation; process controller scaling and adjustment; and space for comments.
 6. Each active Analog Subsystem element and each I/O module shall have a Component Calibration Sheet. These sheets shall have the following information, spaces for data entry, and a space for sign-off by the Control System Integrator.
 - a. Project Name
 - b. Loop Number
 - c. Component Tag Number of I/O Module Number
 - d. Component Code Number Analog System
 - e. manufacturer (for Analog system element)
 - f. Model Number/Serial Number (for Analog system)
 - g. Summary of functional requirements shall include, but not be limited to, scale and chart ranges of indicators, recorders, and transmitters/converters; functions of computing elements; and parameters of controllers (i.e.,

- proportional, integral, derivative, reverse/forward acting, etc.)
- h. Calibrations shall include testing of analog input and output signals at zero, 10, 50, and 100% of span. Where appropriate, discrete input signals shall include details regarding actual trip points and reset points.
 - i. Space for comments
 - j. Space for sign-off by the Control System Integrator
- D. The Control System Integrator shall maintain the Loop Status Reports at the job site and make them available to the ENGINEER and OWNER at any time.
 - E. These inspections, calibrations, and tests do not require witnessing, however, the OWNER and ENGINEER reserve the right to witness as they deem necessary. The OWNER and ENGINEER may, at their discretion, review Loop Status Reports and spot check the test process periodically. Any deficiencies found shall be corrected by the Control System Integrator prior to commencement of the FDT.
 - F. Prior to checkout of the I/O to the HMI, the Control System Integrator shall thoroughly test all I/O from the field device to the PLC terminals, and verify the PLC is powered up and the PLC is communicating to the HMI servers. After the Control System Integrator has successfully tested all I/O from the field devices to the PLC terminals, the Control System Integrator test all I/O from the HMI to the field device. Should this test prove to be unsuccessful, the Control System Integrator and
 - G. Control System Integrator shall test from the HMI to the terminations located in the OWNER's termination cabinet, and the Control System Integrator shall inform the OWNER in writing of the discrepancy with the existing field wire.
 - H. Remote Manual start/stop, open/close commands of all devices controlled by the control system shall be verified by the Control System Integrator during the ORT.
 - I. For all panels with enclosures (new and existing) modified by this contract, heat load tests shall be performed to ensure proper cooling/ventilation is being provided.
 - J. Upon successful completion of the ORT, the Control System Integrator shall submit a record copy of the test results to the OWNER and ENGINEER and request the scheduling of the FDT as noted in the following section.

3.7 FIELD TESTING FUNCTIONAL DEMONSTRATION TEST (FDT)

- A. Prior to the 30-day Site Acceptance Test(s), the entire installed instrument and control system shall be certified that it is ready for operation. All preliminary testing, inspection, and calibration shall be complete as defined in the ORT.
- B. Once a process area has been started up and is operating, a witnessed FDT shall be performed on that system to demonstrate that it is operating and is in compliance with these Specifications. A witnessed FDT shall be performed on each process area. Each specified function shall be demonstrated on a paragraph-by-paragraph, loop-by-loop, and site-by-site basis.
- C. Loop-specific and non-loop-specific tests shall be conducted in the same manner as specified under FAT, except that the entire installed system shall be tested and all functions demonstrated using live field data to the greatest extent possible.

- D. Updated versions of the documentation specified to be provided for during the factory tests shall be made available to the ENGINEER at the job site both before and during the tests. In addition, one copy of all O&M Manuals shall be available for reference at the job site, both before and during testing.
- E. The daily schedule specified to be followed during the factory tests shall also be followed during the FDT.
- F. During the FDT, a demonstration of communication failure and recovery shall be accomplished. This test shall be scheduled and coordinated with OWNER's personnel to minimize the impact on plant operations.
- G. Following initial startup, the entire process control system shall operate for a continuous 100 hours without failure before this test will be started.
- H. Punch list items and resolutions noted during the test shall be documented on the Punch list form. In the event of rejection of any part or function test procedure, perform repairs, replacement, and/or retest within 10 days.
- I. Upon successful completion of the FDT, the Control System Integrator shall submit a copy of the test results to the OWNER and ENGINEER and request the scheduling of the SAT as noted in the following section.

3.8 FIELD TESTING 30-DAY SITE ACCEPTANCE TEST (SAT)

- A. After completion of the Operational Readiness and Functional Demonstration Tests, the system shall undergo a 30-day Site Acceptance Test (SAT), under conditions of full plant process operation, without a single non-field-repairable malfunction.
- B. During this test, plant operations and Control System Integrator personnel shall be present as required to address any potential issues that would impact the overall system operation. Provide personnel for this test who have an intimate knowledge of the hardware and software of the system. When not on site, provide cell phone/pager numbers that the OWNER personnel can use to ensure that support staff is available by phone and/or on site within four hours of a request by operations staff.
- C. While this test is proceeding, the ENGINEER and OWNER shall have full use of the system. Only plant operating personnel shall be allowed to operate equipment associated with live plant processes. Plant operations shall remain the responsibility of OWNER and the decision of plant operators regarding plant operations shall be final.
- D. Any malfunction during the tests shall be analyzed, documented and corrected. The ENGINEER and/or OWNER will determine whether any such malfunctions are sufficiently serious to warrant a repeat of this test.
- E. Any malfunction during this 30-consecutive-day test period which cannot be corrected within 24 hours of occurrence, or more than two similar failures of any duration, will be considered as a non-field-repairable malfunction. Upon completion of repairs, the SAT will be re-started from the date on which the malfunction(s) were successfully corrected, and the OWNER and ENGINEER had accepted and signed off on the repairs.
- F. In the event of rejection of any part or function, perform repairs or replacement within 10 days.
- G. All database, process controller logic, and graphical interface system errors must be

functioning as required per the specifications prior to the start of each test period. The 30-day test will not be considered successful until all data base points and logic functions are tested and verified to be correct.

- H. The total availability of the system shall be greater than 99.5% during this test period. Availability shall be defined as follows:

Availability in percent = $100 * (\text{Total Testing Time} - \text{Down Time}) / \text{Total Testing Time}$

- I. Down times due to power outages or other factors outside the normal protection devices or backup power supplies provided shall not contribute to the availability test times above.
- J. A failure is the inability of a component to perform its function regardless of the cause or severity of the failure.
- K. Failures may range in severity from loss of a single keyboard contact, to inoperability of a workstation or print device, to complete inoperability.
- L. Failures may be caused by hardware or software faults. Software faults will be charged against the appropriate hardware component.
- M. Failures may be continuous or intermittent. An intermittent failure is a failure that occurs and then disappears before corrective maintenance can be completed. Examples of intermittent failures include, but are not limited to, the following:
 - 1. Communication errors caused by defective master station equipment.
 - 2. "Sticky" keyboard contacts.
 - 3. Peripheral device errors
 - 4. Operating system errors
- N. Downtime is the period of time between notification that a failure has occurred and notification that repair has been completed.
 - 1. For intermittent failures, downtime is the accumulation of the greater of the actual duration of each intermittent failure or 15 min. per occurrence. This accumulation starts at failure modification and ends at repair complete notification, subject to verification of the repair by the OWNER.
 - 2. Verify the end of downtime by testing repairs.
- O. A component is any equipment that is consistent in nature and function as those specified. Component examples include, but are not limited to, operation workstations, PLCs, disk drives, the master station computers, printers, data network, modems and similar hardware.
- P. Availability is the fraction of operating time a component is capable of performing its intended function.
- Q. A PLC unit is considered down and downtime will be recorded upon occurrence of any of the following:
 - 1. Errors in data translation
 - 2. Loss of numerical data
 - 3. Failure to perform logic

- R. Throughout the duration of the 30-day SAT, no software or hardware modifications shall be made to the system without prior approval from the OWNER and ENGINEER.
- S. Upon successful completion of the 30-day operation test and subsequent review and approval of complete system final documentation, the system shall be considered substantially complete and the warranty period shall commence.
- T. Certification of Installation: Following successful completion of the 30-day test, issue a Certification of Installation. Certification shall be on corporate letterhead and signed by an officer of the firm. Certification shall state that the process control system has been completed in conformance with plans and specifications. Certification shall be submitted to the ENGINEER as specified herein.
- U. Work Scope: Provide engineering, furnishing, installing, PLC programming, calibrating, adjusting, testing, documenting, starting up, training, and all related activities required for a complete Control System for the Project.

END OF SECTION

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SECTION 40 61 93
CONTROL SYSTEM INPUT/OUTPUT LIST

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Input-Output lists.
- B. System Requirements
 - 1. Provide and install the hardware required for the monitoring and control of the Input/Output subsystem.
- C. Related Sections include but are not necessarily limited to:
 - 1. Division 00 - Procurement and Contracting Requirements.
 - 2. Division 01 - General Requirements.
 - 3. Section 40 63 43 - Programmable Logic Controllers (PLCs)
 - 4. Section 40 61 96 - Control System Configuration

1.2 REFERENCES

- A. Refer to Section 40 61 01 - Instrumentation and Control System Abbreviations and References. In case of conflict between the requirements of this Section and those of the listed standards, the requirements of this Section shall prevail.

1.3 ADMINISTRATIVE REQUIREMENTS - NOT USED

1.4 SUBMITTALS

- A. Input/Output (I/O) List Submittal
 - 1. Submit a complete system Input/Output (I/O) address list for equipment connected to the control system under this Contract.
 - 2. I/O list shall be based on the P&ID's, the Drawings, the design I/O list (if included), and requirements in the Specifications.
 - 3. The I/O list shall be submitted in both a Microsoft Excel readable electronic file format and an 8 1/2 inch by 11 inch hard copy.
 - 4. The I/O list shall reflect all active and spare I/O points. Add points to accommodate spare I/O as required in the specifications.
 - 5. The I/O list shall be arranged such that each control panel has a dedicated worksheet. At a minimum, I/O worksheet shall include the following information:
 - a. TAG NUMBER(S): As indicated on the drawings, the identifier assigned to a device that performs a function in the control system. As part of this information, the loop number of the tag shall be broken out to allow for sorting by loop.
 - b. DESCRIPTION: A description of the function of the device (text that includes signal source, control function, etc.) Include the text "Spare Points" for all I/O module points that are not connected to equipment.
 - c. PHYSICAL LOCATION: The Control Panel designation of where the I/O point is

- wired to.
 - d. Physical POINT ADDRESS: Rack, Slot, and Point (or Channel) assignment for each I/O point.
 - e. I/O TYPE: use DO - Discrete Output, DI - Discrete Input, AO - Analog Output, AI - Analog Input, PI - Pulse Input, or PO – Pulse Output.
 - f. RANGE/STATE: The range in engineering units corresponding to an analog 4-20 mA signal, or, the state at which the value of the discrete points are "1."
 - g. ENGINEERING UNITS: The engineering units associated with the Analog I/O.
 - h. ALARM LIMITS: Include alarm limits based on the control descriptions and the Drawings.
 - i. P&ID – the P&ID or drawing where the I/O point appears on. Mark as "NA" (Not Applicable) if the I/O point is derived from a specification requirement and is not on the P&IDs.
- 6. The I/O list shall be sorted in order by:
 - a. Physical location
 - b. I/O Type
 - c. Loop Number
 - d. Device Tag
 - 7. Once the I/O list is approved, the PLC I/O addresses shall not be modified without approval by the ENGINEER.

1.5 QUALITY ASSURANCE - NOT USED

1.6 DELIVERY, STORAGE, AND HANDLING - NOT USED

1.7 SITE CONDITIONS - NOT USED

1.8 WARRANTY - NOT USED

PART 2 - PRODUCTS

2.1 INPUT/OUTPUT LIST REQUIREMENTS

- A. The Input/Output list shall contain all configuration items of the point and shall be capable of being imported and exported into the system via an Excel spread sheet.

PART 3 - EXECUTION

3.1 INPUT/OUTPUT LIST

- A. The preliminary Input/Output list for each system PLC is available on engineering drawing E-007

END OF SECTION

SECTION 40 61 96
CONTROL SYSTEM CONFIGURATION

PART 1 - GENERAL

1.1 SUMMARY

- A. Provide and install instrumentation system for monitoring and control of the PFAS treatment plant system as described herein, and as indicated on the Plans. Control Narratives of the system process have been provided.
- B. All Programmable Logic Controller (PLC) programming and Operator Interface Terminal (OIT)
- C. Hardware components, equipment, and related items for the instrumentation system shall be as indicated on the Plans and Specifications.
- D. Monitoring and control of various functions of this plant comprise of control narratives as described in this Section, with a description of instruments and related items given in other sections of the specifications and as shown on the drawings. The following description is brief for the purpose of understanding the control philosophy only. Important loops have been described; for the remaining loops, refer to plans and other sections of the Specifications.
- E. Related Sections include but are not necessarily limited to:
 - 1. Division 00 - Procurement and Contracting Requirements.
 - 2. Division 01 - General Requirements.

1.2 REFERENCES

- A. Refer to Section 40 61 01 - Instrumentation and Control System Abbreviations and References. In case of conflict between the requirements of this Section and those of the listed standards, the requirements of this Section shall prevail.

1.3 ADMINISTRATIVE REQUIREMENTS - NOT USED

1.4 SUBMITTALS

- A. General Requirements
 - 1. Comply with the submittal requirements of Section 01 31 00 - Project Management and Coordination, Section 40 61 00 - Instrumentation and Control System General Provisions, and as described below.
 - 2. Submittals require information on related programming to be furnished under this Section. Incomplete submittals not containing the required information on the related equipment will be returned un-reviewed.
 - 3. Control Strategy shall be submitted for each individual remote site with related Logic Flow Chart fully indicating all logic steps as defined herein and as required to fully implement all functionality as described in the contract documents.
- B. Submittal Content
 - 1. The Control System Integrator shall create shop drawings, including all logic flow charts and diagrams, in the Control System Integrator's Engineering Department. All shop drawings shall bear the Control System Integrator's logo, drawing file numbers,

and shall be maintained on file in the Control System Integrator's archive file system. Photocopies or electronically created copies of the ENGINEER's Diagrams or specifications are unacceptable as shop drawings and shall be returned un-reviewed.

C. Required Submittals

1. All work described herein shall be incorporated into a work plan submittal as defined in Related Work sections.
2. Shop Drawings
 - a. Shop Drawings shall include the following:
 - 1) A Communication Memory Map shall be submitted and include specific Tag Names, Data type, expected range, and register. A separate map for any data concentrator and PLC for each remote site shall be submitted, if applicable. These Maps shall fully document all communications in and out of the remote site and these communications shall be as further defined herein.
 - b. Data Communications Interconnecting Diagrams
 - 1) Provide interconnecting diagrams showing Data connections between equipment and include the Requester and the rate at which the data will be transmitted.
3. Factory Tests.
 - a. Submittals shall be per testing as specified in Section 40 61 21 - Instrumentation and Control System Testing and Commissioning.
4. Site Tests and Commissioning.
 - a. Submittals shall be per testing and commissioning as specified in Section 40 61 21 - Instrumentation and Control System Testing and Commissioning.
5. Operation and Maintenance Manuals.
 - a. Operation and maintenance manuals shall be as specified in Section 40 61 00 - Instrumentation and Control System General Provisions.

1.5 QUALITY ASSURANCE - NOT USED

1.6 DELIVERY, STORAGE, AND HANDLING - NOT USED

1.7 SITE CONDITIONS - NOT USED

1.8 WARRANTY - NOT USED

PART 2 - PRODUCTS

2.1 DEVELOPMENT OF CONTROL STRATEGY

A. General

1. Control Strategies and Process Instrumentation Diagrams (PIDs) have been developed by the ENGINEER. These briefs and PIDs outline the basic requirements for controlling the process. The guidelines will be utilized on the project, but they do not outline the detail control requirements or understanding of the process automation. These Control Strategies will need to be developed further and a mutual understanding of

the control process will need to be agreed upon by the ENGINEER, Control System Integrator, and the OWNER. The following workshops will be held;

2. HMI workshops

- a. Schedule two (2) mandatory workshops with the OWNER/ENGINEER to discuss development of the graphic screens.
- b. Discussion shall follow guidelines from ANSI/ISA-101.01-2015 (Human Machine Interfaces for Process Automation Systems). Two weeks before scheduling the first workshop, the Control System Integrator shall purchase and download this document from the ISA website and submit this document to the OWNER for review in preparation of the first workshop.
- c. Prior to the first workshop, the Control System Integrator shall arrange a meeting with OWNER to obtain all existing graphic files that require duplication, if applicable. The Control System Integrator shall use these existing graphics as the basis for generating new and improved screens.
- d. The purpose of the first workshop shall be focused on screen duplication and shall be as follows:
 - 1) Review existing graphic standards or Control System Integrator standards
 - 2) Review existing HMI guidelines or Control System Integrator guidelines for various display types such as overviews, system overview, trends, popups, alarming, equipment control, navigation, information density, etc.
 - 3) Graphic symbol library to be used on the graphics
 - 4) Navigation convention, color usage convention, font type, size, etc.
 - 5) Conventions for displaying alarms, device status, process variables.
 - 6) Alarm acknowledgment, alarm color, background color, etc.
 - 7) Conventions for naming and identifying devices
 - 8) General guidelines for layout of overview graphics, typical unit process graphics, typical content, and information density of graphics for both HMI and OIT's.
 - 9) Analog popups and equipment control popups
 - 10) Usage of trends in various sections of each main graphics
- e. Submittal Requirements: The items discussed during the first workshop shall be used to generate the Standard HMI Screens Submittal. This submittal shall be successfully reviewed prior to scheduling the second workshop.
- f. The second workshop shall be scheduled after submitting the graphics submittal based on topics discussed during the first and second workshops. The purpose of the second workshop is for the OWNER to communicate comments to address any concerns for the Control System Integrator to finalize the graphics submittal.

3. PLC code standardization and development workshops

- a. Schedule two (2) mandatory workshops with the OWNER/ENGINEER to discuss development of the new PLC program. The initial workshop shall be conducted to discuss monitor and control templates (objects) which will be used as the basic building blocks for comprehensive control strategy development. No control strategy development shall be performed prior to completion of

- template development with submittal approved by the OWNER/ENGINEER.
- b. The purpose of the initial workshop is for the Control System Integrator to:
 - 1) Present how the new PLC's native Function Blocks will be implemented.
 - 2) Solicit OWNER preference on a specific type of IEC language used or a combination thereof.
 - 3) Present how the PLC's alarms will be processed and time/date stamp will be implemented. All analog alarm limits shall be programmed in the PLC.
 - 4) Present Communication protocol used to communicate with the HMI.
 - 5) Present how IEC61131 programming languages will be implemented.
 - 6) Present any custom User-Defined Function Blocks (UDFBs) will be used for monitoring and control.
 - 7) Present PLC programming standards to be implemented to meet the functional requirements.
 - c. Submittal Requirements: The items discussed during the first workshop shall be used to generate the PLC Code Standardization Submittal.
 - d. A second workshop shall be scheduled 10 business days after submitting the PLC code standardization submittal. The purpose of the second workshop is for the Control System Integrator to present the proposed PLC programming methodology and address any OWNER concerns or comments. All comments shall be incorporated into the re-submittal for approval.
4. Control Strategy Development and I/O Database Workshops
- a. Schedule three (3) mandatory workshops with the OWNER/ENGINEER to discuss development and modification to existing control strategy and database specific to PLC at each remote station. The existing tag I/O database shall be retained as much as practical.
 - b. During the initial site visit, the Control System Integrator shall download the PLC program at each existing PLC, if applicable, analyze the PLC code, and translate the PLC code into a new draft version of the control narrative to be submitted for review. The Control System Integrator shall then schedule a workshop to discuss the field I/O list, monitoring and control aspects of each remote station.
 - c. The purpose of the first workshop is related to field I/O database and to:
 - 1) Review OWNER's guidelines and/or standards documents.
 - 2) Review existing tag naming convention
 - 3) Discuss any revision to the I/O database
 - 4) Discuss naming convention for pseudo I/O points such as equipment start/stop request, runtime, no. of starts, flow totals, alarms, etc.
 - 5) Other database related topics
 - d. Submittal Requirements: The items discussed during the first workshop (Field I/O Database) shall be used to generate the I/O database submittal. This submittal shall include field I/O for all remote sites.
 - e. The purpose of the second workshop is related to control strategy and to:
 - 1) Ensure Control System Integrator's understands the monitoring and control function of each remote site.

- 2) Review the Control System Integrator's approach to programming the new PLC to ensure all existing monitoring and control functionalities are retained or enhanced.
 - 3) Present to the OWNER/ENGINEER sample PLC programs, methodology, program documentation, any User-defined blocks to be used in conjunction with standard blocks used in control strategy generation.
 - 4) Present memory map address ranges for specific input and output functions.
 - 5) Other related topics
- f. Submittal Requirements: The items discussed during the second workshop (Control Strategy) shall be used to generate the Control Strategy submittal. This submittal shall include control strategy for each individual remote site.
 - g. The Control System Integrator shall incorporate all comments provided by OWNER into the Field I/O database and Control Strategy submittals and submit them for OWNER/ENGINEER review and then schedule a third workshop with the OWNER/ENGINEER to finalize the control strategy and I/O database for each remote station.
5. Reports and Contents Workshop
 - a. Schedule two (2) mandatory workshops with the OWNER/ENGINEER to discuss development of the reports. The purpose of the reports workshops is to:
 - a) Discuss all existing reports required in the new SCADA HMI.
 - b) Discuss all existing reports required modifications and any new reports needed.
 - c) Discuss layouts for daily, monthly, and yearly reports.
 - d) Discuss report formatting.
 - e) General guidelines for format of typical reports, the guidelines will establish the typical content and information of each report.
 - f) Develop a list of reports to be generated.
 - g) Discuss methodology on Daylight Savings and leap year to be automatically built into each report.
 - h) Other topics related to reports generation.
 - 2) It is anticipated there will be ten (10) reports to be developed. Out of those reports, seven (7) reports will be medium complexity and three (3) reports will be complex. Medium complexity report is defined as up to two (2) standard 8 1/2x11 inch pages. Complex report is defined as up to five (5) standard 8 1/2x11 inch pages.
 - 3) Submittal Requirements: The items discussed during the first reports workshop shall be used to generate the Reports and Contents submittal.
 - 4) A second workshop shall be scheduled after submitting the Reports submittal. The purpose of the second workshop is for the Control System Integrator to present the proposed reports generation methodology and address any OWNER concerns or comments. All comments shall be incorporated into the re-submittal for approval.

2.2 PROGRAMMING/CONFIGURATION REQUIREMENTS

A. General Requirements

1. All PLC programming and HMI configuration shall be performed in accordance with control narratives. All calculations, totalizations, lead/lag control and sequencing needed for the PLC programs shall be accomplished at the PLC level.
2. All time synchronization logic, PLC heartbeats, shall be performed at the PLC level. Other PLC health status such as I/O, PLC Run, Halt, Failure, low battery, etc. shall be read from the PLC.
3. All analog I/O points and related values shall be scaled within the PLC, at each remote station, to an IEEE 32-bit floating point value and displayed at the HMI systems.

B. Alarms

1. Physical Input Alarms

- a. Physical input alarms shall be used to control strategies and shall be transmitted for the HMI annunciation and required action. When a physical alarm used in control strategy prevents an action from occurring, the alarm must be cleared and acknowledged at the HMI for the equipment to be controlled from the PLC again.

2. PLC Generated Alarms

a. Discrepancy

- 1) When control system controlled equipment are requested to start/stop, open/close, change speed, etc. a discrepancy timer (timer length to be individually programmed at the PLC for each piece of equipment) shall begin in the PLC upon request of action. If the discrepancy timer expires before reaching the commanded state, a discrepancy alarm shall be generated at the PLC and an alarm signal shall be provided to the HMI. The HMI shall process this alarm in the same manner as a physical alarm. The operator shall reset this alarm in the PLC only at the HMI. The equipment remains not available to the control strategy until the alarm is reset.

b. Deviation

- 1) When control system controlled equipment (in control system controlled mode) changes state (start/stop, open/close, etc.) without control system command, a deviation alarm shall be generated at the PLC and an alarm signal shall be provided to the HMI. The HMI shall process this alarm in the same manner as a physical alarm. The operator shall reset this alarm in the PLC only at the HMI. The equipment remains not available to the control strategy until the alarm is reset.
- 2) When locally controlled (On/Off selector switch) equipment has been placed in the "ON" position (True) and the unit is not running "RUN STATUS" (False), after a time delay, a deviation alarm shall be generated at the PLC and an alarm signal shall be provided to the OIT. The OIT shall process this alarm in the same manner as a physical alarm. The operator shall reset this alarm only at the HMI.

c. Out of Range

- 1) Analog inputs shall be configured for 4-20 mA, and all transmitters and

equipment shall be configured for 4-20 mA. For readings below 3.9 mA, the PLC shall be configured to report the value of the transmitter or equipment as minimum and the PLC shall generate an alarm signal to the OIT. The analog value's color and symbol shall be changed to bright yellow upon out-of-range alarm. The operator shall reset this alarm only at the HMI. The PLC shall utilize an average of the last minute of readings for any logic involving the signal.

d. System Alarms

- 1) The PLC and Network Equipment shall be capable of generating alarms. The alarms shall be transmitted to the HMI for acknowledgement and action. Types of alarms typically generated in this manner are PLC fault, loss of communication, low battery, etc.

C. System Clock

1. Provide a master system clock time, which will synchronize all PLCs at 3:20 A.M. each day. The system clock shall be used to determine start of each day for various calculations.

D. PID

1. All tuning parameters for each PID in the PLC shall be available at the HMI (server/workstations) for monitoring and adjustment. The tuning parameters shall be viewable by all, but changeable only by the people with appropriate security. Tuning trends shall be provided to monitor the PID functions.
2. A method of bumpless transfer shall be implemented in the PLC programs to prevent unwanted process interruptions during operational transitions from "MANUAL-to-AUTO", and "AUTO-to-MANUAL" modes.

E. Equipment Runtimes

1. Each piece of monitored equipment shall be provided with 2 separate runtime calculations. Based upon security privileges, the operator will be allowed to reset 1 of the runtimes after the piece of equipment has been serviced. The second runtime will continue until reset by plant personnel with the appropriate security level. Both runtimes shall be displayed via the process graphic screen. Runtimes shall be displayed in hours in "XXXXXX.X" format with .X = 6 minutes.

F. Totalizers

1. The PLC shall be implemented with double precision real counters to accumulate flows. The PLC scan time shall not affect the accumulation accuracy more than 0.5%. All calculations shall be performed in the PLC, and the totaled value in engineering units shall be stored locally in the PLC. The PLC shall reset the totaled values each day at midnight, via the PLC clock. When the PLC clock reaches midnight, the current day total will be stored as the previous day's total, and the current day total will be reset to zero.
2. Do not totalize if the analog signal is outside the 4-20 mA range. Each flow totalization shall come with a reset button on the HMI screen. Do not totalize if the value of the flow input is less than 2% of the full range of the input.

G. Time and Timer Values

1. Time and Timer Values will be sent and received via the HMI as integers. All

conversion will be handled in the PLC. Time will be broken into fields such as: Hours, Minutes and Seconds. Three separated HMI tags shall be used.

H. Control Modes

1. Computer (Remote) Manual: In this mode, all automatic functions associated with a specific control loop are disabled except for safety interlocks and alarms. Provisions shall be provided to allow Operations staff to access the following functions from the HMI:
 - a. Start and Stop Motors
 - b. Open and Close Valves – All valves that are electrically actuated are to have the ability to be manually controlled from the Water Transmission System Hybrid Telemetry SCADA whether there is any automatic control or not.
 - c. Adjust Variable Motor Speeds.
 - d. Adjust Modulating Valve Positions.
 - e. The following list summarizes the safety monitoring and control features active in this mode:
 - 1) Permissives (Conditions that must be met for a machine to begin operation)
 - a) Field equipment HOA Switch must be in "AUTO" position.
 - b) Computer Mode (software switch) must be in "MANUAL".
 - 2) Interlocks (Conditions that must be met for a machine to begin or continue operation)
 - a) No active alarms.
 - b) Additional interlocks are dependent on each individual loop. See individual loop descriptions below.
 - 3) Alarms Displayed on graphical user interfaces (HMI, OIT, etc.)
 - a) Fail To Operate (Open, Close, Start, Stop, Discrepancy, etc.).
 - b) Additional alarms are dependent on each individual loop. See individual loop descriptions below.
 - c) individual loop descriptions below.
2. Computer (Remote) Auto: In this mode, all automatic functions associated with a specific control loop are controlled by the PLC/RTU automatic logic. Operations staff can only adjust the following functions from the HMI:
 - a. Control Mode.
 - b. PID Loop Setpoints (Level Setpoints, Timer Values, etc.).
 - c. Pump Lead/Lag Settings.
 - d. The following list summarizes the safety monitoring and control features active in this mode:
 - 1) Permissives (Conditions that must be met for a machine to begin operation)
 - a) HOA Switch must be in "AUTO" position
 - b) Computer Mode (software switch) must be in "AUTOMATIC".
 - 2) Interlocks (Conditions that must be met in order for a machine to begin or continue operation)
 - a) No active alarms

- b) Additional interlocks are dependent on each individual loop. See individual loop descriptions below.
 - 3) Alarms Displayed on graphical user interfaces (HMI, OIT, etc.)
 - a) Fail to Operate (Open, Close, Start, Stop, etc.).
 - b) Additional alarms are dependent on each individual loop. See loop individual descriptions below.
- 3. Local Manual: This mode is available only with those pieces of equipment (motors, valves, etc.) that have an HOA, LOR, or similar switch. In this mode, all remote control (remote manual or remote auto) functions associated with that piece of equipment are disabled, including any PLC-based safety Permissives. Operations staff can set or adjust the following functions from the local control devices (e.g. pushbuttons, hand switch, etc.):
 - a. Start and Stop Motors
 - b. Open and Close Valves
 - c. Adjust Variable Motor Speeds
 - d. Adjust Modulating Valve Positions
 - e. The following list summarizes the safety monitoring and control features active in this mode:
 - 1) Permissives (Conditions that must be met for a machine to begin operation)
 - a) HOA Switch must be in HAND position
 - 2) Interlocks (Conditions that must be met in order for a machine to begin or continue operation)
 - a) Additional interlocks are dependent hardwired points associated with each individual loop. See individual loop descriptions below.
 - 3) Alarms Displayed on graphical user interfaces (HMI, OIT, etc.)
 - a) Fail to Operate (Open, Close, Start, Stop, etc.) are disabled.
 - b) "UNAVAILABLE" shall be displayed in the HMI when a piece of monitored equipment is not in AUTO.
 - c) Additional alarms are dependent on each individual loop and may still be active in the HMI. See loop individual descriptions below.
 - f. Motor control programming in the PLC shall incorporate bump-less transfer such that switching the motor controller HOA (or LOR) switch from "HAND" (or "LOCAL") to "AUTO" (or "REMOTE") results in a smooth transition without upset to running status or speed.

2.3 OPERATION AND CONTROL STRATEGIES

A. General

- 1. The control loop descriptions provide the functional requirements of the control loops represented in the Contract Documents. Descriptions are provided as follows:
 - a. Control system overview and general description
 - b. Major equipment to be controlled
 - c. Major Field mounted instruments (does not include local gauges)

- d. Manual control functions
- e. Automatic control functions/interlocks
- 2. The control loop descriptions are not intended to be an inclusive listing of all elements and appurtenances required to execute loop functions but are rather intended to supplement and complement the drawings and other specification sections. The control loop descriptions shall not be considered equal to a bill of materials or an all-inclusive listing.
- 3. Provide instrumentation hardware and software as necessary to perform control functions specified herein and shown on drawings.
- 4. Refer to Part 4 for the specific operation and control strategies.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Deliver, handle and store control system components in accordance with manufacturer's written instructions and the requirements of Section 01 60 00 - Product Requirements.
- B. Specific requirement for the control system:
 - 1. Computer and network equipment shall not be placed into service until the room or building is fully enclosed and has functional HVAC equipment.

3.2 TESTING, COMMISSIONING AND TRAINING

- A. Testing and Commissioning: Accomplished in accordance with the requirements of Section 01 70 00 - Execution Requirements and Section 40 61 21 - Instrumentation and Control System Testing and Commissioning.
- B. Training: Accomplished in accordance with the requirements of Section 40 61 26 - Instrumentation and Control System Training and Section 01 70 00 - Execution Requirements.

PART 4 - CONTROL STRATEGIES

4.1 RELOCATED SODIUM HYPOCHORITE FEED SYSTEM

- A. Existing chemical feed system will remain flow-paced. It will be based on the forward flow through the magnetic flow meters on the vessel influent [priority will be the lag vessel reading, secondary will be the primary vessel reading]. A deviation alarm will be included, if the mag meter flow readings are off from the positive displacement meter in the well house.
- B. Existing I/O and logic will be moved to new PFAS PLC
- C. Operational and alarm logic to be messaged to Well #7 registers for telemetry

4.2 RELOCATED SODIUM HYDROXIDE FEED SYSTEM

- A. Existing chemical feed system will remain flow-paced. It will be based on the forward flow through the magnetic flow meters on the vessel influent [priority will be the lag vessel reading, secondary will be the primary vessel reading]. A deviation alarm will be included, if the mag meter flow readings are off from the positive displacement meter in the well house.

- B. Existing I/O and logic will be moved to new PFAS PLC
- C. Operational and alarm logic to be messaged to Well #7 registers for telemetry

4.3 BUILDING SUMP

- A. New Duplex Sump Pumps float switches and control panel furnished by single vendor.
- B. Level Transmitter furnished for information to SCADA system via PLC
- C. High-High Level switch furnished and wired to PFAS Building PLC for remote alarm annunciation

4.4 REDUCED PRESSURE BACKFLOW ASSEMBLY (RPBP)

- A. Provided by a single vendor
- B. Emergency shutoff valve wired to vendor supplied controller
- C. Emergency alarm wired to PFAS PLC for remote alarm annunciation

4.5 TREATMENT UNITS (TNK-601, TNK-602)

A. Normal Operation

1. Treatment process called to run via tank level
2. Well No.7 called to run from PFAS PLC via local PLC communications
 - a. Local Manual
 - 1) Operator controls well start/stop control and well VFD setpoint
 - 2) Operator controls PFAS units manually
 - b. Local Auto
 - 1) Operator controls system operation, sets flow rate and enable operation
 - 2) PLC controls PFAS units automatically
 - c. Remote Auto
 - 1) Operator controls system operation, sets flow rate and enable operation
 - 2) PLC controls PFAS units automatically
 - d. Treatment units are run in a series operation
 - 1) Flow is through TNK-601 first and on to TNK-602 (or vice versa).
 - 2) Flow setpoint is from primary treatment meter (FIT-620 or FIT-621) to VFD controller as a remote setpoint
 - e. Alarms
 - 1) Fail to Run Alarm
 - a) System called to run but did not start with 30 seconds
 - 2) High Treatment Unit Head Loss
 - a) Differential pressure transducer provides headloss signal to PLC
 - b) Alarm occurs when headloss meter exceeds operator alarm set point (10 PSI).

B. Backwash Operation

1. Upon Operator initiation, an automated backwash will occur

2. Backwash operation will be per manufacturer's requirements. In general, a multi-rate backwash will occur with the following parameters:
 - a. Valves will manually Open/Close to backwash position based on the manufacturer's sequence:
 - 1) Charge backwash water supply.
 - 2) Open the backwash discharge valve to adjust backwash flow rate. Backwash activated carbon in an up flow at the determined flow rate to fluidize the carbon bed. Carbon granules should not be exiting the adsorber. Backwash should take 42 minutes and continue until the exiting water is clear of carbon fines.
 - 3) Slowly close all valves in reverse order. Repeat the process for each vessel with newly installed carbon.
 - 4) The system is now ready for operational service.
 - b. Local backwash flow controller logic (in PLC) will throttle backwash valve using the Treatment Units flowmeter for rate control
 - c. The backwash sequence will follow a starting rate, followed by a ramp up to the first sequence rate, then a second and third rate, followed by a ramp down rate.
 - d. All rate and time delays will be user-configurable from the OIT

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SECTION 40 63 43
PROGRAMMABLE LOGIC CONTROLLERS (PLCS)

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section of the Specifications describes the requirements for Programmable Logic Controllers (PLCs) to be furnished under other Sections of the Specifications as listed in the Related Work paragraph of this Section.
- B. All equipment described herein shall be submitted and furnished as an integral part of equipment specified elsewhere in these Specifications.
- C. Provide equipment, materials, software, calibrations, training, and services required to successfully interface and interconnect the system and associated equipment that are specified or designated in drawings or provisions of these specifications for the purpose of providing a fully integrated and functional control system as specified.
- D. Furnish and install cabling and cable accessories, including tools necessary for connecting the system and peripherals, Programmable Logic Controllers (PLCs), Operator Workstations, Data Highway, and input/output devices.
- E. Furnish startup, training, and system check out services.
- F. Furnish and install all items obviously necessary for the proper functioning of the equipment even if omitted at no additional cost to the OWNER.
- G. The Contract Documents Supplement this Section and provide additional details showing panel elevations, functional requirements of the system, and interaction with other equipment.
- H. Coordinate and schedule all testing procedures with the OWNER/ENGINEER.
 - 1. All software packages provided shall be licensed under the OWNER's name and address. The Control System Integrator shall coordinate with the OWNER for correct name and address.
- I. Related Sections include but are not necessarily limited to:
 - 1. Division 00 - Procurement and Contracting Requirements.
 - 2. Division 01 - General Requirements.

1.2 REFERENCES

- A. Refer to Section 40 61 01 - Instrumentation and Control System Abbreviations and References. In case of conflict between the requirements of this Section and those of the listed standards, the requirements of this Section shall prevail.

1.3 ADMINISTRATIVE REQUIREMENTS - NOT USED

1.4 SUBMITTALS

- A. General Requirements: Comply with the submittal requirements of Section 01 31 00 - Project Management and Coordination, Section 40 61 00 - Instrumentation and Control System General Provisions, and as described below.

- B. Submittals for equipment specified herein shall be made as a part of equipment furnished under other Sections. Individual submittals for equipment specified herein will not be accepted and will be returned un-reviewed.
- C. Submit catalog data for all items supplied from this specification Section as applicable. Submittal shall include catalog data, functions, ratings, inputs, outputs, displays, etc., sufficient to confirm that the equipment provides every specified requirement. Any options or exceptions shall be clearly indicated.
- D. Submit a bill of materials for each PLC clearly identifying all components and quantities.
- E. Submit catalog data sheets for all software licenses provided under this Specification Section.
- F. Operation and Maintenance Manuals.
 - 1. Operation and Maintenance manuals shall include the following information:
 - a. Manufacturer's contact address and telephone number for parts and service.
 - b. Instruction books and/or leaflets
 - c. Recommended renewal parts list
 - d. Record Documents for the information required by the Submittals above.
 - e. Copy of the software license data including serial numbers, license key, etc.

1.5 QUALITY ASSURANCE

- A. manufacturer Qualifications: Five years' experience in the design, manufacture and installation of this type of system.
- B. Source Limitations for PLC: Obtain from single source. PLC I/O modules shall be selected within one I/O family.

1.6 DELIVERY, STORAGE, AND HANDLING - NOT USED

1.7 SITE CONDITIONS - NOT USED

1.8 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of the control system that fail(s) in materials or workmanship within the specified warranty period.
 - 1. Warranty Period: Two (2) years from the date of completion of the Site Acceptance Test.
 - 2. Cost for the removal, shipment, repair or replacement, and installation of components by CONTRACTOR shall be included in the warranty, as well as replacement of defective work.

1.9 SOFTWARE SERVICE AGREEMENT

- A. Technical Support: Beginning with Substantial Completion, provide software support for 2 years.
- B. Upgrade Service: Update software to latest version at Project completion. Install and program software upgrades that become available within 2 years from date of Substantial

Completion. Upgrading software shall include operating system. Upgrade shall include new or revised licenses for use of software.

1. Provide 30 days' notice to OWNER to allow scheduling and access to system and to allow OWNER to upgrade computer equipment if necessary.
2. Miscellaneous components (including cables): Provide spares for each unique component installed.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, have been named within the various paragraphs of this Section.
- B. The listing of specific manufacturers within the various paragraphs of this Section does not imply acceptance of their products that do not meet the specified ratings, features and functions. manufacturers listed within the various paragraphs of this Section are not relieved from meeting these specifications in their entirety.

2.2 PROGRAMMABLE LOGIC CONTROLLER (CHASSIS MOUNTED)

A. GENERAL

1. Provide Programmable Logic Controller equipment with the required memory and functional capacity to perform the specified sequence of operation with the scheduled input and output points.
2. Processor Systems shall include processor, power supply, input/output modules, communication modules, redundancy modules, and remote interface modules as required to meet system requirements.
3. All equipment furnished shall be designed and constructed so that in the event of power interruption the systems shall go through an orderly shutdown with no loss of memory, and resume normal operation without manually resetting when power is restored.
4. The PLCs shall communicate between the operator workstation and field-mounted transducers, switches, controllers, and process actuators. Communications protocol shall be completely transparent to process operators at the Human Machine Interface (HMI).
5. The PLC shall be capable of stand-alone operation in the event of failure of the communication link to the HMI subsystem.
6. Remote Input/Output Units shall include input/output modules, interface modules, communication modules, and power supply to meet system input and output requirements.
7. Agency and environmental specifications:
 - a. Electrical supply voltage to the PLC shall be 120 Vac, plus or minus 15%, 48-63 Hz. PLC system power supplies shall be fused for overload protection.
8. All major assemblies and sub-assemblies, circuit boards, and devices shall be identified using permanent labels or markings.
9. All necessary cables shall be included. All cables and connectors shall be as specified

by the manufacturer. Cables shall be assembled and installed per the manufacturer recommendations.

- B. Subject to compliance with the Contract Documents, the following manufacturers are acceptable, no substitutions are acceptable:
 - 1. Allen-Bradley
- C. Programming Languages
 - 1. Each PLC shall support IEC Standard 61131-3 for all of the following programming languages:
 - 2. Ladder (LD)
 - 3. Function Block Diagram (FBD)
 - 4. Structured Text (ST)
 - 5. PLC shall support user defined functions for customization and user defined tag structures.
 - 6. PLC shall have application-specific instructions for process, drive, batch, motion and safety applications built into the controller.
- D. Central Processor Unit (CPU)
 - 1. Each processor shall have the maximum IEC Program Memory size available at time of procurement.
 - 2. Provide hardware employing identical revisions of software and firmware as applicable.
 - 3. Processor shall have a minimum IEC program memory size of 1,024 kB.
 - 4. The CPU shall contain a minimum of 1 serial configuration port and 2 Ethernet ports.
 - 5. The CPU shall be able to do time synchronization for the system.
- E. Physical Construction (Chassis)
 - 1. The PLC shall be of the modular construction, consisting of a back plane, plug in modules for the processor, communication modules, I/O modules and expansion modules.
- F. Power Supply (PS)
 - 1. The power supply shall be 120 Vac and shall be sized for the total quantity of modules including the power requirement of spare I/O module slots.
- G. I/O Modules: The following types of process I/O interface capabilities shall be provided for the PLC:
 - 1. Discrete Input Requirements:
 - a. Responsible for the PLC interface with the status and alarm contacts.
 - 1) For the "dry" contacts: PLC shall sense the states of these contacts by applying a voltage and observing the extent to which current flows.
 - 2) This voltage shall be obtained from a separate, isolated power supply furnished by the CONTRACTOR
 - 3) Voltage applied across the open contacts shall be 24 Vdc (nominal), or 110 Vac.
 - b. Exact input configuration sized to meet the existing discrete input needs as

- specified on the Drawings.
- c. Final configuration based on the standard product offering of the PLC manufacturer.
- d. Discrete inputs shall be 24 Vdc and be individually buffered with external relays.
- e. Number of Points per Card: 16
- 2. Discrete Output Requirements:
 - a. Discrete output logic shall process the control commands received from the common logic. Control schemes, in which a single message with undetected errors can cause a false command, shall be unacceptable.
 - b. Discrete output drive circuitry shall be designed such that any single logic component failure in the PLC does not energize a discrete output.
 - c. Exact output configuration sized to meet existing discrete output needs as specified on the Drawings.
 - d. Final configuration based on the standard product offering of the PLC manufacturer.
 - e. Discrete outputs shall be of the relay type and individually buffered with external relays.
 - f. Number of Points per Card: 16
- 3. Analog Output Requirements:
 - a. Provide analog output modules having a 4-20 mA at 24 Vdc; suitable for interfacing to an electronic 3-mode controller or direct to a variable frequency drive.
 - b. Analog outputs are driven from the isolated 24 Vdc power supply supplied in the PLC Panel. The module shall have broken wire fault detection.
 - c. Exact output configuration sized to meet analog output needs as specified on the Drawings.
 - d. Final configuration based on the standard product offering of the PLC manufacturer.
 - e. Number of Points per Card: 8
- 4. Analog Input Requirements:
 - a. Analog inputs from the transducers shall be 4-20 mA dc and all transducer power shall be provided by the dedicated 24 Vdc plus 10% power supply supplied in the PLC Panel, or from an isolated output of the field device. The module shall be Bi-Polar with broken wire and Out of Range fault detection.
 - b. Exact input configuration sized to meet the analog input needs as specified on the Drawings.
 - c. Final configuration based on the standard product offering of the PLC manufacturer.
 - d. Number of Points per Card: 8
- H. PLC Power Supply: PLC power supplies shall be supplied with 110 Vac. PLC power supplies shall contain a "POWER OK" LED.
- I. Remote I/O: The PLC shall support remote I/O racks connected to the PLC via an open

protocol. The Remote I/O rack shall utilize the same rack and power supply as the PLC.
Provide prefabricated remote I/O drop cables and connectors from the PLC manufacturer.

2.3 PLC SOFTWARE REQUIREMENTS

- A. The PLC shall be programmed to provide the overall system functions as described in the specifications. Specific functions which shall be performed via PLC-level software include, but are not limited to, the functions described below. Software shall be the latest version of PLC manufacturer's programming package.
- B. General Requirements: The following are requirements for the PLC programming software package.
 - 1. Windows® Based
 - 2. Be able to monitor and modify the PLC online
 - 3. Contain a equation editor for complex algorithms
 - 4. Have quick key support
 - 5. Be compliant with IEC Ladder Logic, Function Block, Structured Text, or Sequential Function Chart program formats.
 - 6. Have On-line help menus.
- C. Diagnostics and System Programming. The PLC shall be programmed to provide the basic system functions as described in the specifications. Specific functions, which shall be performed via PLC-level software include, but are not limited to, the following functions:
 - 1. PLC network configuration, including IP addressing.
 - 2. CPU module configuration.
 - 3. I/O module configuration.
 - 4. I/O database definition.
 - 5. Peer-to-Peer communication, where specified.
- D. Other Requirements:
 - 1. Licenses: Provide two copies of fully-licensed versions of the PLC Programming Package.
 - 2. PLC Programming Software shall be the full version of package provided by the manufacturer, including all latest service packs provided by the manufacturer.
 - 3. Provide all updates provided by the manufacturer for any provided software during the warranty period.

2.4 PROGRAMMING CABLES

- A. Provide 2 programming cables for each type of PLC/RTU to be programmed.

2.5 OPERATOR INTERFACE TERMINALS (OIT)

- A. OITs shall be mounted on control panels, where shown on drawings and shall run interface software separate from the control system software specified in Section 40 68 00 - Control System Software.
- B. manufacturers
 - 1. Provide operator interface terminals (OIT) from one of the following:

- a. Allen-Bradley PanelView Plus 6 series
 - b. GE Loaded QuickPanel View series
 - c. Pro-face AGP3000/ AST3000 series
 - d. Siemens SIMATIC HMI IPC series
 - e. Or equal
 - C. Software
 - 1. The Operator Interface Terminal shall be pre-packaged with all configuration and programming software necessary to perform functions as shown on drawings and within the specifications.
 - 2. The integrated OIT software shall have the following features
 - a. Trending
 - b. Data Logging
 - c. Alarms
 - d. Graphic Symbols
 - e. Animations
 - D. I/O Ports and Devices
 - 1. The OIT shall have a minimum of one Ethernet 10/100 Mbps for connectivity or programming.
 - 2. The OIT shall have a minimum of 1 Serial RS232 port.
 - 3. Compact flash ports shall be Type 2.
 - 4. The OIT shall have a minimum of 1 USB port.
 - E. Display
 - 1. The OIT display size shall be a minimum of 6 inches for wall mounted panels and 12 inches for floor mounted panels
 - 2. The type of display for the OIT shall be Color Active Matrix TFT.
 - 3. Display shall support touch screen input.
 - F. Environmental
 - 1. Rating: OIT shall be rated to maintain the rating of the control panel it will be mounted in.
 - 2. Temperature: Operating temperature range of the OIT shall range 0-50°C.
- 2.6 SOURCE QUALITY CONTROL
- A. Factory Demonstration Test:
 - 1. PLCs shall be integrated with other components of the PLC system and tested as in accordance with the Factory Demonstration Test specified in Section 40 61 21 - Instrumentation and Control System Testing and Commissioning.
 - 2. In addition to the Factory Demonstration Test requirements, each PLC shall be subjected to the tests described in this section with a written confirmation of the test results.
 - B. PLC Functional Test: PLC shall successfully pass the following functional tests to be

performed in conjunction with the system Factory Demonstration Test:

1. A close and open operation on each control point, showing proper sequence of operations.
2. Verify the proper operation of the digital outputs.
3. Test showing that the proper indications are given at an Operator Workstation when one or more status input points change momentarily.
4. A simulation test of a status change followed by an intermittent failure of the communication channel, showing proper indication of the status change by the System upon recovery of the communication failure.
5. A series of communications tests showing all message protocols and formats to which the equipment is designed to respond, and demonstrating that all error-detection or error-correction capabilities function properly, and that the equipment does not respond to erroneous commands.
6. Telemeter readings of selected analog points to verify that the readings are within the specified accuracy when the inputs are at 0, 50, and 100% of full-scale.
7. Test showing that as a result of a scan request from the MMI, all requested analog, indication, and alarm points are transmitted from the PLC.
8. Test showing that the PLC successfully performs its various modes of operation while the power source for the PLC is varied over its specified range.
9. Test verifying that all common equipment, wiring, files, and power supplies are provided for expansion of the PLC to the ultimate point count specified. This test shall also verify that the power supplies are capable of carrying the increased load for this expanded point count.
10. Test to verify the proper operation of the stand-alone capabilities of the PLCs. This shall include configuration of the loops or downloading from the MMI and testing the actual control strategy with test signals.

2.7 EXTRA MATERIALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
- B. The following PLC spare parts shall be furnished
 1. Processors: Provide spare processor unit(s) for each unique processor installed.
 2. Memory Cards: Provide spares for each type of card installed.
 3. I/O Cards: Provide spares for each unique I/O module type installed. Provide 2 or 10% of installed quantity, whichever is greater.
 4. Network interface, remote I/O, and communication modules: Provide 1 spare communication module for each unique communication module installed.
 5. Specialty Modules: Provide as a minimum a spare of each type of module identified. Provide an additional spare for every 10 modules of a specific type installed.
 6. PLC Power supplies: Provide spare power supplies for each unique power supply installed.
 7. Chassis: Provide spare chassis for each unique chassis installed.
 8. Fixed PLCs: Provide spares for each unique type of PLC installed.

9. Miscellaneous components (including cables): Provide spares for each unique component installed.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install the programmable logic controllers in accordance with the manufacturer's instructions, the shop drawings, the Drawings, and the requirements of Section 01 40 00 - Quality Requirements.

3.2 TESTING, COMMISSIONING AND TRAINING

- A. Testing and Commissioning: Accomplished in accordance with the requirements of Section 01 70 00 - Execution Requirements and Section 40 61 21 - Instrumentation and Control System Testing and Commissioning.
- B. Training: Accomplished in accordance with the requirements of Section 40 61 26 - Instrumentation and Control System Training and Section 01 70 00 - Execution Requirements.

END OF SECTION

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**SECTION 40 72 00
LEVEL MEASUREMENT**

PART 1 - GENERAL

1.1 SUMMARY

- A. Section provides requirements for furnishing, installation, and services for level measurement instruments as detailed on the Drawings.
- B. Instrument Schedules have been provided at the end of the specification section. Schedules may not be all inclusive. Refer to P&IDs and Mechanical sheets for instruments to be furnished and installed on the project.
- C. Related Sections include but are not necessarily limited to:
 - 1. Division 00 - Procurement and Contracting Requirements.
 - 2. Division 01 - General Requirements.
 - 3. Section 40 70 00 – Instrument Measuring Devices

1.2 REFERENCES

- A. Refer to Section 40 61 01 "Instrumentation and Control System Abbreviations and References." In case of conflict between the requirements of this Section and those of the listed standards, the requirements of this Section shall prevail.
- B. Where reference is made to one of the standards, the revision in effect at the time of bid opening shall apply.
- C. All material and equipment, for which a UL standard exists, shall bear a UL label. No such material or equipment shall be brought onsite without the UL label affixed.
- D. If the issue of priority is due to a conflict or discrepancy between the provisions of the Contract Documents and any referenced standard, or code of any technical society, organization or association, the provisions of the Contract Documents shall take precedence if they are more stringent or presumptively cause a higher level of performance. If there is any conflict or discrepancy between standard specifications, or codes of any technical society, organization, or association, or between Laws and Regulations, the higher performance requirement shall be binding on the Control System Integrator unless otherwise directed by the OWNER/ENGINEER.

1.3 ADMINISTRATIVE REQUIREMENTS – NOT USED

1.4 SUBMITTALS

- A. General Requirements: Comply with the submittal requirements of Section 40 70 00 "Instrument Measuring Devices" and Section 40 61 00 "Instrumentation and Control System General Provisions", and as described in this Section.
- B. Submit to the ENGINEER the following:
 - 1. Manufacturer's name and address, as well as Manufacturer's product name and complete model number for all equipment and accessories proposed for use.
 - 2. Materials of Construction for equipment housing.
 - 3. Dimensions.

4. Measurement accuracy.
 5. Measurement range for proposed level measurement system.
 6. Enclosure NEMA rating(s) for components.
 7. NEC Area Classification for model(s) chosen.
 8. Power requirements and consumption in Voltage, Wattage and Amperage.
 9. Signal/Data output options.
 10. Parts list for all components in sufficient detail to allow an item-by-item comparison with the Contract documents.
- C. Manufacturer's Instructions for the shipping, handling, storage, installation, start-up, operation, and maintenance, with schedule, of the equipment (in both hardcopy and digital formats). Include spare parts lists, instructions for instrument calibration and programming, instrument testing sheets, and schematics.
- D. Manufacturer's certification of satisfactory installation, calibration, and testing.
- E. Proof of Warranty as indicated.

1.5 QUALITY ASSURANCE

- A. Manufacturer:
1. Products:
 - a. Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include (unless "No Equal" is quantified), but are not limited to, have been named within the various paragraphs of this Section.
 - b. The listing of specific manufacturers within the various paragraphs of this Section does not imply acceptance of their products that do not meet the specified ratings, features and functions. manufacturers listed within the various paragraphs of this Section are not relieved from meeting these specifications in their entirety.
 - c. Manufacturer of the products under this Section shall be experienced, producing meters that are fully developed, field proven, and of standardized designs.
 - d. To the greatest extents possible, provide equipment that is the product of one (1) manufacturer to achieve standardization of operation, maintenance, spare parts, and Manufacturer's service.
 2. Services:
 - a. If indicated in the individual instrumentation paragraphs, the instrument manufacturer or manufacturer's certified service representative shall provide start-up and training services. This work shall not be done by the CONTRACTOR or Control System Integrator.
 - b. The start-up services shall be to calibrate, oversee the installations of the sensor, and start-up the sensor/transmitter to provide reliable measurement at the instrument and to a remote system. The vendor shall work with the Control System Integrator to verify the transmitter sends correct information to the remote system (i.e., that the scaling and units are the same at the instrument

and on the remote operator interface).

- c. While the instrument manufacturer or manufacturer's certified service representative is starting up the instrumentation, training shall be provided to the Owner's instrumentation technicians. The training shall be in how to calibrate, install, troubleshoot, read the diagnostics, and maintain the sensor and transmitter.
- d. An authorized Manufacturer's representative shall inspect the installation of all work furnished in this Section and shall provide a Manufacturer's certificate showing that the equipment has been satisfactorily installed, calibrated, and tested.

B. Installer:

- 1. Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Store all instruments in a dedicated structure with space conditioning to meet the recommended storage requirements provided by the Manufacturer.
- B. The Contractor shall be responsible for replacing, at his expense, instruments that are not stored in strict conformance with the Manufacturer's recommendations.

1.7 SITE CONDITIONS

A. Operating Conditions:

- 1. Ambient Conditions: Provide equipment suitable for ambient conditions in accordance with environmental requirement paragraphs specified below.
- 2. Field Locations: Field equipment may be subjected to ambient temperatures from 0-120° F, with direct radiation, and relative humidity from 45 to 96% with condensation. Field equipment will also experience rain, freezing rain, and snow.
- 3. Power Supply: Power supply will be 120 Vac, single-phase, 60 Hz commercial power. Voltage variations will be at least plus or minus 8%. Certain loops shall have integral power supply as indicated on the drawings.
- 4. Standard Signal:
 - a. Output Signal. Each instrument which outputs a signal, shall output the standard 4-20 mA signal. The signal shall be constant over a load range of 0-600 Ω .
 - b. Input Signal.
 - 1) Electronic devices, such as controllers, match function devices, etc., shall have an input impedance of one mega-ohm minimum for an input signal of 1-5 Vdc.
 - 2) The 1-5 Vdc signal shall be developed by the standard 4-20 mA transmitted signal through a precision 250 Ω , 1 W resistor.
 - 3) These requirements allow several receiving units to monitor the same transmitting unit without causing any perturbation of the received signal.
 - 4) Receiving devices shall not be wired in parallel.

- B. Components, Hazardous Area Location:
 - 1. Assure equipment located in hazardous areas is suitable for applicable classification by use of explosion-proof housings or equipment and barriers approved as "intrinsically safe" by either UL or FM.
 - 2. Locate barriers in cabinets at hazardous area boundaries. Use dual barriers in loops to prevent grounding loop at the barrier.
- C. Components, Submerged Locations:
 - 1. Those instruments that are submerged in a liquid or located in submersible areas shall meet NEMA 6P ratings approval.

1.8 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of the control system that fail(s) in materials or workmanship within the specified warranty period.
 - 1. Warranty Period: Two (2) years from the date of completion of the Site Acceptance Test.
 - 2. Cost for the removal, shipment, repair or replacement, and installation of components by CONTRACTOR shall be included in the warranty, as well as replacement of defective work.

PART 2 - PRODUCTS

2.1 ULTRASONIC LEVEL (120VOLT POWERED)

- A. Transmitter shall be composed of non-contact, ultrasonic level transducer and compatible controller/transmitter, refer to Instrument Schedule at the of this specification section for a listing of instruments.
- B. Manufacturers:
 - 1. Emerson/Rosemount;3105 Transducer with 3490 Control Unit (Transmitter)
 - 2. Endress+Hauser; FDU92 Transducer with FMU90 Control Unit (Transmitter)
 - 3. Siemens; XRS-15 Transducer with LUT400 Control Unit (Transmitter)
- C. Requirements:
 - 1. Transducer
 - a. Function/Performance
 - 1) Measuring Range: Transducer range shall be suitable for the installation indicated on the Drawings, up to 50 ft (15m).
 - 2) Temperature Range: -20 to 60 degrees C.
 - 3) Relative Humidity: Zero to 100 percent.
 - 4) Temperature Compensation: Transducers shall be provided with integral temperature sensors for temperature compensation at above temperature ranges.
 - b. Physical
 - 1) Transducers shall be potted/encapsulated in a Kynar or other chemical and corrosion-resistant housing. Where indicated on the Drawings, transducers

shall be approved for installation in Class I, Division 1, Groups C and D (Zone 0) environments.

- 2) The surface of transducers shall be Teflon-coated where mounted on chemical tanks and exposed to vapors in the tanks that are not compatible with the transducer material.
- 3) Transducers shall be capable of being completely submerged without damage.
- 4) Transducers shall be suitable for bracket, or flange mounting as indicated on the Drawings or Instrument Device Schedule. Appropriate mounting hardware shall be provided. Flanges shall be eight or six inch, as indicated on drawings and resistant to attack by the medium being metered or, where required, shall be protected by corrosion- resistant coatings and facings.

c. Options/Accessories Required

- 1) Transducers located in areas where freezing condensation may occur shall be provided with special heaters or other type of transducer protection designed to prevent sensor icing.
- 2) Signal cable as recommended by the manufacturer, for installation between the transducer(s) and the transmitter. Length, up to 1000 feet (300 m), shall be as required by installation indicated on the Drawings.

2. Controller (Transmitter)

a. Functional/Performance

- 1) Resolution (including transducer): Plus or minus 0.1 percent of range or 0.08 inches (2 mm), whichever is greater.
- 2) Accuracy (including transducer): Plus or minus 0.25 percent of range or 0.24 inches (6 mm).
- 3) Range: As required by the installation indicated on the Drawings.
- 4) Temperature Range: -20 to 50 degrees C.
- 5) Output: Minimum one isolated 4-20 mA output and minimum four alarm contacts (number of contacts above 4 required of each device to be determined by signals required as shown on the drawings adjustable to trip at any point in the instrument range. Output contacts shall be rated 5 A at 230 VAC.
- 6) Temperature Compensation: Compensation over the temperature range of the sensor.
- 7) Display: Digital indicator displaying level/differential level or volume in engineering units or percent as indicated on the Drawings or in the Instrument Device Schedule.
- 8) Diagnostics: On-screen instructions and display of self- diagnostics.
- 9) Loss of Signal: Transmitter shall ignore momentary loss-of-echo signals and shall indicate loss of echo on the transmitter unit.
- 10) Configuration Protection: Programmable parameters shall be protected using E2PROM. Battery backup protection is not acceptable.

b. Physical

- 1) Transmitter shall be suitable for surface or pipe stand mounting.
 - 2) Enclosure shall be NEMA 4X.
 - c. Power Requirements:
 - 1) Transmitter shall be 120 VAC powered instrument.
 - d. Accessories Required
 - 1) Hand-held programmer where required for configuration and calibration of the instrument.
- D. Accessories/Documentation Required:
 - 1. Provide a certificate of conformance/calibration subsequent to installation for each flowmeter.
 - 2. The supplier shall be responsible for coordinating all transducer mounting requirements and shall furnish dimensional and elevation drawings to ensure a proper and satisfactory installation.
 - 3. Transducer located in areas where freezing condensation may occur shall be provided with special heaters or other types of transducer protection designed to prevent sensor icing.
 - 4. .

2.2 FLOAT SWITCH (PLUNGER)

- A. Float switch shall be composed of a hermetically sealed reed switch located inside the stem. The switch is activated by a magnet located in the float. As the float rises and falls, the magnetic field passing the switch (in the stem) causes the switch to actuate, refer to Instrument Schedule at the end of this specification section for a listing of instruments.
- B. Manufacturers:
 - 1. Contegra FS 202
- C. Requirements:
 - 1. Function/Performance
 - a. Differential: Less than 3/8" rise..
 - b. Switch Rating: 0.5 amps at 120 VAC
 - c. Provide NO or NC type contact for fail-safe operation or as shown on the drawings.
 - 2. Physical
 - a. All construction shall be of PVC, PBT and Buna N for corrosion resistance.
 - b. The junction box shall be NEMA 4X.
- D. Accessories/Documentation Required:
 - 1. Provide with 1/2" Threaded Fitting.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Coordination: Coordinate equipment delivery with completion of other work to minimize field handling of each device.

3.2 INSTALLATION

A. General Requirements:

1. Examine contract drawings and shop drawings for equipment to determine the best arrangement for work as a whole.
2. Mount pipe, and connect field devices in accordance with contract drawings, specification, and manufacturer's installation instructions.
3. Avoid tubing, piping, and conduit interferences.
4. Locate equipment to be accessible for operation, maintenance, and replacement.
5. Mount field transmitters 40 inches above floor, work platform, or as sensing line slope requires per manufacturer's instructions and in a location to allow convenient access for readability, calibration, and maintenance. Coordinate tap location and meter location with ENGINEER prior to beginning work.

B. Device Mounting and Location Requirements.

1. Where specifications and contract drawings do not delineate precise installation procedures, use API RP550 as a guide to installation procedures. Submit sketch for OWNER approval prior to installation.
2. Locate field-mounted instruments as shown on drawings or as designated by the OWNER's representative or ENGINEER.
3. Secure support pipes, stands or brackets of material with sufficient strength to prevent excess vibration or movement.
4. Where field devices are shown as yoke mounted on a floor stand, a wall bracket fabricated from two channel sections, 1 5/8 inches sized, mounted to a wall or column is considered equal.
5. Make channel section long enough to mount at least two field devices. Use aluminum or stainless steel for fabrication.
6. Locate instrument-mounting stands within 5 feet of primary element, unless otherwise indicated. Make stands freely accessible.
7. Locate indicating instruments which must be visible for automatic control adjustment or manual operation to be visible from the adjustment or operating point. If plot or piping arrangement precludes this, make other provisions for indication at the adjustment or operation point.
8. Install instrument mounting stands after all conduit and pipe has been installed, except conduit serving devices on stand.
9. Install instrument process piping and tubing from each primary shutoff valve to appropriate gauge, sensor, meter, analyzer, control panel connections, etc.
10. Clean piping, tubing and components thereof prior to installation. This shall include but is not limited to special cleaning procedures for oxygen service when so required.
11. Adjust pulsation dampers to eliminate rapid fluctuations of gauge or switch but to retain sensitivity to pressure changes.

3.3 COMMISSIONING

A. Commissioning:

1. Commissioning of instruments shall be in accordance with manufacturers'

instructions, the product data and shop drawings, Section 40 61 00 "Instrumentation and Control System General Provisions."

B. Manufacturers' Start-Up and Training Services

1. Where indicated in the product description, the instrument manufacturer or manufacturer's certified service representative shall provide start-up and training services. This work shall not be done by the Control System Integrator.
2. The start-up services shall be to calibrate, oversee the installations of the sensor, and start-up the sensor/transmitter in order to provide reliable measurement at the instrument and to a remote system. The vendor shall work with the Process Control System Integrator to verify the transmitter sends correct information to the remote system (i.e., that the scaling and units are the same at the instrument and on the remote operator interface).
3. While the instrument manufacturer or manufacturer's certified service representative is starting up the instrumentation, training shall be provided to the OWNER's instrumentation technicians. The training shall be in how to calibrate, install, troubleshoot, read the diagnostics, and maintain the sensor and transmitter.

C. General Requirements

1. Notify the OWNER/ENGINEER in writing at least 24 hours in advance of any test. All tests executed without such notification are invalid and shall be repeated. The OWNER/ENGINEER reserves the right to witness any test, inspection, calibration, or start-up activity.
2. Perform commissioning of each device, subsystem, and system under direct supervision of the individual manufacturer's factory-trained representative.
3. Reports:
 - a. Prepare Report showing test procedures, conditions, and results of each test. In the test report, give applicable contract requirements, manufacturer's performance specifications, and permissible tolerances at each test point, actual values of test signals and actual values of test results.
 - b. Check off List:
 - 1) Maintain a check off list by loop number indicating tasks remaining to be done to make loop operational.
 - 2) Submit check off list form at least 60 days before commissioning starts.
 - 3) Submit check off lists when requested by OWNER/ENGINEER.
 - 4) Lists will be requested no more frequently than once a week.

D. Scheduling Guidelines for Commissioning Phases

1. Perform all commissioning in accordance with the instructions on the Contract Drawings, these Specifications, manufacturer's instruction manuals and the direction of the OWNER/ENGINEER.
2. Commission field devices, after installation of field instruments and prior to commissioning the instrument or the control panel.
3. After installation of the instrument or control panel and prior to loop commissioning, commission panel-mounted devices and systems.
4. After commissioning field devices and panel-mounted devices, commission loops.

E. Requirements

1. Transmitters and Receivers:

- a. Remove shipping stops before starting with these procedures.
- b. Have manufacturer's instruction manuals available.
- c. Install miscellaneous components such as charts, illumination, etc., which have been supplied separately but are integral parts of equipment.
- d. Test and exercise each instrument to demonstrate correct operation, first individually, then collectively as a functional network.
- e. Check calibration of and recalibrate, where necessary, instruments at a minimum of 4 points over full operational range and prove instruments to be within specified accuracy.
- f. Calibrate instruments individually and, where applicable, as loop (i.e., transmitter, controller and valve).
- g. Specified accuracy for loop is defined as root-mean- square-summation (rms) of individual device specified accuracies.
- h. Individual device specified accuracy requirements shall be as specified by contract requirements or by published manufacturer accuracy specifications whenever contract accuracy requirements are not specified.
- i. Test each loop by applying simulated analog and/or discrete inputs to first elements of loop (i.e., applying simulated analog and/or discrete sensor signals) and measuring outputs from final elements of loop, (i.e., controllers, alarms, indicators, etc.).
- j. Apply continuously variable analog inputs to verify proper operation and setting of discrete devices (i.e., alarms, etc.).
- k. Make provisional settings on controllers, alarms, etc., during loop installation tests.
- l. Prepare calibration report on each instrument and loop.
- m. Integrators, Ratio Relay, and Related Devices:
- n. Check devices in conformance with manufacturer's recommendations.
- o. Receiver integrators may be calibrated for proper operation and multiplication factor by feeding maximum input signal for a specified period of time using a stopwatch.
- p. Ratio signals may be simulated to check proper ratio settings and output.

2. Flow Meters and Level Transmitters:

- a. Perform volumetric draw down test for all flow meters and level transmitters.
- b. Prepare test report for each meter and level transmitter.
- c. If test results conflict with calibration report, recalibrate in accordance with subparagraph A above and repeat volumetric draw down test.
- d. Continue until draw down test results prove calibration to be correct.

3. Level Switches:

- a. Perform draw down test for each level switch. Set switch in accordance with Specifications or in absence of switch setting in Specifications, set in accordance

with instructions from OWNER/ENGINEER.

4. Interlocks: Ring and check interlocking circuits for conformance to Plans and Specifications.
5. Start-up of Instruments:
 - 1) Test each control loop under start-up and steady-state operating conditions to verify that proper and stable control is achieved using instruments in each instrument panel and control panel.
 - 2) Test control of final control elements using specified modes of manual and automatic control.
 - 3) Demonstrate bumpless transition between control station modes.
 - 4) Use signals from transducers, sensors, and transmitters.
 - 5) Simulated input data signals may be used subject to prior written approval by the OWNER/ENGINEER.
 - b. Set proportional band, reset rate, and derivative settings for each control as recommended by manufacturer.
 - c. Verify transient stability of each control loop by applying control signal disturbances, monitoring amplitude and decay rate of control parameter oscillations and making necessary controller adjustments to eliminate excessive oscillatory amplitudes and decay rates while retaining control sensitivity. Verify proper suppression of "reset wind-up."
6. Component Calibration Sheet
 - a. CONTRACTOR shall be responsible for calibration and ringing out all devices that are to be interfaced with the distributed control system. This shall include devices purchased and installed under other contracts.
 - b. Each active instrument element (except simple hand switches, lights, etc.) and each I/O module shall have a Component Calibration Sheet. These sheets shall have the following information, spaces for data entry, and a space for signoff by the Process Control System Integrator or its subcontractor.
 - 1) Project name.
 - 2) Loop name.
 - 3) Component tag number or I/O module number.
 - 4) Component code number.
 - 5) manufacturer.
 - 6) Module number/serial number.
 - 7) Summary of function requirements, for example:
 - 8) For indicators and recorders: scale and chart ranges.
 - 9) For transmitters/converters: input and output ranges.
 - 10) For computing elements.
 - 11) I/O modules: required and actual inputs or outputs of 0, 10, 50, and 100% of span, rising and falling.
 - 12) Space for comments.
 - 13) Space for signoff by Process Control System Integrator.

7. The Control System Integrator shall maintain the Loop Status Reports and Component Calibration Sheets at the job site and make them available to the ENGINEER at any time.

3.4 TESTING AND TRAINING

- A. Testing: Accomplished in accordance with the requirements of Section 40 61 21 "Instrumentation and Control System Testing and Commissioning" and Section 01 70 00 "Execution and Closeout Requirements."
- B. Training: Accomplished in accordance with the requirements of Section 40 61 26 "Instrumentation and Control System Training" and Section 01 70 00 "Execution and Closeout Requirements."

3.5 INSTRUMENT SCHEDULES

- A. Provide field instruments, as listed in the Instrument Schedules after END OF SECTION, of the range, type, in accordance with the mechanical drawings, control narratives, and P&ID's. Schedules may not be all inclusive.

END OF SECTION

ULTRASONIC LEVEL (120VOLT POWERED) INSTRUMENT SCHEDULE

[illegible]

Notes:
1. Field Mount Surge Suppressor
2. WP Switch for 120V Power
3. Sunshield
4
5

1. Field Mount Surge Suppressor
2. WP Switch for 120V Power
3. Sunshield
- 4
- 5

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SECTION 40 73 00
PRESSURE, STRAIN, AND FORCE MEASUREMENT

PART 1 - GENERAL

1.1 SUMMARY

- A. Section provides requirements for furnishing, installation, and services for pressure measurement instruments as detailed on the Drawings.
- B. Instrument Schedules have been provided at the end of the specification section. Schedules may not be all inclusive. Refer to P&IDs and Mechanical sheets for instruments to be furnished and installed on the project.
- C. Related Sections include but are not necessarily limited to:
 - 1. Division 00 - Procurement and Contracting Requirements.
 - 2. Division 01 - General Requirements.
 - 3. Section 40 70 00 – Instrument Measuring Devices

1.2 REFERENCES

- A. Refer to Section 40 61 01 "Instrumentation and Control System References and Abbreviations." In case of conflict between the requirements of this Section and those of the listed standards, the requirements of this Section shall prevail.
- B. Where reference is made to one of the standards, the revision in effect at the time of bid opening shall apply.
- C. All material and equipment, for which a UL standard exists, shall bear a UL label. No such material or equipment shall be brought onsite without the UL label affixed.
- D. If the issue of priority is due to a conflict or discrepancy between the provisions of the Contract Documents and any referenced standard, or code of any technical society, organization or association, the provisions of the Contract Documents shall take precedence if they are more stringent or presumptively cause a higher level of performance. If there is any conflict or discrepancy between standard specifications, or codes of any technical society, organization or association, or between Laws and Regulations, the higher performance requirement shall be binding on the Control System Integrator unless otherwise directed by the OWNER/ENGINEER.

1.3 ADMINISTRATIVE REQUIREMENTS – NOT USED

1.4 SUBMITTALS

- A. General Requirements: Comply with the submittal requirements of Section 40 70 00 "Instrument Measuring Devices", Section 40 61 00 "Instrumentation and Control System General Provisions", and as described below.
- B. Submit to the ENGINEER the following:
 - 1. Manufacturer's name and address, as well as Manufacturer's product name and complete model number for all equipment and accessories proposed for use
 - 2. Materials of Construction for equipment housing
 - 3. Dimensions

4. Measurement accuracy
 5. Measurement range for proposed level measurement system
 6. Enclosure NEMA rating(s) for components
 7. NEC Area Classification for model(s) chosen
 8. Power requirements and consumption in Voltage, Wattage and Amperage
 9. Output options
 10. Parts list for all components in sufficient detail to allow an item-by-item comparison with the Contract documents.
- C. Manufacturer's Instructions for the shipping, handling, storage, installation, start-up, operation, and maintenance, with schedule, of the equipment (in both hardcopy and digital formats). Include spare parts lists, instructions for instrument calibration and programming, instrument testing sheets, and schematics.
- D. Manufacturer's certification of satisfactory installation, calibration, and testing.
- E. Proof of Warranty as indicated.

1.5 QUALITY ASSURANCE

- A. Manufacturer:
1. Products:
 - a. Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include (unless "No Equal" is quantified), but are not limited to, have been named within the various paragraphs of this Section.
 - b. The listing of specific manufacturers within the various paragraphs of this Section does not imply acceptance of their products that do not meet the specified ratings, features and functions. manufacturers listed within the various paragraphs of this Section are not relieved from meeting these specifications in their entirety.
 - c. Manufacturer of the products under this Section shall be experienced, producing meters that are fully developed, field proven, and of standardized designs.
 - d. To the greatest extents possible, provide equipment that is the product of one (1) manufacturer in order to achieve standardization of operation, maintenance, spare parts, and Manufacturer's service.
 2. Services:
 - a. If indicated in the individual instrumentation paragraphs, the instrument manufacturer or manufacturer's certified service representative shall provide start-up and training services. This work shall not be done by the CONTRACTOR or Control System Integrator.
 - b. The start-up services shall be to calibrate, oversee the installations of the sensor, and start-up the sensor/transmitter in order to provide reliable measurement at the instrument and to a remote system. The vendor shall work with the Control System Integrator to verify the transmitter sends correct information to the remote system (i.e., that the scaling and units are the same

- at the instrument and on the remote operator interface).
- c. While the instrument manufacturer or manufacturer's certified service representative is starting up the instrumentation, training shall be provided to the Owner's instrumentation technicians. The training shall be in how to calibrate, install, troubleshoot, read the diagnostics, and maintain the sensor and transmitter.
- d. An authorized Manufacturer's representative shall inspect the installation of all work furnished in this Section and shall provide a Manufacturer's certificate showing that the equipment has been satisfactorily installed, calibrated, and tested.

B. Installer:

1. Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Store all instruments in a dedicated structure with space conditioning to meet the recommended storage requirements provided by the Manufacturer.
- B. The Contractor shall be responsible for replacing, at his expense, instruments that are not stored in strict conformance with the Manufacturer's recommendations.

1.7 SITE CONDITIONS

A. Operating Conditions:

1. Ambient Conditions: Provide equipment suitable for ambient conditions in accordance with environment requirement paragraphs specified below.
2. Field Locations: Field equipment may be subjected to ambient temperatures from 0-120° F, with direct radiation, and relative humidity from 45 to 96% with condensation. Field equipment will also experience rain, freezing rain, and snow.
3. Power Supply: Power supply will be 120 Vac, single-phase, 60 Hz commercial power. Voltage variations will be at least plus or minus 8%. Certain loops shall have integral power supply as indicated on the drawings.
4. Standard Signal:
 - a. Output Signal. Each instrument, which outputs a signal, shall output the standard 4-20 mA signal. The signal shall be constant over a load range of 0-600 Ω .
 - b. Input Signal.
 - 1) Electronic devices, such as controllers, match function devices, etc., shall have an input impedance of one mega-ohm minimum for an input signal of 1-5 Vdc.
 - 2) The 1-5 Vdc signal shall be developed by the standard 4-20 mA transmitted signal through a precision 250 Ω , 1 W resistor.
 - 3) These requirements allow several receiving units to monitor the same transmitting unit without causing any perturbation of the received signal.
 - 4) Receiving devices shall not be wired in parallel.

- B. Components, Hazardous Area Location:
 - 1. Assure equipment located in hazardous areas is suitable for applicable classification by use of explosion-proof housings or equipment and barriers approved as "intrinsically safe" by either UL or FM.
 - 2. Locate barriers in cabinets at hazardous area boundaries. Use dual barriers in loops in order to prevent grounding loop at the barrier.
- C. Components, Submerged Locations:
 - 1. Those instruments that are submerged in a liquid or are located in submersible area shall meet NEMA 6P ratings approval

1.8 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of the control system that fail(s) in materials or workmanship within the specified warranty period.
 - 1. Warranty Period: Two (2) years from the date of completion of the Site Acceptance Test.
 - 2. Cost for the removal, shipment, repair or replacement, and installation of components by CONTRACTOR shall be included in the warranty, as well as replacement of defective work.

PART 2 - PRODUCTS

2.1 DIFFERENTIAL GAUGE PRESSURE INDICATING TRANSMITTERS

- A. Transmitter shall be microprocessor based, intelligent type designed to measure differential pressure across two or more points as indicated on the Drawings.
- B. Manufacturers:
 - 1. Emerson/Rosemount; 2051
 - 2. Endress+Hauser; PMD75
 - 3. Siemens; Sitrans, P320
- C. Requirements:
 - 1. Function/Performance:
 - a. Range: -300 to 300 psi [-250 to 250 inches of water column]
 - b. Accuracy: 0.05 percent of span.
 - c. Operating Temperature: -20 to 80 degrees C.
 - d. Temperature Effect: Combined temperature effects shall be less than 0.2 percent of maximum span per 28 degrees C temperature change.
 - e. Output: 4-20 mA DC linear with pressure or level, with HART protocol. Zero adjustable over the range of the instrument provided calibrated span is greater than the minimum calibrated span.
 - f. Stability: 0.05 percent of upper range limit for 3 years.
 - g. Display: Digital indicator displaying pressure or level in the engineering units indicated in the Instrument Device Schedule.

- h. Configuration: Programmable using the local display and pushbuttons without the use of an external programming device.
 - i. Over Range Protection: Provide positive over range protection to 150 percent of the maximum pressure of the system being monitored by the instrument.
 - 2. Physical:
 - a. Process Connection: Stainless steel coplanar integral flange.
 - b. Enclosure/Housing: NEMA 4X (IP66), explosion proof, approved for Class I, Division 1, Groups C and D (EEx d IIC T5). Constructed of stainless steel.
 - c. Process Wetted Parts: Isolating diaphragm and other wetted metal parts shall be 316L stainless steel, unless otherwise indicated in the device schedule.
 - d. O rings: Glass-filled PTFE (Teflon).
 - e. Sensor Fill Fluid: Silicone.
 - f. Power Requirements: 24 VDC Loop powered.
 - g. Conduit Entry: 1/2-14 NPT.
- D. Accessories Required:
 - 1. When required by detail, provide a 316 stainless steel block & bleed shut off valve. Valves may be mounted directly to the instrument or separately mounted. Refer to Section 40 70 00 for requirements.
 - 2. Diaphragm seals or pressure seal rings shall be provided when shown Drawings or indicated in Instrument Schedule. Refer to Section 40 70 00 for requirements.
 - 3. [Provide NSF61 Drinking Water Approval certificate.]

2.2 LIQUID FILLED PRESSURE INDICATING DIAL GAUGE

- A. Gauge shall be C-type Bourdon tube.
- B. Manufacturers:
 - 1. Ashcroft
- C. Requirements:
 - 1. Function/Performance:
 - a. Range: Range of the gauge shall be the standard range of the manufacturer closest to the pressure range to be metered.
 - b. Accuracy: 1 percent of full scale
 - c. Operating Temperature: -40 to 140 degrees C.
 - 2. Physical:
 - a. Measuring Element: 316 stainless steel C-Type Bourdon tube
 - b. Connection: 1/2" NPT, 316 Stainless Steel
 - c. Case: 304 Stainless Steel with safety relief plug
 - d. Cover Ring: Polished 304 stainless steel
 - e. Lends: Instrument glass
 - f. Pointer: Black finished aluminum
 - g. Dial: 4" or 4 1/2" aluminum, white background with black scale, single scale UV resistant.

h. Fill Liquid: Glycerin

D. Accessories Required:

1. When required by detail, provide a 316 stainless steel block & bleed shut off valve. Valves may be mounted directly to the instrument or separately mounted. Refer to Section 40 70 00 for requirements.
2. Diaphragm seals or pressure seal rings shall be provided when shown Drawings or indicated in Instrument Schedule. Refer to Section 40 70 00 for requirements.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Coordination: Coordinate equipment delivery with completion of other work to minimize field handling of each device.

3.2 INSTALLATION

A. General Requirements:

1. Examine contract drawings and shop drawings for equipment in order to determine best arrangement for work as a whole.
2. Mount pipe, and connect field devices in accordance with contract drawings, specification and manufacturer's installation instructions.
3. Avoid tubing, piping and conduit interferences.
4. Locate equipment to be accessible for operation, maintenance and replacement.
5. Mount field transmitters 40 inches above floor, work platform, or as sensing line slope requires per manufacturer's instructions and in a location to allow convenient access for readability, calibration and maintenance. Coordinate tap location and meter location with ENGINEER prior to beginning work.

B. Device Mounting and Location Requirements.

1. Where specifications and contract drawings do not delineate precise installation procedures, use API RP550 as a guide to installation procedures. Submit sketch for OWNER approval prior to installation.
2. Locate field-mounted instruments as shown on drawings or as designated by the OWNER's representative or ENGINEER.
3. Secure support pipes, stands or brackets of material with sufficient strength to prevent excess vibration or movement.
4. Where field devices are shown as yoke mounted on a floor stand, a wall bracket fabricated from two channel sections, 1 5/8 inches sized, mounted to a wall or column is considered equal.
5. Make channel section long enough to mount at least two field devices. Use aluminum or stainless steel for fabrication.
6. Locate instrument-mounting stands within 5 feet of primary element, unless otherwise indicated. Make stands freely accessible.
7. Locate indicating instruments which must be visible for automatic control adjustment or manual operation to be visible from the adjustment or operating point. If plot or piping arrangement precludes this, make other provisions for indication at the

- adjustment or operation point.
8. Install instrument mounting stands after all conduit and pipe has been installed, except conduit serving devices on stand.
 9. Install instrument process piping and tubing from each primary shutoff valve to appropriate gauge, sensor, meter, analyzer, control panel connections, etc.
 10. Clean piping, tubing and components thereof prior to installation. This shall include but is not limited to special cleaning procedures for oxygen service when so required.
 11. Adjust pulsation dampers to eliminate rapid fluctuations of gauge or switch but to retain sensitivity to pressure changes.

3.3 COMMISSIONING

A. Commissioning:

1. Commissioning of instruments shall be in accordance with manufacturers' instructions, the product data and shop drawings, Section 40 61 00 "Instrumentation and Control System General Provisions" and 40 70 00 "Instrument Measuring Devices".

B. Manufacturers' Start-Up and Training Services

1. Where indicated in the product description, the instrument manufacturer or manufacturer's certified service representative shall provide start-up and training services. This work shall not be done by the Control System Integrator.
2. The start-up services shall be to calibrate, oversee the installations of the sensor, and start-up the sensor/transmitter in order to provide reliable measurement at the instrument and to a remote system. The vendor shall work with the Process Control System Integrator to verify the transmitter sends correct information to the remote system (i.e., that the scaling and units are the same at the instrument and on the remote operator interface).
3. While the instrument manufacturer or manufacturer's certified service representative is starting up the instrumentation, training shall be provided to the OWNER's instrumentation technicians. The training shall be in how to calibrate, install, troubleshoot, read the diagnostics, and maintain the sensor and transmitter.

C. General Requirements

1. Notify the OWNER/ENGINEER in writing at least 24 hours in advance of any test. All tests executed without such notification are invalid and shall be repeated. The OWNER/ENGINEER reserves the right to witness any test, inspection, calibration or start-up activity.
2. Perform commissioning of each device, subsystem and system under direct supervision of the individual manufacturer's factory-trained representative.
3. Reports:
 - a. Prepare Report showing test procedures, conditions and results of each test. In the test report, give applicable contract requirements, manufacturer's performance specifications, and permissible tolerances at each test point, actual values of test signals and actual values of test results.
 - b. Check off List:
 - 1) Maintain a check off list by loop number indicating tasks remaining to be

done to make loop operational.

- 2) Submit check off list form at least 60 days before commissioning starts.
- 3) Submit check off lists when requested by OWNER/ENGINEER.
- 4) Lists will be requested no more frequently than once a week.

D. Scheduling Guidelines for Commissioning Phases

1. Perform all commissioning in accordance with the instructions on the Contract Drawings, these Specifications, manufacturer's instruction manuals and the direction of the OWNER/ENGINEER.
2. Commission field devices, after installation of field instruments and prior to commissioning the instrument or the control panel.
3. After installation of the instrument or control panel and prior to loop commissioning, commission panel-mounted devices and systems.
4. After commissioning field devices and panel-mounted devices, commission loops.

E. Requirements

1. Transmitters and Receivers:
 - a. Remove shipping stops before starting with these procedures.
 - b. Have manufacturer's instruction manuals available.
 - c. Install miscellaneous components such as charts, illumination, etc., which have been supplied separately but are integral parts of equipment.
 - d. Test and exercise each instrument to demonstrate correct operation, first individually, then collectively as a functional network.
 - e. Check calibration of and recalibrate, where necessary, instruments at a minimum of 4 points over full operational range and prove instruments to be within specified accuracy.
 - f. Calibrate instruments individually and, where applicable, as loop (i.e., transmitter, controller and valve).
 - g. Specified accuracy for loop is defined as root-mean-square-summation (rms) of individual device specified accuracies.
 - h. Individual device specified accuracy requirements shall be as specified by contract requirements or by published manufacturer accuracy specifications whenever contract accuracy requirements are not specified.
 - i. Test each loop by applying simulated analog and/or discrete inputs to first elements of loop (i.e., applying simulated analog and/or discrete sensor signals) and measuring outputs from final elements of loop, (i.e., controllers, alarms, indicators, etc.).
 - j. Apply continuously variable analog inputs to verify proper operation and setting of discrete devices (i.e., alarms, etc.).
 - k. Make provisional settings on controllers, alarms, etc., during loop installation tests.
 - l. Prepare calibration report on each instrument and loop.
- m. Integrators, Ratio Relay, and Related Devices:
- n. Check devices in conformance with manufacturer's recommendations.

- o. Receiver integrators may be calibrated for proper operation and multiplication factor by feeding maximum input signal for a specified period of time using a stopwatch.
 - p. Ratio signals may be simulated to check proper ratio settings and output.
2. Start-up of Instruments:
- 1) Test each control loop under start-up and steady-state operating conditions to verify that proper and stable control is achieved using instruments in each instrument panel and control panel.
 - 2) Test control of final control elements using specified modes of manual and automatic control.
 - 3) Demonstrate bumpless transition between control station modes.
 - 4) Use signals from transducers, sensors and transmitters.
 - 5) Simulated input data signals may be used subject to prior written approval by the OWNER/ENGINEER.
- b. Set proportional band, reset rate, and derivative settings for each control as recommended by manufacturer.
 - c. Verify transient stability of each control loop by applying control signal disturbances, monitoring amplitude and decay rate of control parameter oscillations and making necessary controller adjustments to eliminate excessive oscillatory amplitudes and decay rates while retaining control sensitivity. Verify proper suppression of "reset wind-up."
3. Component Calibration Sheet
- a. CONTRACTOR shall be responsible for calibration and ringing out all devices that are to be interfaced with the distributed control system. This shall include devices purchased and installed under other contracts.
 - b. Each active instrument element (except simple hand switches, lights, etc.) and each I/O module shall have a Component Calibration Sheet. These sheets shall have the following information, spaces for data entry, and a space for signoff by the Process Control System Integrator or its subcontractor.
 - 1) Project name.
 - 2) Loop name.
 - 3) Component tag number or I/O module number.
 - 4) Component code number.
 - 5) manufacturer.
 - 6) Module number/serial number.
 - 7) Summary of function requirements, for example:
 - 8) For indicators and recorders: scale and chart ranges.
 - 9) For transmitters/converters: input and output ranges.
 - 10) For computing elements.
 - 11) I/O modules: required and actual inputs or outputs of 0, 10, 50, and 100% of span, rising and falling.
 - 12) Space for comments.

- 13) Space for signoff by Process Control System Integrator.
4. The Control System Integrator shall maintain the Loop Status Reports and Component Calibration Sheets at the job site and make them available to the ENGINEER at any time.

3.4 TESTING AND TRAINING

- A. Testing: Accomplished in accordance with the requirements of Section 40 61 21 "Instrumentation and Control System Testing and Commissioning" and Section 40 70 00 "Instrument Measuring Devices".
- B. Training: Accomplished in accordance with the requirements of Section 40 61 26 "Instrumentation and Control System Training" and Section 40 70 00 "Instrument Measuring Devices".

3.5 INSTRUMENT SCHEDULES

- A. Provide field instruments, as listed in the Instrument Schedules after END OF SECTION, of the range, type, in accordance with the mechanical drawings, control narratives, and P&ID's. Schedules may not be all inclusive.

END OF SECTION

[illegible]

**LIQUID-FILLED PRESSURE INDICATING DIAL GAUGE
INSTRUMENT SCHEDULE**

[illegible]

Notes:

1. Threaded Flush Diaphragm Seal
2. Diaphragm Pressure Seal
3. Pressure Sensing Ring
- 4
- 5

SECTION 40 74 00
TEMPERATURE MEASUREMENT

PART 1 - GENERAL

1.1 SUMMARY

- A. Section provides requirements for furnishing, installation, and services for temperature measurement instruments as detailed on the Drawings.
- B. Instrument schedule/tables have been provided at the end of the specification section. Schedule/Tables may not be all inclusive, CONTRACTOR shall determine his own schedule by referring to P&IDs and Mechanical sheets for instruments to be furnished and installed on the project.
- C. Related Sections include but are not necessarily limited to:
 - 1. Division 00 - Procurement and Contracting Requirements.
 - 2. Division 01 - General Requirements.
 - 3. Section 40 70 00 – Instrument Measuring Devices

1.2 REFERENCES

- A. Refer to Section 40 61 01 "Instrumentation and Control System Abbreviations and References." In case of conflict between the requirements of this Section and those of the listed standards, the requirements of this Section shall prevail.
- B. Where reference is made to one of the standards, the revision in effect at the time of bid opening shall apply.
- C. All material and equipment, for which a UL standard exists, shall bear a UL label. No such material or equipment shall be brought onsite without the UL label affixed.
- D. If the issue of priority is due to a conflict or discrepancy between the provisions of the Contract Documents and any referenced standard, or code of any technical society, organization or association, the provisions of the Contract Documents shall take precedence if they are more stringent or presumptively cause a higher level of performance. If there is any conflict or discrepancy between standard specifications, or codes of any technical society, organization or association, or between Laws and Regulations, the higher performance requirement shall be binding on the Control System Integrator unless otherwise directed by the OWNER/ENGINEER.

1.3 ADMINISTRATIVE REQUIREMENTS – NOT USED

1.4 SUBMITTALS

- A. General Requirements: Comply with the submittal requirements of Section 01 30 00 "Administrative Requirements", Section 40 61 00 "Instrumentation and Control System General Provisions", and as described below.
- B. Submit to the ENGINEER the following:
 - 1. Manufacturer's name and address, as well as Manufacturer's product name and complete model number for all equipment and accessories proposed for use
 - 2. Materials of Construction for equipment housing

3. Dimensions
 4. Measurement accuracy
 5. Measurement range for proposed level measurement system
 6. Enclosure NEMA rating(s) for components
 7. NEC Area Classification for model(s) chosen
 8. Power requirements and consumption in Voltage, Wattage and Amperage
 9. Output options
 10. Parts list for all components in sufficient detail to allow an item-by-item comparison with the Contract documents.
- C. Manufacturer's Instructions for the shipping, handling, storage, installation, start-up, operation, and maintenance, with schedule, of the equipment (in both hardcopy and digital formats). Include spare parts lists, instructions for instrument calibration and programming, instrument testing sheets, and schematics.
- D. Manufacturer's certification of satisfactory installation, calibration, and testing.
- E. Proof of Warranty as indicated.

1.5 QUALITY ASSURANCE

- A. Manufacturer:
1. Products:
 - a. Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include (unless "No Equal" is quantified), but are not limited to, have been named within the various paragraphs of this Section.
 - b. The listing of specific manufacturers within the various paragraphs of this Section does not imply acceptance of their products that do not meet the specified ratings, features and functions. manufacturers listed within the various paragraphs of this Section are not relieved from meeting these specifications in their entirety.
 - c. Manufacturer of the products under this Section shall be experienced, producing meters that are fully developed, field proven, and of standardized designs.
 - d. To the greatest extents possible, provide equipment that is the product of one (1) manufacturer in order to achieve standardization of operation, maintenance, spare parts, and Manufacturer's service.
 2. Services:
 - a. If indicated in the individual instrumentation paragraphs, the instrument manufacturer or manufacturer's certified service representative shall provide start-up and training services. This work shall not be done by the CONTRACTOR or Control System Integrator.
 - b. The start-up services shall be to calibrate, oversee the installations of the sensor, and start-up the sensor/transmitter in order to provide reliable measurement at the instrument and to a remote system. The vendor shall work with the Control System Integrator to verify the transmitter sends correct

information to the remote system (i.e., that the scaling and units are the same at the instrument and on the remote operator interface).

- c. While the instrument manufacturer or manufacturer's certified service representative is starting up the instrumentation, training shall be provided to the Owner's instrumentation technicians. The training shall be in how to calibrate, install, troubleshoot, read the diagnostics, and maintain the sensor and transmitter.
- d. An authorized Manufacturer's representative shall inspect the installation of all work furnished in this Section and shall provide a Manufacturer's certificate showing that the equipment has been satisfactorily installed, calibrated, and tested.

B. Installer:

- 1. Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Store all instruments in a dedicated structure with space conditioning to meet the recommended storage requirements provided by the Manufacturer.
- B. The Contractor shall be responsible for replacing, at his expense, instruments that are not stored in strict conformance with the Manufacturer's recommendations.

1.7 SITE CONDITIONS

A. Operating Conditions:

- 1. Ambient Conditions: Provide equipment suitable for ambient conditions in accordance with environment requirement paragraphs specified below.
- 2. Field Locations: Field equipment may be subjected to ambient temperatures from 0-120° F, with direct radiation, and relative humidity from 45 to 96% with condensation. Field equipment will also experience rain, freezing rain, and snow.
- 3. Power Supply: Power supply will be 120 Vac, single-phase, 60 Hz commercial power. Voltage variations will be at least plus or minus 8%. Certain loops shall have integral power supply as indicated on the drawings.
- 4. Standard Signal:
 - a. Output Signal. Each instrument, which outputs a signal, shall output the standard 4-20 mA signal. The signal shall be constant over a load range of 0-600 Ω .
 - b. Input Signal.
 - 1) Electronic devices, such as controllers, match function devices, etc., shall have an input impedance of one mega-ohm minimum for an input signal of 1-5 Vdc.
 - 2) The 1-5 Vdc signal shall be developed by the standard 4-20 mA transmitted signal through a precision 250 Ω , 1 W resistor.
 - 3) These requirements allow several receiving units to monitor the same transmitting unit without causing any perturbation of the received signal.
 - 4) Receiving devices shall not be wired in parallel.

- B. Components, Hazardous Area Location:
 - 1. Assure equipment located in hazardous areas is suitable for applicable classification by use of explosion-proof housings or equipment and barriers approved as "intrinsically safe" by either UL or FM.
 - 2. Locate barriers in cabinets at hazardous area boundaries. Use dual barriers in loops in order to prevent grounding loop at the barrier.
- C. Components, Submerged Locations:
 - 1. Those instruments that are submerged in a liquid or are located in submersible area shall meet NEMA 6P ratings approval

1.8 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of the control system that fail(s) in materials or workmanship within the specified warranty period.
 - 1. Warranty Period: Two (2) years from the date of completion of the Site Acceptance Test.
 - 2. Cost for the removal, shipment, repair or replacement, and installation of components by CONTRACTOR shall be included in the warranty, as well as replacement of defective work.

PART 2 - PRODUCTS

2.1 TEMPERATURE ELEMENT/TRANSMITTER

- A. Sensor
 - 1. Type: Shall be three wire platinum RTD.
 - 2. Manufacturers:
 - a. Smar
 - b. Rosemount
 - c. Foxboro
 - d. Siemens
 - e. Or equal.
 - 3. Requirements:
 - a. Function/Performance:
 - 1) Range: As required by the measuring range indicated in the Instrument Device Schedule.
 - 2) Accuracy: Resistance versus temperature shall meet performance requirements of IEC 751 Tolerance Class B.
 - 3) Maximum Thermal Response Time: 9 seconds to reach 50 percent sensor response when tested in flowing water according to IEC 751.
 - 4) Temperature Coefficient: 100 ohms at 0 degrees C, with temperature coefficient of 0.00385 ohms/ohm/degree C.
 - 5) Self Heating: Maximum self heating factor of 0.15 degrees K/mW when measured as defined in DIN EN 60751.

- b. Physical:
 - 1) 316 stainless steel sheath.
 - 2) Spring loaded sensor assembly.
 - 3) Sensor shall penetrate into the pipe where it is installed, by 1/3 to 1/2 of the pipe diameter.
 - 4) Sensor shall be provided with covered connection head. Sensor and connection head shall be NEMA 4X (IP66). Where indicated on the drawings to be installed in a hazardous location, the sensor assembly shall be explosion proof approved for Class I, Division 1, Groups C and D (EEx d IIC).
- 4. Accessories Required:
 - a. Sensors shall be installed in 316L stainless steel thermowells. Thermowells shall be threaded except for those installed in ozone system piping which shall be welded.
 - b. Extensions shall be provided for sensors installed in insulated pipe. Extensions shall clear the pipe insulation. Extensions shall also be provided where process temperatures are above 100 degrees C.
- B. Transmitter
 - 1. Type: Remotely mounted, intelligent transmitter compatible with sensor provided.
 - 2. Manufacturers:
 - a. Smar TT301
 - b. ABB TTF300
 - c. Rosemount 3144P
 - d. Foxboro RTT20.
 - e. Siemens SITRANS TF
 - f. Or equal.
 - 3. Requirements:
 - a. Function/Performance:
 - 1) Digital Accuracy: plus or minus 0.2 degrees C.
 - 2) Stability: plus or minus 0.1 percent or 0.1 degrees C, whichever is greater, for 24 months.
 - 3) Operating Temperature: -40 to 85 degrees C.
 - 4) Output: 4-20 mA DC linear with temperature. Transmitter shall also communicate using HART protocol.
 - 5) Output may be set as difference or average of two measured temperatures.
 - 6) Output may be configured for custom curves including Callendar-Van Dusen correction.
 - 7) Display: Digital indicator displaying temperature in engineering units.
 - 8) Diagnostics:
 - 9) Self diagnostics with transmitter failure driving output to above or below out of range limits.
 - 10) LED indication of transmitter faults.

- 11) Simulation capability for inputs and loop outputs.
- 12) Test terminals available to ease connection for test equipment without opening the loop.
 - a) Run-time clock available to determine usage for warranty purposes. 5-year warranty on this clock reading is included.
 - b. Physical:
 - 1) Enclosure shall be NEMA 4X (IP66). Where indicated on the drawings to be installed in hazardous locations, the transmitter shall be explosion proof approved for Class I, Division 1, Groups C and D (EEx d IIC).
 - 2) Power supply shall be 24 VDC loop power.
4. Accessories Required:
 - a. Sensors shall be installed in 316L stainless steel thermowells. Thermowells shall be threaded except for those installed in ozone system piping which shall be welded.
 - b. Extensions shall be provided for sensors installed in insulated pipe. Extensions shall clear the pipe insulation. Extensions shall also be provided where process temperatures are above 100 degrees C.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Coordination: Coordinate equipment delivery with completion of other work to minimize field handling of each device.

3.2 INSTALLATION

- A. General Requirements:
 1. Examine contract drawings and shop drawings for equipment in order to determine best arrangement for work as a whole.
 2. Mount pipe, and connect field devices in accordance with contract drawings, specification and manufacturer's installation instructions.
 3. Avoid tubing, piping and conduit interferences.
 4. Locate equipment to be accessible for operation, maintenance and replacement.
 5. Mount field transmitters 40 inches above floor, work platform, or as sensing line slope requires per manufacturer's instructions and in a location to allow convenient access for readability, calibration and maintenance. Coordinate tap location and meter location with ENGINEER prior to beginning work.
- B. Device Mounting and Location Requirements.
 1. Where specifications and contract drawings do not delineate precise installation procedures, use API RP550 as a guide to installation procedures. Submit sketch for OWNER approval prior to installation.
 2. Locate field-mounted instruments as shown on drawings or as designated by the OWNER's representative or ENGINEER.
 3. Secure support pipes, stands or brackets of material with sufficient strength to prevent excess vibration or movement.

4. Where field devices are shown as yoke mounted on a floor stand, a wall bracket fabricated from two channel sections, 1 5/8 inches sized, mounted to a wall or column is considered equal.
5. Make channel section long enough to mount at least two field devices. Use aluminum or stainless steel for fabrication.
6. Locate instrument-mounting stands within 5 feet of primary element, unless otherwise indicated. Make stands freely accessible.
7. Locate indicating instruments which must be visible for automatic control adjustment or manual operation to be visible from the adjustment or operating point. If plot or piping arrangement precludes this, make other provisions for indication at the adjustment or operation point.
8. Install instrument mounting stands after all conduit and pipe has been installed, except conduit serving devices on stand.
9. Install instrument process piping and tubing from each primary shutoff valve to appropriate gauge, sensor, meter, analyzer, control panel connections, etc.
10. Clean piping, tubing and components thereof prior to installation. This shall include but is not limited to special cleaning procedures for oxygen service when so required.
11. Adjust pulsation dampers to eliminate rapid fluctuations of gauge or switch but to retain sensitivity to pressure changes.

3.3 COMMISSIONING

A. Commissioning:

1. Commissioning of instruments shall be in accordance with manufacturers' instructions, the product data and shop drawings, Section 40 61 00 "Instrumentation and Control System General Provisions."

B. Manufacturers' Start-Up and Training Services

1. Where indicated in the product description, the instrument manufacturer or manufacturer's certified service representative shall provide start-up and training services. This work shall not be done by the Control System Integrator.
2. The start-up services shall be to calibrate, oversee the installations of the sensor, and start-up the sensor/transmitter in order to provide reliable measurement at the instrument and to a remote system. The vendor shall work with the Process Control System Integrator to verify the transmitter sends correct information to the remote system (i.e., that the scaling and units are the same at the instrument and on the remote operator interface).
3. While the instrument manufacturer or manufacturer's certified service representative is starting up the instrumentation, training shall be provided to the OWNER's instrumentation technicians. The training shall be in how to calibrate, install, troubleshoot, read the diagnostics, and maintain the sensor and transmitter.

C. General Requirements

1. Notify the OWNER/ENGINEER in writing at least 24 hours in advance of any test. All tests executed without such notification are invalid and shall be repeated. The OWNER/ENGINEER reserves the right to witness any test, inspection, calibration or start-up activity.

2. Perform commissioning of each device, subsystem and system under direct supervision of the individual manufacturer's factory-trained representative.
 3. Reports:
 - a. Prepare Report showing test procedures, conditions and results of each test. In the test report, give applicable contract requirements, manufacturer's performance specifications, and permissible tolerances at each test point, actual values of test signals and actual values of test results.
 - b. Check off List:
 - 1) Maintain a check off list by loop number indicating tasks remaining to be done to make loop operational.
 - 2) Submit check off list form at least 60 days before commissioning starts.
 - 3) Submit check off lists when requested by OWNER/ENGINEER.
 - 4) Lists will be requested no more frequently than once a week.
- D. Scheduling Guidelines for Commissioning Phases
1. Perform all commissioning in accordance with the instructions on the Contract Drawings, these Specifications, manufacturer's instruction manuals and the direction of the OWNER/ENGINEER.
 2. Commission field devices, after installation of field instruments and prior to commissioning the instrument or the control panel.
 3. After installation of the instrument or control panel and prior to loop commissioning, commission panel-mounted devices and systems.
 4. After commissioning field devices and panel-mounted devices, commission loops.
- E. Requirements
1. Transmitters and Receivers:
 - a. Remove shipping stops before starting with these procedures.
 - b. Have manufacturer's instruction manuals available.
 - c. Install miscellaneous components such as charts, illumination, etc., which have been supplied separately but are integral parts of equipment.
 - d. Test and exercise each instrument to demonstrate correct operation, first individually, then collectively as a functional network.
 - e. Check calibration of and recalibrate, where necessary, instruments at a minimum of 4 points over full operational range and prove instruments to be within specified accuracy.
 - f. Calibrate instruments individually and, where applicable, as loop (i.e., transmitter, controller and valve).
 - g. Specified accuracy for loop is defined as root-mean- square-summation (rms) of individual device specified accuracies.
 - h. Individual device specified accuracy requirements shall be as specified by contract requirements or by published manufacturer accuracy specifications whenever contract accuracy requirements are not specified.
 - i. Test each loop by applying simulated analog and/or discrete inputs to first elements of loop (i.e., applying simulated analog and/or discrete sensor signals)

- and measuring outputs from final elements of loop, (i.e., controllers, alarms, indicators, etc.).
- j. Apply continuously variable analog inputs to verify proper operation and setting of discrete devices (i.e., alarms, etc.).
- k. Make provisional settings on controllers, alarms, etc., during loop installation tests.
- l. Prepare calibration report on each instrument and loop.
- m. Integrators, Ratio Relay, and Related Devices:
- n. Check devices in conformance with manufacturer's recommendations.
- o. Receiver integrators may be calibrated for proper operation and multiplication factor by feeding maximum input signal for a specified period of time using a stopwatch.
- p. Ratio signals may be simulated to check proper ratio settings and output.
- 2. Start-up of Instruments:
 - 1) Test each control loop under start-up and steady-state operating conditions to verify that proper and stable control is achieved using instruments in each instrument panel and control panel.
 - 2) Test control of final control elements using specified modes of manual and automatic control.
 - 3) Demonstrate bumpless transition between control station modes.
 - 4) Use signals from transducers, sensors and transmitters.
 - 5) Simulated input data signals may be used subject to prior written approval by the OWNER/ENGINEER.
- b. Set proportional band, reset rate, and derivative settings for each control as recommended by manufacturer.
- c. Verify transient stability of each control loop by applying control signal disturbances, monitoring amplitude and decay rate of control parameter oscillations and making necessary controller adjustments to eliminate excessive oscillatory amplitudes and decay rates while retaining control sensitivity. Verify proper suppression of "reset wind-up."
- 3. Component Calibration Sheet
 - a. CONTRACTOR shall be responsible for calibration and ringing out all devices that are to be interfaced with the distributed control system. This shall include devices purchased and installed under other contracts.
 - b. Each active instrument element (except simple hand switches, lights, etc.) and each I/O module shall have a Component Calibration Sheet. These sheets shall have the following information, spaces for data entry, and a space for signoff by the Process Control System Integrator or its subcontractor.
 - 1) Project name.
 - 2) Loop name.
 - 3) Component tag number or I/O module number.
 - 4) Component code number.
 - 5) manufacturer.

- 6) Module number/serial number.
 - 7) Summary of function requirements, for example:
 - 8) For indicators and recorders: scale and chart ranges.
 - 9) For transmitters/converters: input and output ranges.
 - 10) For computing elements.
 - 11) I/O modules: required and actual inputs or outputs of 0, 10, 50, and 100% of span, rising and falling.
 - 12) Space for comments.
 - 13) Space for signoff by Process Control System Integrator.
4. The Control System Integrator shall maintain the Loop Status Reports and Component Calibration Sheets at the job site and make them available to the ENGINEER at any time.

3.4 TESTING AND TRAINING

- A. Testing: Accomplished in accordance with the requirements of Section 40 61 21 "Instrumentation and Control System Testing and Commissioning" and Section 01 70 00 "Execution and Closeout Requirements."
- B. Training: Accomplished in accordance with the requirements of Section 40 61 26 "Instrumentation and Control System Training" and Section 01 70 00 "Execution and Closeout Requirements."

3.5 INSTRUMENT SCHEDULES

- A. Provide field instruments, as listed in the Instrument Schedules after END OF SECTION, of the range, type, in accordance with the mechanical drawings, control narratives, and P&ID's. Schedules may not be all inclusive.

END OF SECTION

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SECTION 43 31 13.13
ACTIVATED CARBON LIQUID PURIFICATION FILTERS

PART 1 - GENERAL

1.1 SUMMARY

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Related sections:
 - 1. Division 0 - Bidding Requirements, Contract Forms, and Conditions of the Contract.
 - 2. Division 1 - General Requirements.
 - 3. Section 05 05 19 "Post Installed Concrete Anchors"
 - 4. Section 09 90 00 "Painting and Protective Coatings"
 - 5. Division 26 - Electrical Requirements.
 - 6. Division 40 - Process Control System.
 - 7. Section 44 43 00 "Filter Media"

1.2 WORK INCLUDED

- A. Section includes:
 - 1. Furnish, install, startup and test one (1) pair of lead-lag pressure filter vessels as shown in the Contract Drawings and specified. The vessel pair shall include influent, effluent, backwash supply, and backwash waste, piping with valves, carbon fill and discharge piping with valves, vent and pressure relief piping, sample taps, wash water piping and utility connections, fasteners, anchor bolts design, supports, and all items necessary for a complete system.
- B. Description:
 - 1. Supplier shall be responsible for the design, materials, furnishing, testing, and training for a completely pre-engineered granular activated carbon (GAC) liquid adsorption filter system used to remove per- and poly-fluorinated (PFAS) compounds from groundwater.
 - 2. This specification describes a complete adsorption filter system to be furnished by a single responsible equipment Supplier that assumes system and process responsibility to provide a completely integrated and functional system with equipment and appurtenances described in this section, including but not limited to vessel face piping, valves with actuators, media, and instruments. Contractor shall provide wiring for power supply, controls, and programming. The equipment shall be provided with the flexibility to operate with ion exchange resin in the future.
 - 3. The Supplier's representative shall provide on-site supervision during installation of the filter system and shall provide inspection, calibration, startup, functional testing, and training in the operation and maintenance of the filter system.
 - 4. The influent and effluent pipe configuration allows series (lead/lag) and parallel only operating modes. Lead/lag operation allows either;
 - a. Flow from the influent flange to Vessel 1, to the pipe manifold, to Vessel 2, to the pipe manifold then to the effluent flange, or

- b. Flow from the influent flange to Vessel 2, to the pipe manifold, to Vessel 1, to the pipe manifold then to the effluent flange.
- c. The change in flow pattern is accomplished with a manual change of valve positions.
- d. Additionally, the influent and effluent pipe configuration shall allow for one vessel to operate in forward flow while the other vessel is offline, or operates in reverse flow (flush/backwash). This operation shall allow either:
 - 1) Vessel 1 to operate in forward flow while Vessel 2 is offline or operating in reverse flow, or
 - 2) Vessel 2 to operate in forward flow while Vessel 1 is offline or operating in reverse flow.
 - 3) The change in flow pattern is accomplished with a manual change of valve positions.

1.3 QUALITY ASSURANCE

A. Referenced Standards

- 1. ASME Section VIII, Division 1, Boiler and Pressure Vessel Code
- 2. ASME BPVC Section IX - Welding, Brazing, and Fusing Qualifications: Qualification Standard for Welding, Brazing, and Fusing Procedures; Welders; Brazers; and Welding, Brazing and Fusing Operators.
- 3. ASME/ANSI B16.5
- 4. Steel Structures Painting Council Surface preparation Specifications and National Association of Corrosion Engineers
- 5. ASME Section II, Materials, Parts A, B, and C
- 6. AWWA B604, Standard for Granular Activated Carbon
- 7. NSF/ANSI Standard 61: Drinking Water System Components – Health Effects
- 8. NSF/ANSI Standard 372: Drinking Water System Components – Lead Content
- 9. SSPC-SP5/NACE No. 1: White Metal Blast Cleaning
- 10. SSPC-SP6/NACE No. 3: Commercial Blast Cleaning

B. Supplier's supervision report of the installation is required prior to final acceptance.

C. The supplier shall furnish and be responsible for a complete system including instrumentation and connections. Provide all pertinent information and requirements for instrumentation to the electrical contractor. Contractor shall be responsible for system controls.

D. Supplier Requirements:

- 1. All equipment shall be the product of a supplier having at least ten (10) United States of America installations of the type being proposed, each with a minimum of five (5) years of satisfactory service.
- 2. A list of similar installations shall be furnished with the submittal including names and telephone numbers of contacts.
- 3. All equipment of each type specified in this section shall be supplied by a single SUPPLIER who is fully experienced, reputable, and qualified in the manufacture of

the equipment to be furnished. The equipment shall be designed, constructed, and installed in accordance with the best practices and methods.

4. SUPPLIER shall maintain a complete stock of spare parts commonly needed for the equipment specified and shall be capable of shipping spare parts within 48 hours of request.
- E. All surfaces and materials in contact with water, or in contact with a chemical being added to water that is being treated for potable use, shall conform to ANSI/NSF 61 and be certified by an organization accredited by ANSI, or shall meet the Colorado Department of Public Health and Environment (CDPHE) requirements for contact with potable water.
- F. Welding Operations
 1. Requirements for Welding Operations:
 - a. In accordance with AWWA C220, qualify welding processes and welding operators according to one of the following codes:
 - 1) Sec. IX, Part A, of the ASME Boiler and Pressure Vessel Welding Code, and
 - 2) AWS D1.6 "Structural Welding Code-Stainless Steel."
 - b. Certify that each welder has satisfactorily passed AWS qualification tests for welding processes involved and, if pertinent, has undergone recertification.
 - c. Welder's current certification shall be less than one year old.
 2. All shop welds shall be visually inspected by the fabricator's quality control division.
 3. Field welding will not be permitted.
 4. All plates and structural members shall have a minimum thickness of 1/4 inch. Structural steel will conform to ASTM A-36 requirements while all steel pipe will conform to the ASTM A-53 Grade B designation.
 5. All fasteners including anchor bolts, nuts and washers shall be AISI 316 stainless steel furnished in accordance with ASTM A193.

1.4 SUBMITTALS

- A. Action Submittals:
 1. Product Data:
 - a. Submit Supplier's descriptive literature and product specifications for each product. Clearly note the selected materials and/or options chosen for this project. Provide a detailed specifications catalog bulletin illustrating assembly and all components and data describing the materials of construction, thickness, and coatings.
 - b. Installation instructions.
 - c. Supplier's recommended procedures for jobsite storage of equipment, handling, and erection.
 - d. Provide NSF/ANSI 61 and NSF/ANSI 372 certifications for products or surfaces in contact with filtered water.
 2. Design Data:
 - a. Structural design calculations for the seismic / hydrostatic pressure vessels, stamped and sealed by a professional engineer licensed to practice in the State of Colorado. Calculations shall include, but not be limited to, the

following:

- 1) Dead loads.
- 2) Environmental loads (seismic).
- 3) Anchor design.

3. Shop Drawings:

- a. Provide data and descriptions to confirm system materials and components comply with product descriptions noted herein, including design pressure, dimensions, and capacity.
 - b. Submit detailed drawings of special accessory components not included in the Supplier's product data.
 - c. Indicate typical layout including all proposed system components with dimensions, thicknesses, clearances required, and sizes indicated. Indicate total weights of the product when empty, with media only, and with media and water (operating weight). Drawings shall detail orientation of the tank openings, nozzles, flange connections and supports for piping and appurtenances, and anchoring devices and locations. Drawings shall detail lay lengths of all piping, dimensions for connection locations, and all other necessary dimensions so that the Contractor can coordinate connecting piping.
 - d. Computational Fluid Dynamic (CFD) Modeling: Provide CFD Model with the listed project parameters of design flow rate, vessel size and media volume with units of ft/sec to show proper flow distribution from the inlet distributor, through the media bed, and down through the underdrain
 - e. Construction Details: Construction details for assembly and other special configurations, including:
 - 1) Tank support and anchor lugs, including attachment details.
 - 2) Tank nozzles and installation, including cutout reinforcement, gusseting, and similar items.
 - 3) Tank lateral or other support fabrication details, including platform attachment clips and/or shoulders.
 - 4) Anchorage detail and details of supports
 - f. System flow diagram showing all valves, components, instrumentation, and utilities.
 - g. Pressure drop information across the system for clean bed and dirty bed.
 - h. Material specifications for pipe, fittings, and instrumentation.
 - i. Specifications for vessel lining and specifications for vessel painting, including a color chart showing the available colors for external tank coating.
4. Test and Evaluation Reports:
- a. Equipment installation report with field test data and test records in accordance with Section 01 75 00, "Equipment Testing and Facility Startup".

B. Informational Submittals:

1. Source Quality Control Submittals
2. Field / Site Quality Control Submittals

3. Qualification Statements
4. Previous Installations List
5. Certificates:
 - a. Supplier's Certification of Compliance vessel was manufactured in accordance with these specifications.
 - b. Special shipping, storage and protection, and handling instructions.
 - c. Supplier's instructions for installation.
 - d. Supplier's Certificate of Proper Installation.
- C. Closeout Submittals:
 1. Operation and Maintenance Data: Complete operation and maintenance data for all equipment in accordance with Section 01 78 23 "Operation and Maintenance Data".
 2. Warranty Documentation.
 3. Record Documentation.
- D. Maintenance Material Submittals:
 1. Spare Parts / Extra Stock Materials
 - a. List of recommended spare parts.
 - b. Location of nearest stocking distributor of spare parts

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Deliver, handle, and store all components to be installed under this section in accordance with the Supplier's written Pre-Installation Delivery, Storage, and Handling Instructions and the requirements of Section 01 60 00 "Product Requirements".
- B. All assemblies shall be shop tested prior to shipment.
- C. All parts and components shall be factory-assembled in sections convenient for field handling and installation but requiring the minimum amount of work for field assembly.
- D. All assembled parts and components ready for shipment shall be securely bundled, coiled, or crated, and adequately protected from damage and corrosion during shipment and storage.
- E. The equipment shall be shipped by the Supplier, Freight on Board (FOB) to the project location.
- F. Contractor shall be responsible for unloading equipment at the project location and for protection of all equipment against damage during on-site storage and installation. Damaged equipment and materials will be replaced, at no charge to Owner, by the Contractor at the Contractor's expense as determined by the Engineer.
- G. Equipment should be stored onsite by the Contractor per Supplier's recommendations prior to installation.

1.6 SITE CONDITIONS

- A. Environmental Conditions:
 1. All equipment including controls and drives specified herein shall be specifically designed to be installed for this service and the environment encountered in this

installation, unless noted otherwise.

2. All equipment shall be designed and capable of operation at ambient temperatures of 33 degrees F to 140 degrees F.

1.7 WARRANTY

- A. The warranty shall meet the requirements of Section 01 78 36, "Warranties".
- B. All equipment furnished under this section shall have a special warranty in accordance with the Contract Documents for a period of two (2) years after Substantial Completion of the project. The costs of removal, shipment, repair, and installation by Contractor shall be included in the warranty.

1.8 MAINTENANCE

- A. As a minimum, the following spare parts shall be furnished.
 1. A quantity of fasteners equal to 10-percent of each type of fastener used with the exception of anchor bolts.
 2. One set of gaskets for each manway.
 3. Special tools necessary to maintain the equipment.
 4. Other parts recommended by the Supplier as typically needed in the first two years of operation.

PART 2 - PRODUCTS

2.1 SUPPLIERS

- A. Subject to compliance with the Contract Documents, the following suppliers are acceptable:
 1. AqueoUS Vets, PF 12-520 LOW PRO
 2. Calgon Carbon Corporation, Model 12 Adsorption System
 3. Or Engineer Approved Equivalent
- B. The listed suppliers must fulfill all specified requirements. The equipment supplier shall be responsible for the design, arrangement, and performance of all equipment supplied under this Section.
- C. It shall be clearly understood that listing of acceptable suppliers by name will in no way constitute a waiver of the Specifications. Final acceptance will be based on full conformity with the Specifications.

2.2 VESSEL

- A. Design Requirements
 1. The pressure vessels shall be designed per the following requirements:

Description	Units	Value
System Performance		
Design Capacity	gpm	650
Equipment Tags	-	TNK-601, TNK-602

Material	-	Carbon Steel
Type	-	Vertical Tank
Quantity	No.	2
Maximum Vessel Diameter	Ft	12
Maximum Overall Vessel Height (from bottom of support structure to top of inlet piping)	Ft	14.5
Minimum Straight Shell Height	Ft	5
Maximum Hydraulic Loading Rate at Design Flow	gpm/sf	5.7
Minimum Empty Bed Contact Time at Design Flow	Minutes	7.8
Minimum Working Pressure	Psi	125
Design Temperature	°F	140
Total Pressure Drop ¹	Psi	4

1. Total pressure drop is the pressure drop across two vessels in series, without media, at the design flow rate.
- B. The systems shall be shipped to the job site in the least number of pieces permissible for transportation. All vessel face piping must come preassembled on the vessel with only the 8-inch influent and effluent piping shipped loose to connect to the preassembled manifold in the field.
- C. The vessel(s) shall be designed, constructed, and stamped in accordance with Section VIII, Division 1 of the ASME Boiler and Pressure Vessel Code requirements for pressure vessels. Minimum thicknesses shall be furnished in accordance with ASME code requirements and registered with the National Board. Verification of ASME code design to include calculated head and shell thicknesses. Vessels shall be fabricated in a facility holding a current ASME U-stamp.
- D. Vessels shall be vertical, cylindrical pressure vessels with 2:1 elliptical head and bottom. The vessel shall be sufficient to allow for 30-percent expansion of the media bed during backwash.
- E. Vessels shall be fabricated of carbon steel, conforming to ASTM A516 grade 70.
- F. Structural Support
1. The vessels, system piping, and all other shop assembled appurtenances of the system shall be reinforced and supported with structural members as required such that the assembled components can be transported and off-loaded without distortion. The components shall be provided with lifting lugs to enable setting the equipment on a concrete foundation with a suitable capacity crane. System supports shall be designed and drilled for installation and anchoring to a concrete slab. Supplier shall be responsible for anchorage design. Contractor shall be responsible for furnishing of anchors.
 - a. Structural components shall conform to ASTM A 36 specifications.
 - b. Vessels shall be free-standing with four (4) structural steel support legs.

2. The vessel will be structurally sufficient to meet the requirements for seismic characteristics as indicated in the Contract Drawings for the version of the International Building Code which is utilized by the Owner at the time of shop drawing submission.
 - a. Seismic Design Class: D
 - b. Importance Factor: 1.5
- G. Nameplate:
 1. SUPPLIER shall furnish all equipment with a stainless-steel nameplate securely affixed in a conspicuous place on the equipment showing the equipment tag name, ratings, serial number, model number, equipment supplier name, and other pertinent nameplate data.
- H. Underdrain
 1. Each vessel shall be equipped with an underdrain and septa system designed to avoid short circuiting, facilitate even flow distribution, minimize pressure loss, and facilitate removal of GAC media without the need to open vessel manways.
 2. All underdrain material internal to the vessel or in contact with GAC (including septa) shall be 316L stainless steel.
 3. The underdrain shall be external ring header type and shall be designed such that, following initial backwashing to remove fines, the media will be retained by the bottom underdrain screens when the vessel is in normal operation. Screens shall be suitable for use with ion exchange resins in the future.
 4. Underdrains shall be designed to withstand the weight of the media bed in a flooded state.
- I. Inlet Distributor
 1. Each vessel shall be provided with an upper inlet distributor connected to the influent nozzle, designed to facilitate the distribution of water flow evenly across the media bed and to allow for the free passage of accumulated carbon fines to waste while not plugging during backwash.
 2. The inlet distributor open area shall be at least 1.5 times that of the underdrain system, and shall not be closer than 3 inches to the upper head.
 3. Inlet distributor and supports shall be 316 stainless steel.
 4. Inlet distributor shall be suitable for use with ion exchange resins in the future.
- J. Vessel Access
 1. Provide manways as indicated in the Vessel Schedule at the end of this section.
- K. Coatings and Linings
 1. Vessels shall receive independent NACE certified inspection of surface preparation and coating/lining prior to shipment. The Supplier shall pay for certified inspection and any required re-testing of the lining prior to shipment.
 2. Linings: The interior surfaces of the vessel will be lined with a nominal lining thickness of 35 to 45 mil dry film thickness (dft) The lining material meets the requirements of NSF/ANSI 61 when applied and cured per the Supplier's requirements.
 - a. Interior lining must be certified to NSF/ANSI Standard 61 for direct potable

- water contact.
- b. The vessel internal surface will be blasted to a white metal finish per SSPC-SP5.
 - c. All edges shall be ground to 1/8" minimum radius per NACE Standard #RP0178-2007.
 - d. Lining shall extend through penetrations to the flange.
 - e. The following linings are acceptable:
 - 1) Carboline Plasite 4110, vinyl ester lining
 - 2) Enviroline 230, phenolic epoxy
 - 3) Blome International TL-220S AR, vinyl ester lining
 - 4) Carboline Reactamine 760, aromatic polyurethane hybrid
 - 5) Sherwin Williams SherPlate PW, epoxy amine lining
3. Coatings: The exterior surface of the vessels shall be surface prepared and painted in accordance with section 09 90 00 "Painting and Protective Coatings". Color shall be selected by the Owner.

2.3 MEDIA

- A. Media to be furnished and installed by vessel supplier or separate supplier and shall be in accordance with the requirements of Section 44 43 00 "Filter Media".

2.4 PIPING

- A. The process and utility piping on the adsorption system, per vessel, will include:
 - 1. Process piping, including influent water to the system, treated water (effluent), backwash water supply and backwash waste.
 - 2. Vessel washdown piping.
 - 3. Air release/vacuum valve drain.
 - 4. GAC fill and discharge piping.
 - 5. Sample piping.
 - 6. Refer to the Nozzle Schedule and Piping Schedule at the end of this Section for pipe sizes of each nozzle type.
- B. Vessel shall be fabricated with appropriate bracket supports for all piping.
- C. The piping manifold will be provided with a structural steel support frame for support of the piping module.
- D. All vessel piping must come preassembled on the vessel to field with the exception of the influent and effluent piping.
- E. Refer to the Piping Schedule at the end of this section for additional requirements.
- F. Process Piping:
 - 1. Process piping shall be flanged schedule 40 carbon steel piping. Refer to section 40 05 24 "Piping System, Steel Pipe" for requirements. Refer to section 09 90 00 "Painting and Protective Coatings" for coating requirements.
- G. Vessel Vent and Washdown:
 - 1. Vent and washdown piping shall be welded or threaded Schedule 40 galvanized steel.

Refer to section 40 05 24 "Piping System, Steel Pipe" for requirements.

2. GAC Exchange Piping

1. GAC fill and discharge piping shall be schedule 40 carbon steel with Fusion bonded epoxy or polypropylene lining. Refer to section 09 90 00 "Painting and Protective Coatings" for coating requirements.

H. Sample Taps

1. In-bed Sample Taps

- a. Each adsorber will be provided with three side sample nozzles for use with in-bed water sample probes. Refer to the Vessel Schedule for size. In each vessel there shall be three taps located at 25, 50, and 75 percent of the media bed depth.
- b. Sample probes consist of a stainless-steel pipe with a stainless-steel slotted septum to collect a water sample from within the carbon bed. The sample probe will be inserted through a 2-inch flanged nozzle and will be provided with stainless steel tubing drop line and stainless-steel shutoff valve external to the adsorber.

2. Sample outlets

- a. Sample outlets without probes, shall be located on the inlet and outlet piping of each vessel. Refer to paragraph 2.8.
3. All sample piping shall be 1/2-inch-diameter stainless steel tubing with 1/2-inch diameter stainless steel ball valves. Refer to Section 40 05 51 "Common Requirements for Process Valves".

2.5 VALVES AND VALVE ACTUATION

A. Butterfly Valves

1. The process and utility piping, excluding GAC fill, GAC discharge, and ARV drain piping, will be equipped with flanged butterfly valves to direct flow. A total of eleven (11) 8-inch diameter butterfly valves shall be supplied to accommodate the process and backwash functions. Three (3) valves are needed for backwash supply (two (2) manual valves and one (1) electrically actuated valve), two (2) valves are needed for backwash waste, two (2) valves are needed for influent isolation, two (2) valves for effluent isolation, and two (2) valves for staging of the vessels.
2. Refer to section 40 05 64 "Butterfly Valves" for requirements.
3. Operators:
 - a. Vessel effluent valves and the common backwash supply valve shall be electrically actuated. Contractor shall provide wiring for power supply and controls for valve actuator (1) for the modulating backwash supply valve. All other valves shall be manual. Refer to section 40 05 51 "Common Requirements for Process Valves" for manual operator requirements.
 - b. Electric Actuators: Motor operators shall be quarter turn type and have a cast aluminum NEMA 4 watertight housing, open and closed limit switches, open and closed torque switches, end of travel stops, declutching handwheel manual override, self-locking worm gears, dial position indicator, and anti-condensation heater. Operators shall use 120VAC single phase power. Electric

motor operators shall be Bray Series 70 or engineer pre-approved equal. Electric operators shall include a control station integral with the operator with a Local/Remote control switch, an Open/Stop/Close control switch, and indicator lights for full open and full close status. Electric operators shall provide contacts rated 5A at 120V to indicate full open and full close position and when the operator is in Remote, and accept maintained contact open and close command signals for remote operation of the valve when in remote mode.

B. Ball Valves

1. GAC fill and discharge piping will be equipped with full port ball valves for isolation.
2. Refer to Section 40 05 51 "Common Requirements for Process Valves" for ball valve requirements, including material.

C. Combination Air Release/Vacuum (ARV)

1. Each vessel shall be equipped with an air release/vacuum valve at the highest point of the vessel. Supplier shall be responsible for sizing the air release/vacuum valve.
2. Two (2) 1-inch ball valves will be provided to isolate the air release valve:
 - a. One ball valve positioned between the influent pipe and the air release valve, and
 - b. The second mounted at the bottom of the air release piping (at 4 feet above finished floor).
3. Refer to Section 40 05 78 "Air Release and Vacuum Release Valves" and the Contract Drawings.

D. Pressure Relief:

1. Provide pressure relief system consisting of one pressure-relief valves (PRV) for each vessel, sized to maintain a pressure less than the maximum allowable working pressure at a flow rate of 1,000 gpm. Valve shall full nozzle design with side outlet. Valve shall be Class 125, cast iron body, and bronze main valve trim. Valve shall be Cla-Val Clayton 50-01 BKH, or equal.
 - a. Pilot System Adjust Range: 20-200 psi
2. Provide a limit switch assembly for each PRV to indicate when the valve is in the open position. Assembly shall be Cla-Val X105L or equal.
 - a. Switch enclosure shall be NEMA 4 rated.
 - b. Switch rating shall be 15 amps at 125 VAC.

2.6 MISCELLANEOUS APPURTENANCES

A. Basket Strainer:

1. Each vessel will be provided with one (1) 8-inch stainless steel effluent strainer basket mounted in the effluent line from the vessel. The basket strainer shall be constructed of 316 stainless 14 gage plate with 1/8-inch diameter holes drilled on 3/16-inch centers, covered with 40 mesh 316 stainless steel screen and topped by a 4 mesh 316 stainless steel support screen (0.063-inch wire diameter).

B. Hose Connections:

1. The carbon fill and discharge will be fitted with male hose connections, such that

carbon transfer to and from the adsorbers can be facilitated using carbon transfer hoses. These connectors will be Quick Disconnect Adaptors constructed of aluminum as manufactured by Dover Corp. as Kamlock connectors or equal.

2.7 FASTENERS

- A. All anchor bolts, assembly bolts, screws, nuts, etc., shall be of ample size to safely withstand the forces created by operation of the vessel under the design criteria. Quantity, type, and size of fasteners shall be as recommended by the Supplier.
- B. Anchor bolts shall be provided with two nuts each to facilitate installation. Fasteners shall be stainless steel, unless otherwise shown on the Drawings.
- C. Gaskets: provide 1/8-inch thick, NSF-61 EPDM ring gaskets for all flange connections within the system.

2.8 INSTRUMENTATION

- A. Pressure Gauge: The vessel manifold piping shall be equipped with pressure gauges to indicate the pressure of water entering and exiting each vessel, as well as the common influent pressure prior to the see for the Backwash Supply. Refer to the Contract Drawings.
 - 1. Manufacturer: Ashcroft or approved equivalent.
 - 2. Function/Performance:
 - a. Range: Range of the gauge shall be the standard range of the manufacturer closest to the pressure range to be metered (0-100 psi).
 - b. Accuracy: 1 percent of full scale
 - c. Operating Temperature: -40 to 140 degrees C.
 - 3. Physical:
 - a. Measuring Element: 316 stainless steel C-Type Bourdon tube
 - b. Connection: 1/2" NPT, 316 Stainless Steel
 - c. Case: 304 Stainless Steel with safety relief plug
 - d. Cover Ring: Polished 304 stainless steel
 - e. Lends: Instrument glass
 - f. Pointer: Black finished aluminum
 - g. Dial: 4" or 4 1/2" aluminum, white background with black scale, single scale UV resistant.
 - h. Fill Liquid: Glycerin
 - 4. Accessories Required:
 - a. When required by detail, provide a 316 stainless steel block & bleed shut off valve.
- B. Pressure Differential Indicator: Each vessel shall be equipped with a differential pressure transmitter.
 - 1. Manufacturers:
 - a. Emerson/Rosemount; 2051
 - b. Endress+Hauser; PMD75
 - c. Siemens; Sitrans, P320

2. Requirements:
 - a. Function/Performance:
 - b. Range: -300 to 300 psi [-250 to 250 inches of water column]
 - c. Accuracy: 0.05 percent of span.
 - d. Operating Temperature: -20 to 80 degrees C.
 - e. Temperature Effect: Combined temperature effects shall be less than 0.2 percent of maximum span per 28 degrees C temperature change.
 - f. Output: 4-20 mA DC linear with pressure or level, with HART protocol. Zero adjustable over the range of the instrument provided calibrated span is greater than the minimum calibrated span.
 - g. Stability: 0.05 percent of upper range limit for 3 years.
 - h. Display: Digital indicator displaying pressure or level
 - i. Configuration: Programmable using the local display and pushbuttons without the use of an external programming device.
 - j. Over Range Protection: Provide positive over range protection to 150 percent of the maximum pressure of the system being monitored by the instrument.
 3. Physical:
 - a. Process Connection: ½ inch NPT tap, isolation ½ inch isolation ball valve, ¼ inch instrument tubing, coplaner manifold.
 - b. Enclosure/Housing: NEMA 4X (IP66), explosion proof, approved for Class I, Division 1, Groups C and D (EEx d IIC T5). Constructed of stainless steel.
 - c. Process Wetted Parts: Isolating diaphragm and other wetted metal parts shall be 316L stainless steel.
 - d. O rings: Glass-filled PTFE (Teflon).
 - e. Sensor Fill Fluid: Silicone.
 - f. Power Requirements: 24 VDC Loop powered.
 - g. Conduit Entry: 1/2-14 NPT.
- C. Flow Meters: Each vessel shall equipped with a flow meter consisting of a sensor and transmitter capable of measuring flow in the forward direction and backwash flow in the reverse direction.
1. The flow meter shall be composed of a flow tube and compatible transmitter.
 - a. Manufacturers:
 - 1) Endress+Hauser; Promag W 400
 - 2) Engineer Approved Equal.
 - b. Flow Tube Requirements:
 - 1) Function/Performance:
 - a) Flow Range: 200 – 650 gpm
 - b) Operating Temperature: Process liquid temperatures of 0 to 140 degrees F or greater dependent upon liner and an ambient of minus 30 to 150 degrees F.
 - c) Radio Frequency Interference (RFI) protection: RFI protection shall be

provided as recommended by the manufacturer.

- d) Pressure rating: Equal to piping system where meter is installed.
 - e) Additional: Meter shall be capable of running empty indefinitely without damage to any component.
- 2) Flanges: ANSI 150 lb. carbon steel, as required by the piping system, unless otherwise indicated. ANSI 150 lb. stainless steel flanges shall be used on all SS process pipes.
 - 3) Metering Tube: 304 stainless steel or equivalent.
 - 4) Pressure Range: 0-150 PSI.
 - 5) Liner: The sensor tube shall be lined based upon the size of the flow meter and the process media conditions, Contractor to confirm. Default liner shall be polyurethane or composite elastomer or as recommended by the Manufacturer. Liner material to conform to NSF 61 drinking water standard.
 - 6) Electrodes: 316 stainless steel standard minimum requirements. All electrodes to be compatible with process fluid as indicated on the Drawings or electrodes to be supplied as listed in the Instrument Schedule.
 - 7) Housing: Meters above grade shall be NEMA 4X (IP65).
 - 8) Finish: All external surfaces shall have a chemical and corrosion resistant finish.
 - 9) Transmitter:
 - a) Microprocessor based; intelligent transmitter compatible with flow tube provided.
 - b) Functional/Performance:
 - Accuracy (including flow tube): Plus/minus 0.5 percent of flowrate or better.
 - c) Operating Temperature: -20 to 140 degrees F.
 - d) Output: Isolated 4-20 mA. Current output adjustable over the full range of the instrument. Provide dry contacts to indicate reverse flow and pulse totalized reading.
 - e) Diagnostics: Self diagnostics with on screen display of faults.
 - f) Keypad/Display: Digital indicator displaying flow.
 - g) Totalizer: A fully configurable totalizer integral to the transmitter. Totalized flow shall be displayed.
 - h) Empty Tube Zero: The transmitter shall include a feature that will lock the output at zero when no flow is detected. The empty tube zero feature shall be enabled automatically when the transmitter detects no flow or manually through a contact input.
 - 10) Physical:
 - a) Transmitter shall be suitable for surface or pipe stand mounting.
 - b) Enclosure shall be NEMA 4X.
 - 11) Power Requirements:

- a) The transmitter shall be 120 VAC powered instrument.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. The equipment shall be erected by the Contractor. The Contractor will plumb and install the vessels, preassembled valve manifold, vessel influent piping, vessel effluent piping, modulating backwash supply valve, valve manifold piping connections for backwash supply, backwash waste, and continuation of ARV and PRV drain piping; connections to influent and effluent piping, and power supply.
- B. Install and adjust equipment in accordance with the Contract Documents, approved shop drawings, the Supplier's instructions and the supplemental requirements included herein.
- C. Do not cut or weld any stainless steel component in the field. Violation of this requirement will result in rejection of affected components.
- D. Touch up scratches and scrapes in painted surfaces in accordance with Section 09 90 00 "Painting and Protective Coatings".
- E. Align equipment to Supplier's tolerances. Adjust clearances and torques. Expansion joints shall not be used for the purpose of correcting misalignment of units.
- F. Check installation prior to start-up for conformance to Supplier's instructions.
- G. Adjust or modify equipment to ensure proper operation.
- H. The Supplier shall provide installation services as required by Section 01 43 33 "Manufacturer's Field Services" and provide the Certificate of Installation.

3.2 EXAMINATION

- A. Complete equipment installation with controls, safety devices and auxiliary support systems necessary to start the equipment and verify that the equipment functions correctly under no load conditions. Turn rotating equipment by hand to check. Complete cleaning and testing of piping systems. Inspect and clean equipment, devices, piping, and structures of debris and foreign material.
- B. Remove temporary bracing supports and other construction debris that may damage equipment.
- C. Remove protective coatings and oils used for protection during shipment and installation.
- D. Flush, fill, and grease lubricated systems in accordance with the Supplier's instructions.
- E. Check equipment for correct direction of rotation and freedom of moving parts.
- F. Correct any deficiencies or problems noted in Supplier's representative's installation reports.

3.3 CLEANING

- A. Clean as recommended by Supplier. Do not use materials or methods which may damage finish, surface or surrounding construction.

3.4 FIELD SERVICES

- A. Provide Supplier field services in accordance with Section 01 43 33 "Manufacturer's Field Services" and as described herein. Supplier installation, startup, and testing shall meet the requirements of Section 01 75 00 "Starting and Adjusting" and Section 01 79 00 "Demonstration and Testing".
- B. A Supplier's representative for the equipment specified herein shall be present at the jobsite and/or classroom designated by the Owner for the minimum person-days listed for the services hereinunder, travel time excluded:
 - 1. 1 person-days for startup and installation assistance, inspection, and certification of the installation.
 - 2. 2 person-day for functional testing including 8-hour component performance test.
 - 3. 1 person-day for pre-startup classroom or jobsite training.
- C. Functional Test: After the equipment has been installed and approved by the Supplier's field technician, and after acceptance by the Engineer, the equipment shall be tested under the supervision of the Supplier's field technician. The Contractor shall, with the assistance of the supplier's representative, perform the initial equipment checkout and start-up and inspect for proper alignment, quiet operation, lack of excessive vibration, proper connection, proper control system function, instrumentation check and final calibration, and satisfactory performance by means of a functional test. Provide an 8-hour continuous component performance test. Test control system to demonstrate all requirements specified. Demonstrate system for both local operation and operation from plant control system. Adjust parts for smooth, uniform operation. Vibration of installed equipment shall be within Supplier's specified tolerances. Correct all discrepancies or functions prior to the Demonstration Testing period. Provide documentation that the equipment meets the Design Requirements and issue a Certificate of Performance.
- D. Startup services and training of Owner's personnel shall be at such times as requested by the Owner.

3.5 FACILITY FUNCTIONAL INTEGRITY AND DEMONSTRATION TESTING

- A. The Demonstration Test shall include the complete system. The equipment shall be field tested to verify that the performance of all system components conform to the design requirements and prove the functional integrity and performance-based requirements of the facility or entire project system.
- B. The Engineer may require any and all tests of the equipment which in his/her opinion may be necessary to demonstrate to his/her satisfactions that the equipment is installed correctly and is in proper operating condition free from defects or faults of any kind. Furnish all labor and incidentals required to conduct such tests and to correct to the full satisfaction of the Engineer any and all defects or deficiencies noted.
- C. In the event the equipment fails to meet the requirements specified above, the necessary changes shall be made, and the equipment retested. If the equipment remains unable to meet the specified requirements to the satisfaction of the Owner, the equipment shall be removed and replaced with satisfactory equipment at no cost to the Owner.
- D. Supplier installation, startup, and testing shall meet the requirements of Section 01 75 00 "Starting and Adjusting" and Section 01 79 00 "Demonstration and Testing". After initial startup under the supervision of a qualified representative of the Supplier, a preliminary

“running-in” period will be provided for the Contractor, per the Contract Documents, to make field tests and necessary adjustments.

- E. Place each piece of equipment in operation, until the entire system is functioning. All components shall continue to operate without alarms or shutdowns, except for as intended, for three (3) consecutive 24-hour days to be considered started up.
- F. Operate the equipment through the design performance range consistent with available flows. Adjust, balance, calibrate and verify that the equipment, safety devices, controls, and process system operate within the design conditions. Each safety device shall be tested for proper setting and signal. Response shall be checked for each equipment item and alarm. Simulation signals may be used to check equipment and alarm responses.
- G. Prepare supplier's installation report and submit within 30 days after completion of demonstration testing. Report to include the following information:
 - 1. Demonstration testing results.
 - 2. Descriptions of installation deficiencies not resolved to the supplier's satisfaction.
 - 3. Description of problems or potential problems.
 - 4. Names of the Owner's personnel who attended operations and maintenance training sessions.
 - 5. Record copy of materials used for training session including outlined summary of course.
 - 6. Supplier's Certificate of Proper Installation, Certification of Compliance, and Certificate of Performance.
- H. Supplier's installation report and complete and final Operation and Maintenance Manuals are required prior to Substantial Completion and final acceptance of equipment.

3.6 ATTACHMENT

- A. The Vessel Nozzle Schedule and Vessel Piping Schedule included after “END OF SECTION” shall be part of this Section.

END OF SECTION

TABLE 1: VESSEL NOZZLE SCHEDULE

Description Quantities are per Vessel	Units	Value
Top Manway, Elliptical	Inches	14 x 18
Side Manway, Circular (minimum)	Inches	20 (diam.)
Influent Flange (Raw Water, RW)	Inches	8
Effluent Flange (TVE)	Inches	8
Backwash Supply Flange (BWS)	Inches	8
Backwash Waste Flange (BWW)	Inches	8
Washdown Flange (WASH)	Inches	2
Media Fill Flange (FILL)	Inches	4
Media Discharge or Spent Carbon Flange (SC)	Inches	4
Sample Taps (3)	Inches	2
Flow Meter	[-]	Per Manufacturer Recommendation
Differential Pressure Indicator	[-]	Per Manufacturer Recommendation
ARV Flange	[-]	Per Manufacturer Recommendation
Pressure Relief Valve Flange	[-]	Per Supplier Recommendation

TABLE 2: VESSEL PIPING SCHEDULE¹

Description	Size (inches)	Material	Lining	Coating	Min. Pressure Class
Influent (Raw Water, RW)	8	Carbon Steel	Epoxy	Painted	150
Effluent (TVE)	8	Carbon Steel	Epoxy	Painted	150
Backwash Supply (BWS)	8	Carbon Steel	Epoxy	Painted	150
Backwash Waste (BWW)	8	Carbon Steel	Epoxy	Painted	150
ARV Drain (ARV-D) ²	Per Supplier Recommendation	Galvanized Steel	N/A	N/A	Schedule 40
Washdown Line (WASH)	2	Galvanized Steel	N/A	N/A	Schedule 40
Sample	1/2	316 SS	N/A	N/A	150
Media Fill (FILL)	4	Carbon Steel	Epoxy or polypropylene	N/A	150
Media Discharge or Spent Carbon (SC)	4	Carbon Steel	Epoxy or polypropylene	N/A	150

1. Refer to section 40 08 00 Field Testing of Process Interconnections for test pressure requirements.
2. Refer to the Contract Drawings for additional information on Contractor and Supplier piping limits.

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SECTION 44 43 30
FILTER MEDIA

PART 1 - GENERAL

1.1 WORK OF THIS SECTION

- A. Provision and installation of filter media in two (2) 12 feet diameter by 5 feet tall (side shell height) pressure adsorption vessels. Install granular activated carbon (GAC), as specified, to the limits shown on Drawings.
- B. The specified underdrain system shall support media specified herein without support gravel or coarse sand layer. Refer to section 43 31 13.13 "Activated Carbon Liquid Purification Filters".

1.2 REFERENCES

- A. The following is a list of specifications related to this section:
 - 1. Section 43 31 13.13 "Activated Carbon Liquid Purification Filters"
- B. The following is a list of standards which may be referenced in this section:
 - 1. American Water Works Association (AWWA):
 - a. B100, Filtering Material.
 - b. B604, Granular Activated Carbon.
 - 2. ASTM International (ASTM): C117, Standard Test Method for Materials Finer Than 75-Micrometer (No. 200) Sieve in Mineral Aggregate by Washing.
 - 3. NSF International (NSF):
 - a. NSF/ANSI 61, Drinking Water System Components – Health Effects.
 - b. NSF/ANSI 372, Drinking Water System Components – Lead Content.

1.3 SUBMITTALS

- A. See Section 01 33 00 "Submittal Procedures".
- B. Shop Drawings: Submit within 14 days following Bid manufacturer's product information, including grain size ranges for each fin media layer specified. Media sizes shall be in millimeters. Testing shall have been performed by a certified testing laboratory in accordance with AWWA B100. Provide sufficient information to demonstrate compliance with this Specification. Provide a detailed list of any exceptions taken to these specifications. Include specification reference and proposed alternative with reason stated for exception. If Manufacturer and/or Contractor fails to describe such exceptions, the responsible entity will not be relieved of the responsibility for executing the work as described herein, even though such shop drawings have been reviewed by the Engineer.
- C. The Supplier's Certificate of Analysis for the lot of virgin GAC provided. The procedure for sampling, analysis, and reporting shall be as follows:
 - 1. The certified laboratory selected by the Supplier shall analyze the material based upon the requirements of these specifications. Testing methods shall be in accordance

with Section 4 (Testing Methods) of the AWWA B604, the Food Chemical Codex protocol (National Academy press), and appropriate ASTM standards.

2. A test report shall be submitted by the Supplier showing compliance with the specifications as described herein, along with a statement certifying that the material for shipment is equal in quality to and from the same lot as the representative sample submitted.

3. Test reports on the representative samples of GAC shall contain the Supplier's name, date of sampling, lot number, and the following information:

- a. Apparent density
- b. U.S. mesh size
- c. Uniformity coefficient
- d. Hardness
- e. Iodine number
- f. Moisture as packed (percent)
- g. Water soluble ash (percent)

- D. Submit Contractor's or subcontractor's written proposed procedures for placement of media.
- E. Samples: Prior to loading and shipment, submit sample of media material. The minimum sample size shall be 10 pounds. The Engineer/Owner retains the right to have the samples tested to determine acceptance or rejection in accordance with procedures in AWWA B100.
- F. Provide proof of ANSI/NSF Standard 61 toxicological certification.
- G. Informational Submittals: Submit gradation test results of GAC media, including sieve analysis prior to loading and shipment.
- H. Delivered Media Testing: An independent third-party laboratory shall conduct testing to demonstrate the media delivered to the project site (prior to installation) matches the manufactured media. Sample collection and frequency shall be in accordance with AWWA B100 and AWWA B604. Submit test results to the Engineer to verify compliance.
- I. Case Study Demonstration: Provide historic influent and effluent water quality data from one (1) previous installation demonstrating adequate removal of the constituents listed in Table 1 to the applicable maximum contaminant level.

1.4 QUALITY ASSURANCE

- A. The Owner may consider the qualifications and experience of the Contractor, subcontractor, and suppliers to perform the specialized work described herein as part of its evaluation and selection. The Contractor or its subcontractor performing the Work, shall demonstrate a minimum of 5 years of experience with filter media installation. Experience shall include at least 2 projects completed during the previous 5 years that included installation of media in drinking water treatment plant filters.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Components and Materials in Contact with Water for Human Consumption: Comply with the requirements of the Safe Drinking Water Act and other applicable federal, state, and local requirements. Provide certification by manufacturer or an accredited certification organization recognized by the Authority Having Jurisdiction that components and materials comply with the maximum lead content standard in accordance with NSF/ANSI 61 and NSF/ANSI 372.
1. Use or reuse of components and materials without a traceable certification is prohibited.
- B. The PFAS raw water influent quality from February 2023-May 2024 is presented in Table 1. GAC media will be required to treat the listed constituents to the applicable maximum contaminant level for 100 days at the design flow rate (650 gpm).

Table 1: Influent Water Quality

Parameter	Average	Minimum	Maximum	95 th Percentile
PFOA	< 10	< 3.9	20	< 19
PFAS	< 28	< 9.2	63	< 60
PFHxS	< 47	< 15	89	< 84
PFNA	< 6.0	< 2.1	19	< 16
HFPO-DA	N/A	N/A	N/A	N/A
PFPeA	< 23	< 8.2	38	< 37

2.2 MANUFACTURERS

- A. Media:
1. Calgon Carbon Corporation (GAC); Filtrasorb 400
 2. AqueoUS Vets; AV EcoCarb 1240 BA
 3. Norit Activated Carbon; NORIT GAC 400
- B. Naming of a manufacturer does not indicate approval nor eliminate their responsibility of providing materials/equipment in compliance with the component features as specified herein. All manufacturers are required to comply fully with these specifications. Any deviations without sufficient evidence proving equal or superior quality shall be rejected without further review.

2.3 GRANULAR ACTIVATED CARBON FILTERS

- A. Granular Activated Carbon Media:
1. GAC shall consist of a six (6) foot deep blanket of graded material as specified hereinafter.
 2. The GAC shall be virgin and composed of hard durable grains. Average apparent specific gravity shall be determined by the procedure set forth in ASTM C128. The GAC shall meet the physical properties listed herein and be manufactured from only selected grades of bituminous coal combined with suitable binders as required to produce a highly active, durable granular material capable of withstanding the

abrasion and dynamics associated with repeated backwashing, surface washing and hydraulic transport. Activation shall be carefully controlled to produce a material having a high internal surface area with optimum pore size for effective adsorption of a broad range of high and low molecular weight organic contaminants. The density and particle size shall be designed for packed bed type of adsorption. The material shall have sufficient density to allow backwash agitation and bed expansion, yet settle rapidly for immediate resumption of service. The carbon shall contain less than 5 -percent acid soluble material according to the test procedure established by the most current AWWA standard specification B100. The material shall be free of foreign materials such as clay, dirt, etc. Lignite, peat, wood, and sub lignite of based carbons will not be accepted.

3. GAC to be placed in each filter vessel shall have a uniformity coefficient and size as specified herein. The particle size shall be determined by screening through standard sieves calibrated in accordance with ASTM E 11. Effective size is defined as the theoretical size of the sieve (in millimeters) that will pass 10% of the sample by weight. The uniformity coefficient is defined as the theoretical size of the sieve (in millimeters) that will pass 60% of the sample by weight divided by the effective size. No more than 5% by weight shall be finer than the lower designated size limit and no more than 15% by weight shall be coarser than the upper designated side limit.
4. Clean, hard, durable particles in conformance with AWWA B604, modified as follows:

Total Surface Area, mg/g	950-1050
Bulk Density, g/cc	0.48-0.57
Effective Size, mm	0.55 to 1.0
Uniformity Coefficient	<1.9
Iodine Number, mg/g	>1000
Water Extractables	<2%
Abrasion Number	>75
5. Provide sufficient excess GAC media to anticipate media settlement and compaction during installation.

2.4 SOURCE QUALITY CONTROL

- A. Owner reserves the right to test Samples in accordance with procedures specified in AWWA B100a.

PART 3 - EXECUTION

3.1 PRODUCT HANDLING, STORAGE, AND DELIVERY

- A. Packaging: Deliver filter media via bulk delivery truck or package filter media in 1-ton to 2-ton capacity, ultraviolet resistant polyethylene bags, or super sacks with bottom pour spout, placed on pallets. Clearly mark each bulk delivery or bag of material with the following information:
 1. Effective size.
 2. Uniformity coefficient.

3. Source.
 4. Date of bagging.
 5. Production lot or stockpile identification.
 6. Net weight of the material.
 7. Name of Manufacturer.
 8. Name/type of GAC.
 9. Brand name, if applicable.
- B. Place or store all filter media only in designated staging areas where approved by the Engineer.
- C. All filter media at the Job Site shall be stored off the ground, protected from weather, and covered with a suitable membrane to prevent contamination of the media from windblown debris and soil.
- D. Conveying of the new filter media by compressed air through ducts, pipes, or hose is not permitted. Placement of filter media in the filters shall comply in all respects with AWWA B100, except as modified or supplemented herein.

3.2 INSTALLATION

- A. General:
1. Plant staff shall operate all filter backwash controls when washing the new filter media installed in the filter basins.
 2. Contractor shall submit a written plan for media installation, including a proposed schedule, for review, and shall meet with the Engineer and Owner, a minimum of 14 days prior to commencement of Work to discuss logistics and operational requirements.
 3. Follow underdrain manufacturer's installation instructions to protect underdrain system.
 4. Do not permit workers to walk or stand directly on underdrain media retention cap or media. Use boards that will sustain workers' weight without displacing media.
 5. Before media is placed, mark top of all layers on each side of filter.
- B. Media:
1. Transport and place media carefully to prevent contamination of any sort.
 2. Replace contaminated media with clean media.
 3. Install in following sequence (sequence is based on water temperature of 55 deg. F):
 - a. Place 6 feet of GAC and finish off smooth to proper elevation.
 - b. Fully submerge GAC bed in clean, contaminant free water for at least 16 hours.
 - c. Backwash bed at a rate of 5 gallons per minute (gpm) per square foot (sf) for two minutes.
 - d. Backwash bed at a rate of 6 gpm/sf and maintain for 2 minutes.
 - e. Backwash bed at a rate of 7 gpm/sf and maintain for 2 minutes.
 - f. Backwash bed at a rate of 10 gpm/sf and maintain for 30 minutes.
 - g. Backwash bed at a rate of 7 gpm/sf and maintain for 2 minutes.
 - h. Backwash bed at a rate of 6 gpm/sf and maintain for 2 minutes.
 - i. Backwash bed at a rate of 5 gpm/sf and maintain for 2 minutes.

3.3 STARTUP

1. Follow manufacturer's recommendations for soaking and flushing procedures to meet the volatile organics and inorganics water quality parameters required by the CDPHE and EPA.

3.4 FIELD SERVICES

- A. A Manufacturer's representative for the equipment specified herein shall be present at the jobsite and/or classroom designated by the Owner for the minimum person-days listed for the services hereinunder, travel time excluded:
 1. 1 person-days for startup and installation assistance, inspection, and certification of the installation.
 2. 2 person-day for functional testing including 8-hour component performance test.

END OF SECTION

APPENDIX A
Geotechnical Report by Kumar and Associates, Inc.
Date August 6, 2024



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and Environmental Scientists

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GEOTECHNICAL ENGINEERING STUDY
TOWN OF FRISCO WELL 7
PROPOSED PFAS MITIGATION IMPROVEMENTS
624 RECREATION WAY
FRISCO, COLORADO

Prepared By:

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FIG. 1 – LOCATION OF EXPLORATORY BORING

FIG. 2 – LOG OF EXPLORATORY BORING

FIGS. 3 and 4 – GRADATION TEST RESULTS

FIG. 5 – ELECTRICAL RESISTIVITY

TABLE I – SUMMARY OF LABORATORY TEST RESULTS

SUMMARY

1. One (1) exploratory boring was drilled for this study. The boring encountered a thin veneer of aggregate surfacing underlain by naturally deposited (natural) granular soils extending to the maximum depth drilled of about 25 feet. Although not indicated in our boring, pre-existing fill materials may be present across the site, and should be anticipated.

The natural granular soils encountered were fine- to coarse-grained with gravel and cobbles increasing in frequency with depth, and were slightly moist, tan to brown to gray-brown. Based on sampler penetration resistance values, the natural granular soils ranged from medium dense to very dense.

Groundwater was not encountered in the boring at the time of drilling. The boring remained open for 17 days to measure stabilized groundwater levels. Groundwater was measured at a depth of about 24 feet when follow-up measurements were made 17 days subsequent to drilling.

2. Shallow foundations placed on undisturbed natural soils or properly compacted structural fill extending to natural soils/bedrock should be designed for an allowable soil bearing pressure of 3,000 psf.
3. Slab-on-grade construction is also feasible at the site. Slab on grade floors should be underlain by properly compacted fill material extending to undisturbed natural soils. Additional design considerations and recommendations are presented herein.
4. Bedding material supporting pipe bottoms should consist of an uncompacted layer of imported granular material meeting the pipe manufacturers specifications for bedding. Based on the assumed pipe diameter for the conduit and AWWA guidelines, we recommend a minimum uncompacted bedding thickness of 6 inches be considered below the pipe. The bedding layer should be of adequate thickness to fully support the pipes when seated on top of the bedding. Prior to placing the bedding, the subgrade should be excavated and loose material removed to provide firm subgrade support. The pipe bedding and pipe-zone fill should be compacted to a relative density of at least 75% as determined by ASTM D4253 and ASTM D4254. Backfill placed above the bedding should be compacted to at least 95% of the standard Proctor (ASTM D 698) maximum dry density at a moisture content within 2 percentage points of optimum.

PURPOSE AND SCOPE OF WORK

This report presents the results of a geotechnical engineering study for the Town of Frisco Well 7 proposed PFAS mitigation improvements project in Frisco, Colorado. The project site is generally shown on Fig. 1. The study was conducted for the purpose of developing recommendations for the design and construction of the proposed structure that will house the PFAS mitigation equipment. The study was conducted in accordance with the scope of work presented in our Proposal No. P-24-330 dated April 2, 2024.

A field exploration program consisting of one exploratory boring was conducted to obtain information on subsurface conditions for the proposed structure. Samples of the soils obtained during the field exploration were tested in the laboratory to determine their classification and engineering characteristics. The results of the field exploration and laboratory testing were analyzed to develop recommendations and construction considerations for the pipeline and associated structures including excavation, pipe bedding and backfill.

This report has been prepared to summarize the data obtained during this study and to present our conclusions and recommendations based on the proposed construction and the subsurface conditions encountered. Design parameters and a discussion of geotechnical engineering considerations related to construction of the proposed pipeline are included in the report.

PROPOSED CONSTRUCTION

The project site is located just south of the existing Frisco Well 7 Building. The improvements will include a new building with a below-grade level with a finished floor elevation approximately 13.5 feet below finished grades. The below grade portion of the structure will have an approximate 30-foot by 45.3-foot footprint. The peak of the roof will extend approximately 15 feet above finished grade elevation. Two smaller chemical storage rooms will be constructed at-grade outside the below-grade portion.

The site is currently occupied by the access drive associated with the existing well house structure. The building will be constructed south of the existing well house and connected to the well house with buried ductile iron pipes.

If the proposed construction varies significantly from that described above or depicted in this report, we should be notified to reevaluate the recommendations provided herein.

SITE CONDITIONS

As mentioned, the existing well house is located just north of the project site. The site is located on the southern end of the Dillon Reservoir peninsula, just north of the Frisco Nordic Center, and the surrounding areas consist of outdoor recreation amenities. The ground surface surrounding the proposed structure is nearly level, but generally sloped down and away in all directions with distance from the site. The access drive servicing the well house consisted of aggregate surfacing and bisects a well-used pedestrian path. A mix of evergreen and deciduous trees are situated around the periphery of the proposed construction area.

SUBSURFACE CONDITIONS

The subsurface conditions at the site were explored by drilling one (1) exploratory boring to a depth of about 25 feet at the approximate location shown in Fig. 1. A graphic log of the boring along with a legend and notes describing the soils encountered are presented in Fig. 2.

The boring encountered a thin veneer of aggregate surfacing underlain by naturally deposited (natural) granular soils extending to the maximum depth drilled of about 25 feet. Although not indicated in our boring, pre-existing fill materials may be present across the site, and should be anticipated.

The natural granular soils were fine- to coarse-grained with gravel and cobbles increasing in frequency with depth, and were slightly moist to wet (below groundwater), tan to brown to gray-brown. Based on field penetration resistance tests, the natural granular soils ranged from medium dense to very dense.

Groundwater Conditions: Groundwater was not encountered in the boring at the time of drilling. The boring remained open for 17 days to measure stabilized groundwater levels. Groundwater was measured at a depth of about 24 feet when the follow-up measurement was made. Groundwater levels are expected to fluctuate with time and may fluctuate upward after wet weather or subsequent to landscape irrigation.

LABORATORY TESTING

Laboratory testing was performed on selected soil samples obtained from the boring to determine in-situ soil moisture content and dry density, Atterberg limits, gradation characteristics, and concentration of water-soluble sulfates. The results of the laboratory tests are shown to the right

of the log on Fig. 2 and summarized in Table I. The results of a gradation tests are graphically plotted on Figs. 3 and 4. The testing was conducted in general accordance with recognized test procedures, primarily those of ASTM and the Colorado Department of Transportation (CDOT).

Specific laboratory testing for properties regarding buried metal corrosion consisted of pH, sulfide content, chloride content, electrical resistivity, and redox potential.

Index Properties: Samples were classified into categories of similar engineering properties in general accordance with the Unified Soil Classification System. This system is based on index properties, including liquid limit and plasticity index and gradation characteristics. Values for moisture content, dry density, liquid limit, and plasticity index, and the percent of soil retained on the U.S. No. 4 and percent passing the No. 200 sieves are presented in Table I and adjacent to the corresponding sample on the boring log.

WATER SOLUBLE SULFATES

The concentration of water-soluble sulfates measured in representative samples of the onsite soils obtained from the exploratory boring ranged from below detection and approximately 0.01%. These concentrations of water-soluble sulfates represent a Class S0 severity exposure to sulfate attack on concrete exposed to these materials. The degree of attack is based on a range of Class S0, Class S1, Class S2, and Class S3 severity exposure as presented in ACI 201.

Based on the laboratory test results, we believe special sulfate resistant cement will generally not be required for concrete exposed to the onsite soils.

GEOTECHNICAL ENGINEERING CONSIDERATIONS

Existing Fill: As mentioned, pre-existing fills were not encountered in our boring, but may be present in other portions of the site. Without documentation of placement conditions, including density testing, documenting the degree of compaction, the pre-existing fill materials, if encountered, are considered non-engineered and generally not suitable for support of foundations or floor slabs.

It is very important to the long-term performance of the structures that all of the existing fill materials be removed from below the proposed foundation elements and floor slabs and to a distance beyond the building area as outlined in the "Foundation Recommendations" section

below. We have no way to accurately predict the total magnitude of potential settlements if the existing fill is left in place; however, movements exceeding 1-inch are possible.

Considering the proposed construction and the subsurface conditions encountered, shallow foundations and soil supported slabs are considered suitable with minimal subgrade preparation.

Excavations will likely encounter large gravels, cobbles, and boulders. The contractor should mobilize equipment sufficient for dealing with these types of materials. In general, the onsite soils appear to be suitable for reuse as structural fill; however, the material will likely need to be screened to meet the material and placement criteria presented in the "Site Grading and Earthwork" section of this report.

FOUNDATION RECOMMENDATIONS

Spread footings, mat, or raft foundation systems are feasible to support the new structure provided the foundations are placed directly on the undisturbed natural soils or on properly compacted structural fill extending to undisturbed natural soils.

The design and construction criteria presented below should be observed for shallow foundation systems. The construction details should be considered when preparing project documents.

1. Shallow foundations placed on natural soils and/or undisturbed natural soils or properly compacted structural fill extending to natural soil should be designed for an allowable soil bearing pressure of 3,000 psf.
2. The foundations should be provided with adequate soil cover above their bearing elevation for frost protection. Placement of foundations at least 48 inches below the exterior grade is typically used in this area.
3. Spread footings should have a minimum footing width of 18 inches for continuous strip footings and 24 inches for isolated pads.
4. The lateral resistance of a spread footing placed on properly compacted structural fill will be a combination of the sliding resistance of the footing on the foundation materials and passive earth pressure against the side of the footing. Resistance to sliding at the bottoms of the footings can be calculated based on a coefficient of friction of 0.35. Passive pressure

against the sides of the footings can be calculated using an equivalent fluid unit weight of 220 pcf. The above passive pressures are working values.

5. Granular foundation soils should be densified with a smooth vibratory compactor prior to the placement of concrete.
6. A representative of the geotechnical engineer should observe all footing excavations prior to concrete placement.

FLOOR SLABS

We recommend slabs-on-grade be placed on properly compacted structural fill extending to undisturbed natural soils to mitigate the potential for settlement due to compression of soils. If pre-existing fill materials are encountered for other portions of the site, the owner should be made aware that there is an increased risk of floor slab movements if existing fills are left in place below floor slabs.

To reduce the effects of some differential movement, floor slabs should be separated from all bearing walls and columns with expansion joints which allow unrestrained vertical movement. Interior non-bearing partitions resting on floor slabs should be provided with slip joints so that, if the slabs move, the movement cannot be transmitted to the upper structure. This detail is also important for wallboards, stairways and door frames. Slip joints which will allow at least 1½ inches of vertical movement are recommended.

Floor slab control joints should be used to reduce damage due to shrinkage cracking. Joint spacing is dependent on slab thickness, concrete aggregate size, and slump, and should be consistent with recognized guidelines such as those of the Portland Cement Association (PCA) and American Concrete Institute (ACI). The joint spacing and slab reinforcement should be established by the designer based on experience and the intended slab use. We suggest joints be provided on the order of about 12 to 15 feet apart in both directions. The requirements for slab reinforcement should be established by the designer based on experience and the intended slab use.

BELOW GRADE STRUCTURES

Retaining structures, such as below-grade walls, should be designed for the lateral earth pressure generated by the backfill materials, which is a function of the degree of rigidity of the retaining structure and the type of backfill material used. Retaining structures that are laterally supported and can be expected to undergo only a moderate amount of deflection, such as basement or vault walls, should be designed for a lateral earth pressure based on the equivalent at-rest fluid pressures. Cantilevered retaining structures that can be expected to deflect sufficiently to mobilize should use the full active earth pressure condition. The following table presents lateral earth pressure values to be used in design of the below ground portions of the structure:

CDOT Class 1 (<20% passing No. 200 Sieve)	55 pcf
Onsite or imported, granular soils	60 pcf

Cantilevered retaining structures that can be expected to deflect sufficiently to mobilize the full active earth pressure condition should be designed for the following equivalent fluid pressures:

CDOT Class 1 (<20% passing No. 200 Sieve)	35 pcf
Imported, non-expansive, silty to clayey sand	40 pcf

Imported CDOT Class 1 material, if utilized, should have a minimum internal angle of friction of 34 degrees.

All retaining structures should also be designed for appropriate surcharge pressures such as traffic, construction materials and equipment. The zone of backfill placed behind retaining structures to within 2 feet of the ground surface should be sloped upward from the base of the structure at an angle no steeper than 45 degrees measured from horizontal. To reduce surface water infiltration into the backfill, the upper 2 feet of the backfill should consist of a relatively impervious imported soil containing at least 30% passing the No. 200 sieve, or the backfill zone should be covered by a slab or pavement structure.

Backfill should be compacted to at least 95% of the standard Proctor (ASTM D698) maximum dry density at moisture contents within 2 percentage points of optimum. Some of the on-site materials may be too granular and not conducive to a Proctor test. Therefore, materials with less than 12% passing the No. 200 sieve should be compacted to at least 75% of the relative density (ASTM D4253 and D4254). Care should be taken not to over compact the backfill since this could cause

excessive lateral pressure on the wall. Hand compaction procedures, if necessary, should be used to prevent lateral pressures from exceeding the design values.

SITE SEISMIC CRITERIA

This area of Colorado is located in a low seismic activity area. The soil profile will generally consist of relatively dense granular soils overlying metamorphic bedrock at an unknown depth. The overburden soils classify as Site Class D in accordance with International Building Code (IBC), which references ASCE 7 for Seismic Site Class determination. Without site specific shear wave velocity testing, we recommend a design soil profile of IBC Site Class D. Based on site seismicity the subsurface profile, liquefaction is not a design consideration.

The ASCE 7 Hazards Tool internet-based calculator was used to determine the following probabilistic ground motion values for the project site.

Spectral Acceleration	Ground Motion (g) 2 percent in 50 Years
S_s (0.2 Sec. Period)	0.31
S_1 (1.0 Sec. Period)	0.065
Peak	0.18

PIPELINE RECOMMENDATIONS

Pipe Backfill: Bedding material supporting the pipe bottom should consist of an uncompacted layer of imported granular material meeting the pipe manufacturers specifications for bedding. Based on the assumed pipe diameter and AWWA guidelines, we recommend a minimum uncompacted bedding thickness of 6 inches be considered. The bedding layer should be of adequate thickness to fully support the pipes when seated on top of the bedding. Prior to placing the bedding, the subgrade should be excavated and loose material removed to provide firm subgrade support.

The pipe-zone material placed above the bedding and surrounding the pipe should consist of granular material similar to that described above for pipe bedding, and should be compacted to at least 75% relative density (ASTM D4253 and ASTM D4254). The pipe-zone material should also be placed and compacted in accordance with the requirements of the pipe manufacturer. Special care should be taken to provide adequate compaction below the haunches of the pipe using a concrete vibrator, vibratory plates or other light compaction equipment as needed. In

confined areas of the pipeline where compaction is difficult, placement of a cementitious flow fill around the pipe should be considered.

Backfill placed above the pipe-zone materials to the surface should consist of suitable on-site soil obtained from the pipeline excavation. Suitable soils should have a maximum size of 4 inches and should be generally free of organics, wood, or other deleterious material that could decay over time. Most of the soils encountered in the exploratory borings satisfy the material requirements based on laboratory testing of selected samples. The backfill should be compacted to at least 95% of the standard Proctor (ASTM D698) maximum dry density at a moisture content within 2 percentage points of optimum or 75% relative density.

Variable moisture contents were indicated for the soils encountered in the exploratory borings. The contractor should anticipate that processing to add water, or allowing time for material to dry out, will likely be required.

The pipe should be buried an adequate depth below the surface to limit pipe deflections caused by current or planned future traffic loading. The minimum burial depth required for the pipe will depend on the material and physical properties of the pipe, the soil/structure interaction between the pipe and the backfill material, and traffic loading conditions. We recommend that the pipe burial depth be at least 3 feet and satisfy manufacturer requirements for maximum allowable deflection and minimum burial depth.

BURIED METAL CORROSION

The potential corrosive environment for metal was evaluated based on data collected during our field exploration and laboratory testing programs. The data included pH, minimum electrical resistivity, sulfides, redox potential, and chlorides. The laboratory test results are shown adjacent to the boring log on Fig. 2 and summarized in Table I.

The test results indicated minimum laboratory electrical resistivity of 10,600 ohm-cm. Based on the Ductile Iron Pipe Research Association (DIPRA) handbook, the material should provide excellent corrosion resistance.

The acidity of the materials was assessed by conducting pH tests, which resulted in a pH of 6.21. The sulfide testing resulted in trace values. The measured concentration of chlorides was 0.63%. The measured Re-Dox potential was 134.9 mV.

The general chemical characteristics of the soils indicate the subsurface profile could result in a slightly corrosive environment to buried metals, but may increase under saturated conditions. We recommend a qualified corrosion engineer review the information presented above to design an appropriate level of corrosion protection for buried metal.

SURFACE DRAINAGE

Proper surface drainage is very important for acceptable performance of the facility during construction and after construction has been completed. Drainage recommendations provided by local, state and national entities should be followed based on the intended use of the facility. The following recommendations should be used as guidelines and changes should be made only after consultation with the geotechnical engineer.

1. Excessive wetting or drying subgrades should be avoided during construction.
2. The ground surface surrounding the exterior of the structures and paved area should be sloped to drain away from those facilities in all directions. We recommend a minimum slope of 6 inches in the first 10 feet in unpaved areas and a minimum slope of 3 inches in the first 10 feet in paved or landscape areas. Site drainage beyond the 10-foot zone should be designed to promote runoff and reduce infiltration. These slopes may be changed as required for handicap access points in accordance with the Americans with Disabilities Act.
3. Exterior backfill should be adjusted to near optimum moisture content (generally $\pm 2\%$ of optimum unless indicated otherwise in the report) and compacted to at least 95% of the standard Proctor (ASTM D 698) maximum dry density.
4. To promote runoff, the upper 1 to 2 feet of the backfill should be a relatively impervious on-site soil or be covered by flatwork or a pavement structure.
5. Ponding of water should not be allowed in backfill material or in a zone within 10 feet of the structures, whichever is greater.

SITE GRADING AND EARTHWORK

Excavation Considerations: Excavations should be constructed in accordance with all OSHA requirements, and other applicable local and state requirements. Based on the OSHA excavation guidelines, we believe the onsite natural soils generally classify as an OSHA Type C soil. We believe onsite soils, similar to those encountered within the explored depths of the exploratory borings, may be excavated with conventional heavy-duty excavation equipment. Cobbles and boulders should be expected to be encountered.

Surface water runoff into the excavations can act to erode and potentially destabilize the trench slopes and result in soft ground conditions along the trench bottom, and should not be allowed. Diversion berms and other measures should be used to prevent surface water runoff into the trenches from occurring.

Although not anticipated, excavations encountering surficial water, perched groundwater, and/or groundwater could require much flatter side slopes than those allowed by OSHA or the use of temporary shoring, and areas where insufficient lateral space exists may require temporary shoring.

Existing fills, if encountered, are considered non-engineered and unsuitable in their current condition for support of structures unless properly prepared. Proper preparation should include complete removal and replacement of existing fill from beneath foundations, and floor slabs.

The existing onsite natural soils should be suitable for use as general site fill and as structural fill beneath structures, provided they do not contain organic material or other deleterious material.

Groundwater is not anticipated to be encountered within the excavations. It is our opinion a groundwater relief system is not warranted given our understanding of the proposed construction and the subsurface conditions encountered.

Cut and Fill Slopes: Permanent unretained cuts in the overburden soils and fill slopes up to 10 feet high should be constructed at a 2H:1V (horizontal to vertical) or flatter inclination for stability purposes and at a 3H:1V or flatter inclination for limiting the potential for erosion. If groundwater seepage is encountered during or prior to cut slope excavation, a stability evaluation should be conducted to determine if the seepage would adversely affect the cut.

Material Specifications: Unless specifically modified in the preceding sections of this report, the following recommended material and compaction requirements are presented for compacted fills on the project site. A geotechnical engineer should evaluate the suitability of all proposed fill materials for the project prior to placement.

1. *Structural Fill beneath Structures and Settlement-Sensitive Exterior Flatwork:* Structural fill should consist of on-site soils or imported non-expansive soils with less than 50% passing the No. 200 sieve, a maximum Liquid Limit of 30, and a maximum Plasticity Index of 12. Fill source materials, including onsite soils, not meeting these criteria may be acceptable if they meet the swell criteria presented in Item 6 below.
2. *Beneath Movement-Tolerant Exterior Flatwork:* Compacted fill should consist of moisture-conditioned onsite materials or non-expansive imported soil materials.
3. *Pipe Bedding Material* Pipe bedding material should be a free draining, coarse-grained sand and/or fine gravel.
4. *Utility Trench Backfill:* Materials excavated from the utility trenches may be used for trench backfill above the pipe zone fill provided they do not contain unsuitable material or particles larger than 4 inches and can be placed and compacted as recommended herein.
5. *Material Suitability:* Unless otherwise defined herein, all fill material should be a non-expansive soil free of vegetation, brush, sod, trash and debris, and other deleterious substances, and should not contain rocks or lumps having a diameter of more than 4 inches. A fill material should be considered non-expansive if the swell potential of the material, when remolded to 95% of the standard Proctor (ASTM D 698) maximum dry density at optimum moisture content, does not exceed 0.5% when wetted under a 200 psf surcharge pressure. If grading is performed during times of freezing weather, the fill should not contain frozen materials, and if the subgrade is allowed to freeze, all frozen material should be removed prior to additional fill placement for footing or slab construction.

Based on the data from the borings and results of the laboratory testing, the onsite soils should be suitable for reuse as compacted site grading fill and as structural fill, but may require screening of the larger particle sizes prior to reuse.

Evaluation of potential structural fill sources, particularly those not meeting the above liquid limit and plasticity index criteria for imported fill materials, should include determination of laboratory moisture-density relationships and swell-consolidation tests on remolded samples prior to acceptance.

Compaction Requirements: We recommend the following compaction criteria be used on the project:

1. *Moisture Content:* Fill materials should be compacted at moisture contents within 2 percentage points of the optimum moisture content. The moisture content requirement is waived if the material falls under compaction criteria associated with the relative density.
2. *Placement and Degree of Compaction:* Unless otherwise defined herein, compacted fill should be placed in maximum of 8-inch-thick loose lifts. The following compaction criteria should be followed during construction:

<u>Fill Location</u>	Percentage of Maximum Modified Proctor Density (ASTM D1557)
Below Foundations and Concrete Structures.....	97%
Beneath Settlement-Sensitive Flatwork Areas	
Fill less than 8 Feet below the final ground surface.....	93%
Fill more than 8 Feet below the final ground surface	97%
Utility Trenches	
Exterior Less Than 8 Feet below the final ground surface.....	93%
Exterior More Than 8 Feet below the final ground surface	97%
Landscape and Other Areas.....	93%

3. *Subgrade Preparation:* Areas receiving new fill should be prepared as recommended in specific sections of this report to provide a uniform base for fill placement. All other areas to receive new fill not specifically addressed herein should be scarified to a depth of at least 8 inches and recompacted to at least 95% of the modified Proctor (ASTM D1557) maximum dry density at moisture contents recommended above.

Subgrade preparation should include proof rolling with a heavily loaded pneumatic-tired vehicle or a heavy, smooth-drum vibratory roller compactor. Areas that deform excessively during proof rolling should be removed and replaced to achieve a reasonably stable subgrade prior to placement of compacted fill or slabs, or flatwork.

DESIGN AND CONSTRUCTION SUPPORT SERVICES

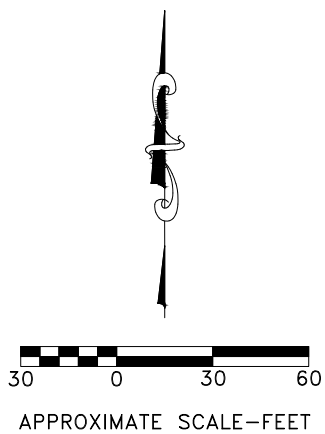
Kumar & Associates, Inc. should be retained to review the project plans and specifications for conformance with the recommendations provided in our report. We are also available to assist the design team in preparing specifications for geotechnical aspects of the project, and performing additional studies if necessary to accommodate possible changes in the proposed construction.

We recommend that Kumar & Associates, Inc. be retained to provide observation and testing services to document the intent of this report and the requirements of the plans and specifications are being followed during construction and to identify possible variations in subsurface conditions from those encountered in this study so that we can re-evaluate our recommendations if needed.

LIMITATIONS

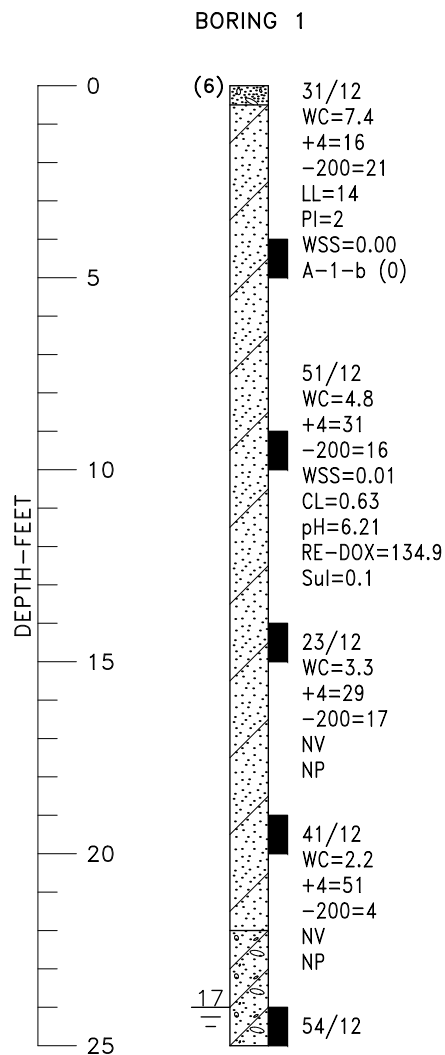
This study has been conducted in accordance with generally accepted geotechnical engineering practices in this area for exclusive use by the client for design purposes. The conclusions and recommendations submitted in this report are based upon data obtained from the exploratory boring at the location indicated on Fig. 1, and the proposed construction. This report may not reflect subsurface variations that occur between the explorations, and the nature and extent of variations across the site may not become evident until site grading and excavations are performed. If during construction, fill, soil, rock or water conditions appear to be different from those described herein, Kumar & Associates, Inc. should be advised at once so a re-evaluation of the recommendations presented in this report can be made. Kumar & Associates, Inc. is not responsible for liability associated with the interpretation of subsurface data by others.

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VICINITY MAP
NOT TO SCALE

July 19, 2024 - 12:58pm
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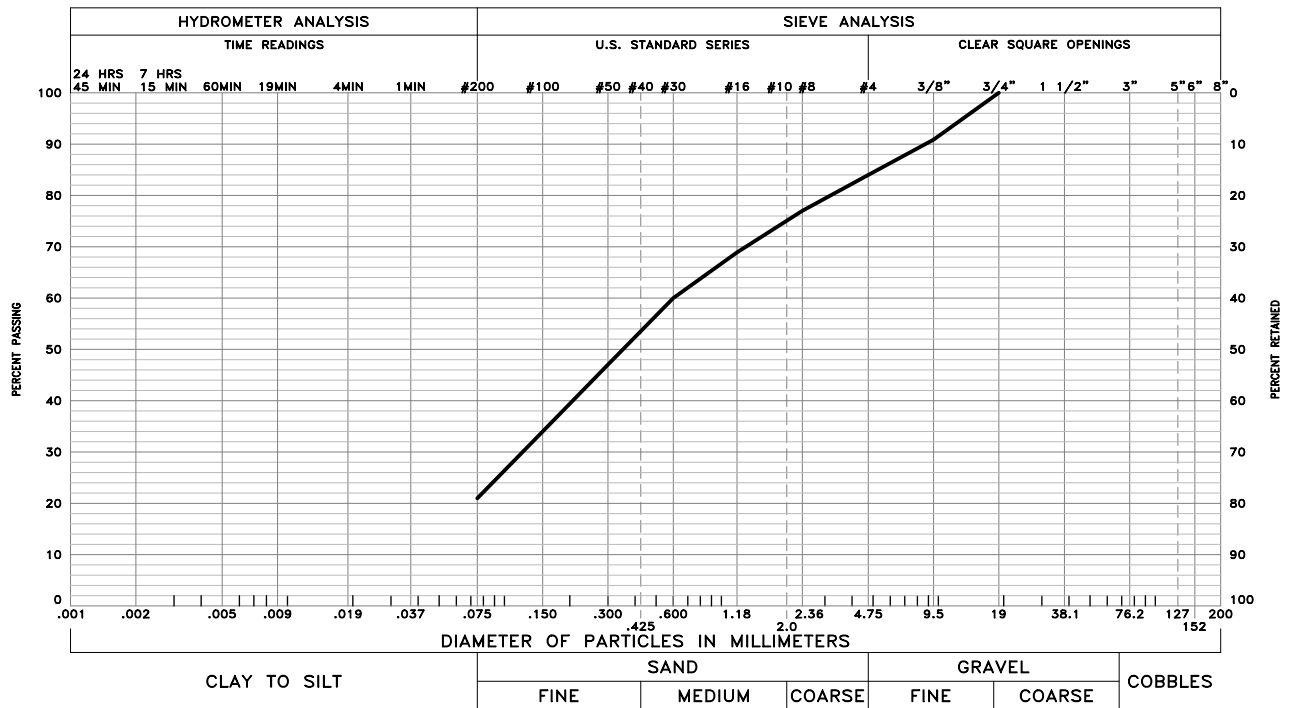


LEGEND

- (6) AGGREGATE ROAD SURFACING, THICKNESS IN INCHES SHOWN IN PARENTHESES TO LEFT OF THE LOG.
- SILTY SAND WITH GRAVEL (SM), FINE- TO COARSE-GRAINED, COBBLES AND SMALL BOULDERS INTER-MIXED, MEDIUM DENSE TO VERY DENSE, SLIGHTLY MOIST, TAN TO BROWN.
- POORLY-GRADED GRAVEL WITH SILT AND SAND (GP-GM), FINE- TO COARSE-GRAINED, COBBLES AND BOULDERS MORE PREVALENT, VERY DENSE, SLIGHTLY MOIST TO WET (BELOW GROUNDWATER), GRAY-BROWN.
- DRIVE SAMPLE, 1-3/8-INCH I.D. SPLIT-SPOON STANDARD PENETRATION TEST.
- 31/12 DRIVE SAMPLE BLOW COUNT. INDICATES THAT 31 BLOWS OF A 140-POUND HAMMER FALLING 30 INCHES WERE REQUIRED TO DRIVE THE SAMPLER 12 INCHES.
- 17 DEPTH TO WATER LEVEL AND NUMBER OF DAYS AFTER DRILLING MEASUREMENT WAS MADE.

NOTES

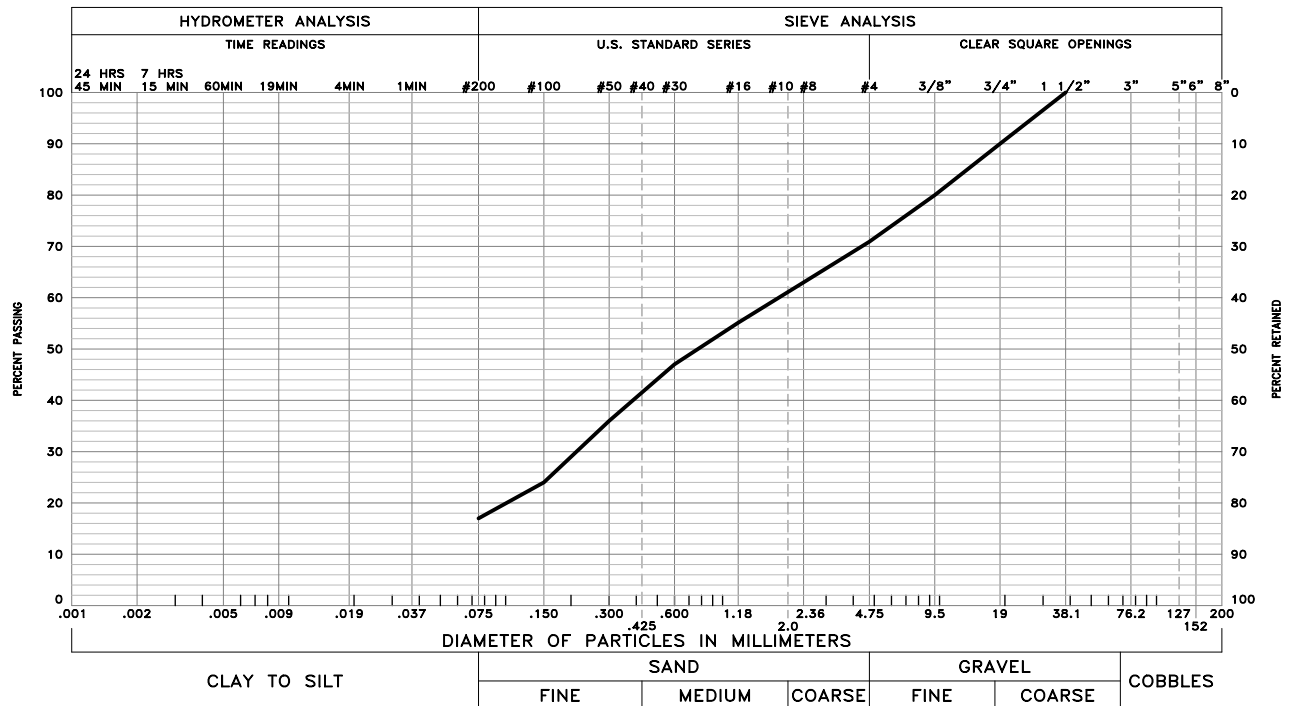
- THE EXPLORATORY BORING WAS DRILLED ON JUNE 14, 2024 WITH 4-INCH-DIAMETER CONTINUOUS-FLIGHT POWER AUGER.
- THE LOCATIONS OF THE EXPLORATORY BORINGS WERE LOCATED BY GPS COORDINATES OBTAINED FROM GOOGLE EARTH™ AND LOCATED IN THE FIELD WITH A HANDHELD GPS UNIT.
- THE ELEVATION OF THE EXPLORATORY BORING WAS NOT MEASURED AND THE LOG OF THE EXPLORATORY BORING IS PLOTTED TO DEPTH.
- THE EXPLORATORY BORING LOCATION SHOULD BE CONSIDERED ACCURATE ONLY TO THE DEGREE IMPLIED BY THE METHOD USED.
- THE LINES BETWEEN MATERIALS SHOWN ON THE EXPLORATORY BORING LOG REPRESENT THE APPROXIMATE BOUNDARIES BETWEEN MATERIAL TYPES AND THE TRANSITIONS MAY BE GRADUAL.
- GROUNDWATER LEVEL SHOWN ON THE LOG WAS MEASURED AT THE TIME AND UNDER CONDITIONS INDICATED. FLUCTUATIONS IN THE WATER LEVEL MAY OCCUR WITH TIME.
- LABORATORY TEST RESULTS:
WC = WATER CONTENT (%) (ASTM D2216);
+4 = PERCENTAGE RETAINED ON NO. 4 SIEVE (ASTM D6913);
-200= PERCENTAGE PASSING NO. 200 SIEVE (ASTM D1140);
LL = LIQUID LIMIT (ASTM D4318);
PI = PLASTICITY INDEX (ASTM D4318);
NV = NO LIQUID LIMIT VALUE (ASTM D4318);
NP = NON-PLASTIC (ASTM D4318);
WSS = WATER SOLUBLE SULFATES (%) (CP-L 2103);
CL = CHLORIDE CONTENT (%) (AASHTO T291);
pH = HYDROGEN ION CONCENTRATION (ASTM E 70);
A-2-6 (0) = AASHTO CLASSIFICATION (GROUP INDEX) (AASHTO M 145);
SUL = SULFIDES (POSITIVE, TRACE, NEGATIVE);
RE-DOX = OXYGEN REDUCTION POTENTIAL (mV).



GRAVEL 16 % SAND 63 % SILT AND CLAY 21 %

LIQUID LIMIT 14 PLASTICITY INDEX 2

SAMPLE OF: Silty Sand with Gravel (SM) FROM: Boring 1 @ 5'

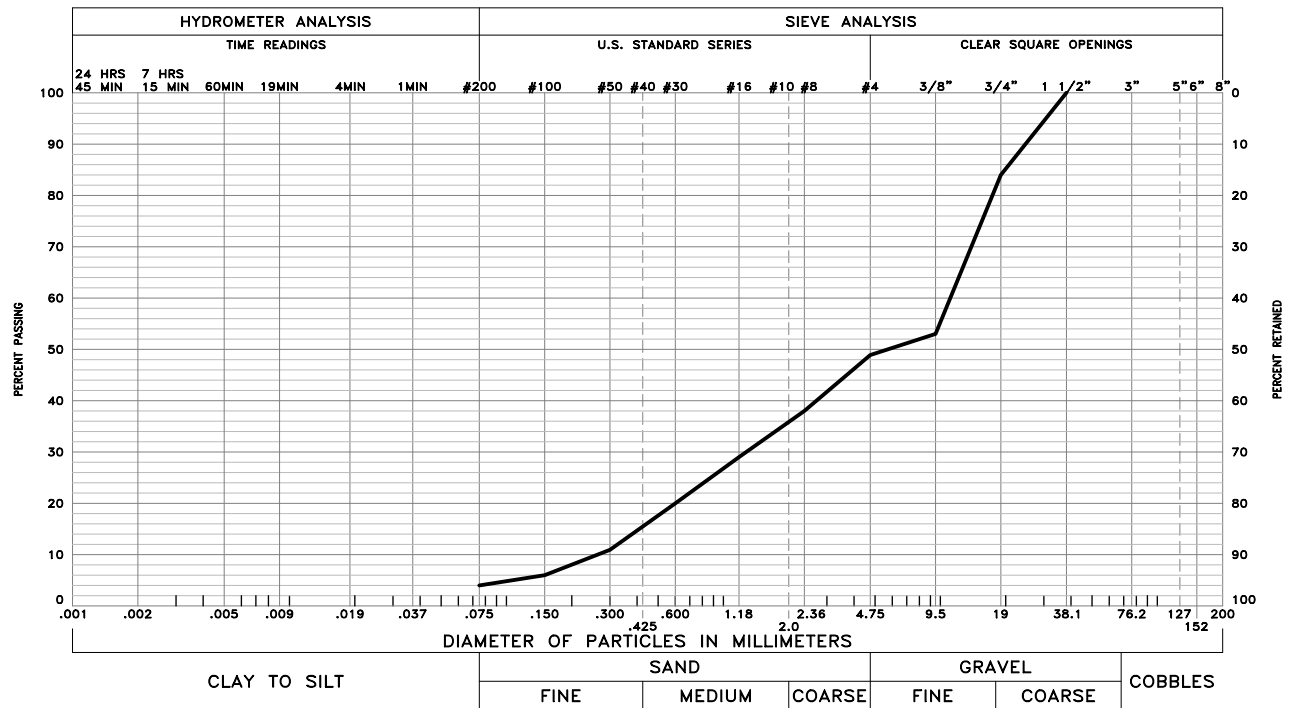


GRAVEL 29 % SAND 54 % SILT AND CLAY 17 %

LIQUID LIMIT NV PLASTICITY INDEX NP

SAMPLE OF: Silty Sand with Gravel (SM) FROM: Boring 1 @ 15'

These test results apply only to the samples which were tested. The testing report shall not be reproduced, except in full, without the written approval of Kumar & Associates, Inc. Sieve analysis testing is performed in accordance with ASTM D6913, ASTM D7928, ASTM C136 and/or ASTM D1140.

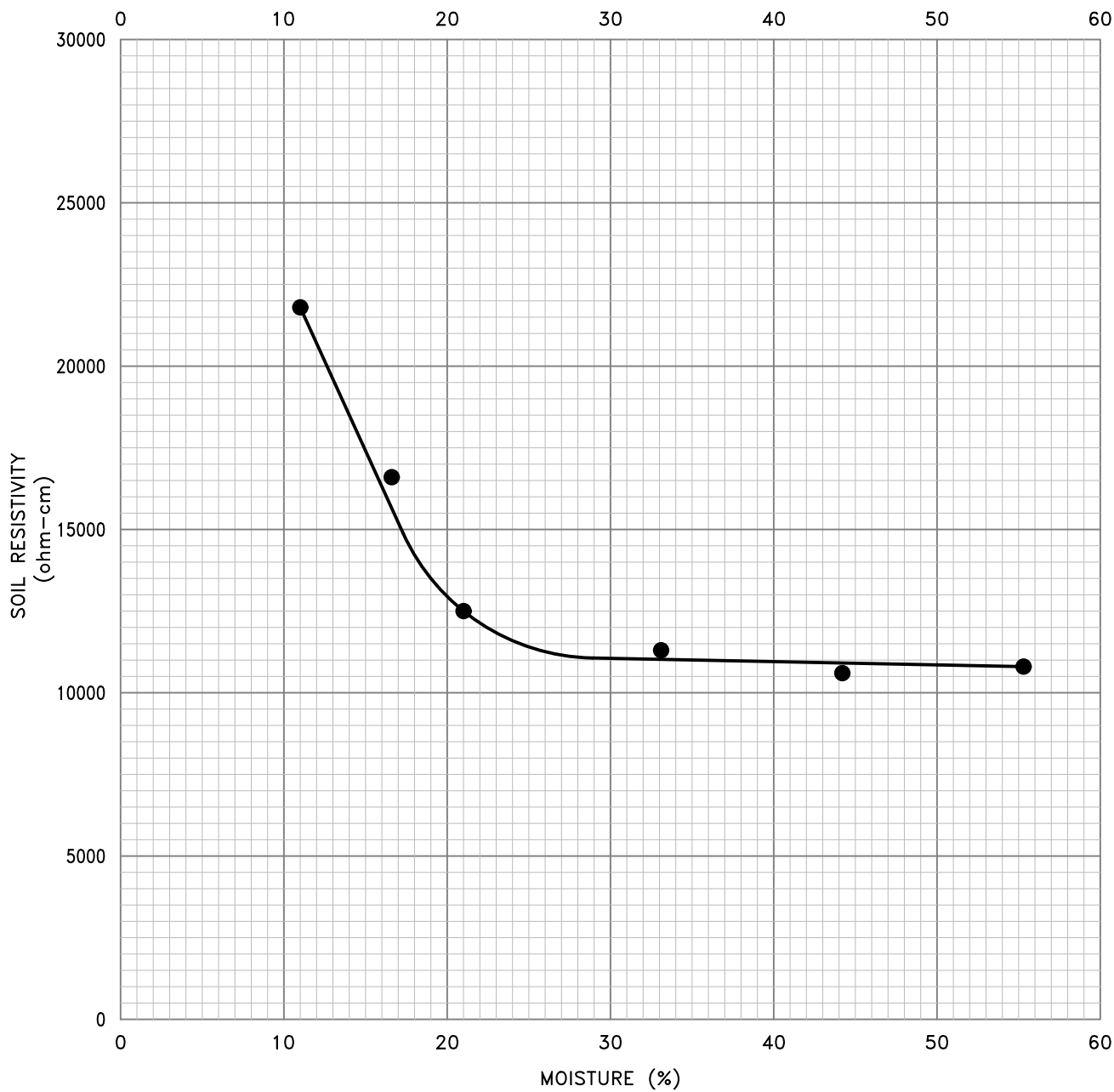


GRAVEL 51 % SAND 45 % SILT AND CLAY 4 %

LIQUID LIMIT NV PLASTICITY INDEX NP

SAMPLE OF: Poorly-Graded Gravel with Silt and Sand (GP-GM) FROM: Boring 1 @ 20'

These test results apply only to the samples which were tested. The testing report shall not be reproduced, except in full, without the written approval of Kumar & Associates, Inc. Sieve analysis testing is performed in accordance with ASTM D6913, ASTM D7928, ASTM C136 and/or ASTM D1140.



CURVE SYMBOL	SAMPLE IDENTIFICATION	SOIL OR BEDROCK TYPE	MINIMUM RESISTIVITY (ohm-cm)	RESISTIVITY AT IN SITU MOISTURE CONTENT (ohm-cm)
●	BORING 1 @ 9'	Silty Sand with Gravel (SM)	10,600	>20,000

Table I
Summary of Laboratory Test Results

Project No.: 24-1-401
 Project Name: Frisco Well House No. 7
 Date Sampled: 6/14/2024
 Date Received: 6/21/2024

Sample Location		Date Tested	Natural Moisture Content (%)	Gradation		Percent Passing No. 200 Sieve	Atterberg Limits		Water Soluble Sulfates (%)	AASHTO Classification (Group Index)	Chloride Content (%)	pH	Sulfide Content (mg/L)	ReDox Potential (mV)	Soil or Bedrock Type
Boring	Depth (Feet)			Gravel (%)	Sand (%)		Liquid Limit (%)	Plasticity (%)							
1	4	6/24/24	7.4	16	63	21	14	2	0.00	A-1-b (0)					Silty Sand with Gravel (SM)
1	9	6/24/24	4.8	31	53	16			0.01		0.63	6.21	0.1	134.9	Silty Sand with Gravel (SM)
1	14	6/21/24	3.3	29	54	17	NV	NP		A-1-b (0)					Silty Sand with Gravel (SM)
1	19	6/21/24	2.2	51	45	4	NV	NP		A-1-a (1)					Poorly-Graded Gravel with Silt and Sand (GP-GM)